PROGRESS REPORT 2007

May 2008

Progress Report to IIASA's National Member Organizations and Governing Council on IIASA's research and other activities in 2007

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Contents

Introduction

This is the second Progress Report for the **IIASA Research Plan 2006-2010** and presents the scientific work carried out at the Institute during 2007. It updates the Council and National Member Organizations of IIASA about the scientific achievements and policy impact of the Institute's Research Program during the last year, and outlines their activities for 2008.

I am very proud that, as authors and reviewers of the "Fourth Assessment Report" of the Intergovernmental Panel on Climate Change (IPCC), **17 IIASA scientists shared the 2007 Nobel Peace Prize** awarded to the United Nations Intergovernmental Panel on Climate Change (IPCC) and Al Gore for their work on climate change. Their work is key to helping policymakers come to grips with this major global problem.

I was saddened to hear **Bert Bolin**, chair of IIASA's Science Advisory Committee from March 2004 to June 2007, died on 30 December at 82. As a distinguished Swedish climate scientist, and as co-founder and first chairman of the IPCC, he played a key role in educating world leaders about the dangers of climate change.

The climate change theme spans all programs at IIASA. Scientists from the **Forestry** (FOR) and **Risk and Vulnerability** (RAV) programs represented the Institute at the **United Nations Climate Change Conference in Bali** in December. FOR presented a side event on "the politics of avoided deforestation," while RAV provided important input to the debate in favor of innovative donor-supported options for sharing extreme-event risks for developing countries.

At the 26th Session of the Subsidiary Body for Scientific and Technological Advice of the UN Framework Convention on Climate Change in Bonn in May, the **Greenhouse Gas Initiative** held a side event relating to its work on medium-term emission reductions, "Keeping Options Open through Mid-Century Targets." The importance of an integrated approach for the control of local air pollution and global greenhouse gases was highlighted at another side event co-organized by the **Atmospheric Pollution and Economic Development Program** at the 15th session of UN Commission on Sustainable Development (CSD-15) in New York in May.

The Global Energy Assessment (GEA), a multi-year, multi-stakeholder initiative looking at integrated solutions to existing and emerging threats associated with major global energy challenges, was officially launched at IIASA in January. The GEA was represented in two events at CSD-15: a lunchtime side event on Global Energy Assessment: Major Energy Challenges and Solutions, and a related evening event on Energy Security through Lived Interdependence. At the invitation of the UN Department of Economic and Social Affairs, IIASA's **Nebojsa Nakicenovic** was a coordinating lead author of a major report on climate change to the CSD-15, "Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable."

It was a good year for propagating IIASA research. A landmark for FOR was the publication of a **CD-ROM on Russian Forests and Forestry** containing consistent and spatial productivity tables for all major tree species in Russia, which is now being used by the Russian Ministry of Natural Resources in its forest management instructions. The **Evolution and Ecology Program** published two articles in *Science*: one urging evolutionary impact assessments for managing fisheries-induced evolution, and the other, with Harvard and Vienna universities, providing details of a new model explaining cooperation based on voluntary teamwork and costly punishment.

The journal *Technological Forecasting and Social Change* dedicated a special issue to new long-term scenarios on the uncertainties of greenhouse gas emissions and their mitigation. Developed by the **Greenhouse Gas Initiative**, the scenarios are based on methods and models from seven IIASA research programs and are available in an online scenario database. The **World Population Program** (POP) published an article in *Nature* showing how the world population will grow older faster, peaking from 2020 to 2030, as well as an article in *Science* on research showing the Millennium Development Goal of universal primary education by 2015 to be "insufficient" in terms of bringing the human capital of the adult labor force to the level required for rapid economic growth.

The **IIASA Conference**, unequivocally our "event of the year," represented an enormous investment of time and expertise by an organizational team headed by IIASA's Deputy Director Sten Nilsson. The two days were packed with contributions from distinguished speakers from business, politics, policy, and science, whose thoughts and ideas still resonate long after the Conference's end. Indeed, I acknowledge participants' sound advice and stimulating suggestions for IIASA's future research and methodology. And I trust that all our guests came away from this much-praised event similarly inspired.

Other notable international work included a study by POP on projecting future population and human capital growth at the level of governorates in Egypt, and Roadshows by the **Processes of International Negotiation Program** (PIN) in Pakistan and China.

Finally, in summer 2007, IIASA welcomed 51 post-graduate students from 20 countries for its annual **Young Scientists Summer Program** as well as two new **IIASA-funded post-doctoral fellows**.

IIASA looks forward to continuing and implementing many of the research strategies and proposals put forward in 2007 in the coming year. I am also delighted to announce that Council has enthusiastically appointed **Detlof von Winterfeldt** as the ninth Director of IIASA, effective January 1, 2009. IIASA is equally fortunate that **Sten Nilsson** will serve as Acting Director from mid-May through December, assuring that there will be no loss of momentum for IIASA.

Leen Hordijk
Director

May 2008

Part I

Environment and Natural Resources

Atmospheric Pollution and Economic Development Program

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Scientific Achievements and Policy Impacts in 2007

In 2007 the Atmospheric Pollution and Economic Development Program (APD) used its newly developed Greenhouse gas—Air pollution Interactions and Synergies (GAINS) model for a variety of policy analyses.

Cost-effective air pollution control strategies

A series of APD analyses assisted the European Commission in proposing for all member states quantitative ceilings to the emissions of five air pollutants. In two policy reports APD examined possible quantitative caps on national emissions that would meet the environmental objectives of the European Union (EU) Thematic Strategy on Air Pollution in 2020. APD explored the robustness of emission ceilings in view of uncertainties about, inter alia, future economic development, EU agricultural policies, the growth in maritime shipping, enforcement of environmental legislation in non-EU countries, and climate strategies. Policy discussions at two stakeholder workshops confirmed the findings of the GAINS model on the paramount impact of climate policy measures on the cost-effective allocation of air pollution control measures. As a consequence, the European Commission postponed its proposal on the revision of the National Emission Ceilings Directive so that it could be aligned with the forthcoming agreement on the "Package of implementation measures for the EU objectives on climate change and renewable energy for 2020."

Co-benefits of greenhouse gas mitigation

The landmark proposal on the EU's climate and energy package, which was introduced by the European Commission in January 2008, was informed, inter alia, by a comprehensive analysis using IIASA's GAINS model. To provide a quantitative basis for the policy discussion on the burden sharing arrangement for the 20 percent reduction target for EU greenhouse gas emissions in 2020, APD estimated for all EU member states the future potentials and costs for mitigation of non-CO_2 greenhouse gases and presented these estimates to all stakeholders (5 September 2007, Brussels). GAINS also computed for the proposed EU energy and climate strategy the associated benefits on air quality and avoided investments into air pollution control measures. It has been demonstrated that these benefits and cost savings constitute a significant fraction of the direct costs of greenhouse gas mitigation (*Figure 1*). A further GAINS study highlighted that an accelerated introduction of carbon capture and storage (CCS) in the EU would not only reduce the release of CO_2 into the atmosphere but at the same time reduce negative impacts of air pollution and save costs for air pollution control measures. Such co-benefits are particularly relevant for the integrated gasification combined cycle (IGCC) technology, which endogenously eliminates emissions of sulfur, nitrogen, and particulate matter.

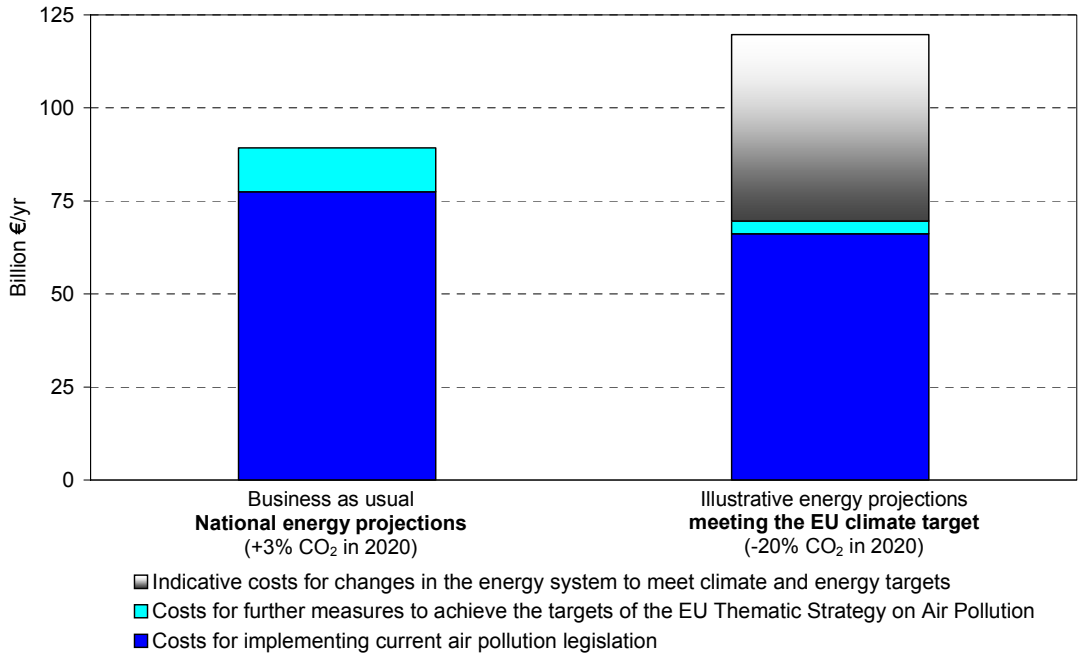

Figure 1. Emission control costs for the EU27 to meet the EU air quality and climate targets in 2020

Air pollution and greenhouse gases in China and India

In contrast to the perspective of global climate negotiations with their primary focus on greenhouse gas emissions, policy priorities in many developing countries are currently more geared toward near-term and local impacts of atmospheric pollution. With its focus on health impacts from fine particulate matter and ground-level ozone and from indoor use of solid fuels, GAINS can point out concrete strategies that maximize the positive side effects of air pollution control strategies on the emissions of greenhouse gases. In 2007 APD continued with the implementations of its GAINS model for China, India, and Pakistan. Preliminary analyses that were presented at workshops in Beijing, New Delhi, and Islamabad highlighted for the three countries an important potential for win–win solutions that do not, at the same time, place an excessive burden on economic development. Such options not only include the more efficient use of all forms of energy, but also foster advanced clean coal technologies (e.g., IGCC) as an essential element. A systems perspective, as offered by GAINS, is crucial for identifying solutions that reap multiple benefits in problem areas that are usually analyzed in isolation. At the same time the initial GAINS analyses revealed cases that involve important trade-offs. For instance, enhanced use of biomass in households is often considered to be a measure with positive climate impacts, although it can cause serious health impacts, especially in developing countries under poor (indoor) combustion conditions (Figure 2).

Insights for global policymaking

To support the forthcoming negotiations on a post-Kyoto climate agreement, APD was invited by the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) to present its GAINS approach for the assessment of co-benefits of greenhouse gas mitigation at the plenary round-table discussion at the Third Workshop of the "Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol," which took place at the 26th Session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (14 May 2007, Bonn).

The importance of an integrated approach to the control of local air pollution and global greenhouse gases was highlighted at a side event that was jointly organized by IIASA and the Italian National Agency for New Technologies, Energy, and the Environment (ENEA) at the 15th session of UN Commission on Sustainable Development (10 May 2007, New York).

A special analysis with GAINS demonstrated that unless targeted counter-measures are taken, air pollution emissions from marine shipping around Europe could surpass the volume of land-based emissions within the next few decades. The air quality targets established by the Thematic Strategy on Air Pollution could be achieved at lower costs if emission controls also included measures for ships in international waters. These findings were presented to the negotiations of the International Maritime Organization (IMO).

A global perspective on air pollution

APD was invited by the UK Royal Society Working Group on "Ground-level ozone in the 21st century" to provide a range of global emission projections of ozone precursor emissions. For this purpose, APD computed for the energy projections of the global long-term SRES scenarios that were developed with IIASA's MESSAGE model the implied emissions of nitrogen oxides (NOx), methane (CH_4), and carbon monoxide (CO), taking into account the recent spread in the adoption of stringent

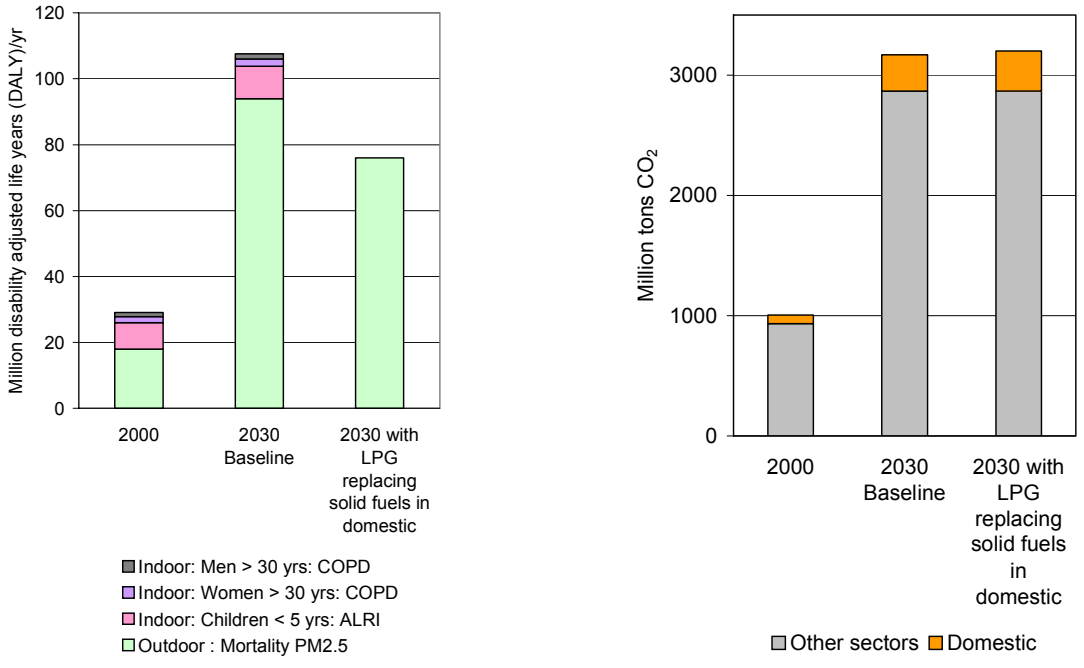

Figure 2. Health impacts from indoor and outdoor pollution in India, and corresponding CO_2 emissions

emission control legislation for vehicles, especially in developing countries. Using these projections, a range of atmospheric chemistry models have demonstrated that if current legislation were fully implemented, dramatic increases in global ozone levels could be avoided at the large scale, although concerns would still prevail for urban areas in developing countries.

Under the umbrella of the EU FP6 European Network of Excellence on "Atmospheric Composition Change" (ACCENT), APD organized a workshop on "Remote Sensing and Inventories of Anthropogenic Emissions" that brought together the scientific communities active in satellite observations of atmospheric pollution with scientists working on bottom-up emission inventories (4–5 December 2007). Presentations discussed potential explanations for the sometimes significant discrepancies obtained for the two different approaches and developed a joint research agenda.

Activities for 2008

In 2008 APD will finalize its GAINS implementations for China and India and disseminate the results among the relevant scientific and policy communities in these countries as well as in the international policy arena. As an input to the negotiations on a post-Kyoto agreement, APD will use its GAINS model to quantify potentials and costs for greenhouse gas mitigation for all Annex 1 countries of the Kyoto Protocol and estimate the associated co-benefits on air pollution. As part of a worldwide scientific initiative to estimate the global burden of disease from air pollution, APD will refine the quantification of health impacts of outdoor and indoor air pollution and apply them on a global scale. Furthermore, in cooperation with IIASA's World Population Program, it will explore the macroeconomic implications of improved health conditions in order to derive a fuller picture of the wellbeing aspects of economic development. Together with IIASA's Land Use Change and Agriculture Program, APD will develop a comprehensive assessment of nitrogen emissions from land use in China and explore measures that simultaneously reduce nitrogen emissions from the agricultural sector and contribute to the adaptation to climate change.

Personnel

Scientific Staff

Markus Amann (Austria), *Program Leader*
Willem Asman (Netherlands)
Hans Benzinger (Germany)
Imrich Bertok (Slovakia)
Adam Chambers (USA)
Janusz Cofala (Poland)
Frantisek Gyarfas (Slovakia)
Christopher Heyes (United Kingdom)
Lena Höglund Isaksson (Sweden)
Sebastian Klaassen (Austria)
Zbigniew Klimont (Poland)
Maciej Makowski (Poland)
Gregg Marland (USA)
Pallav Purohit (India)
Peter Rafaj (Slovakia)
Robert Sandler (Austria)
Wolfgang Schöpp (Austria)
Geza Toth (Hungary)
Fabian Wagner (Germany)
Wilfried Winiwarter (Austria)
Jia Xing (China)
Chuying Zhang (China)

YSSP

Michiel Hekkenberg (Netherlands)
Annemarie Kerkhof (Netherlands)
Imran Shahid (Pakistan)
Gregor Thenius (Austria)

Administrative Support

Margret Gottsleben (Germany)

Scientific Recognition (awards, selected invited lectures, and editorships)

Markus Amann

- Member of the Clean Air Commission of the Austrian Academy of Sciences
- Member of the UK Royal Society Working Group on "Ground-level ozone in the 21st century"
- Member of the Editorial Board of Environmental Modelling and Software.
- Lead Author for the Fourth Assessment Report of Working Group III of the Intergovernmental Panel on Climate Change
- Statement representing the International Council of Scientific Unions (ICSU) at the ministerial section of 15th session of UN Commission on Sustainable Development dealing with air pollution and climate (11 May 2007, New York).

Invited lectures:

- *Future challenges for integrated assessment modelling.* (March) Invited plenary lecture at the Third Workshop on future policy needs on atmospheric pollution, organized by the Swedish ASTA program in Gothenburg (March 2007)
- *Ozone precursor emissions from anthropogenic sources in the 21st century.* Invited lecture at the workshop on Ground-level ozone in the 21st century organized by the Royal Society UK (29 May 2007, London)
- *Reducing greenhouse gas emissions: The added value for human health.* Tenth European Health Forum, 3–6 October 2007, Bad Hofgastein, Austria.

Evolution and Ecology Program

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Introduction

Evolution is the architect and custodian of all biological diversity. Insights about the dynamics of adaptation are thus indispensable for understanding the past, present, and future of Earth's ecosystems. If human interventions directed at responsible conservation and sustainable exploitation are to be successful, they must account for the evolutionary dimensions of anthropogenic environmental change. Responding to this increasingly recognized need, IIASA's Evolution and Ecology Program (EEP) analyzes and forecasts how evolutionary dynamics shape ecological populations and communities. Specific challenges addressed range from assessing and managing human-induced evolutionary changes in exploited fish stocks, to fostering cooperation in groups of unrelated agents, to understanding and forecasting the impact of environmental disturbances on the structure and functioning of food webs. Together with its network of international collaborators, the Program is driving the development and application of adaptive dynamics theory, a framework recognized by many as the most versatile tool currently available for linking the ecological and evolutionary consequences of environmental change. Based on a two-pronged attack through applied and methodological research, the Program establishes bridges between fundamental and policy-oriented, theoretical and empirical, biological and mathematical, and analytical and numerical approaches to the systems analysis of ecological and evolutionary change.

Operations Highlights

The year 2007 saw a significant expansion and intensification of EEP's international collaborative research activities:

1. In December 2007 the journal *Science* published a Policy Forum article on *Managing Evolving Fish Stocks* (Jørgensen et al. 2007) collectively authored by the *Study Group on Fisheries-Induced Adaptive Change*, established by the International Council for the Exploration of the Sea and co-chaired by IIASA scientists Mikko Heino and Ulf Dieckmann.
2. In June 2007 the journal *Science* published the article *Via Freedom to Coercion: The Emergence of Costly Punishment* (Hauert et al. 2007), which explains how voluntary teamwork and costly punishment interact in the emergence of cooperative behavior.
3. In January 2008 the European Science Foundation announced selection and funding of the Research Networking Programme *FroSpects on Frontiers of Speciation Research*. Initiated by IIASA and supported by 15 countries until 2013, the network will organize workshops and stimulate collaborative research on the origin and maintenance of biodiversity.
4. In September 2007 the Australian Research Council decided to fund a Discovery Project on *Plant Ecological Strategies across Species and an Evolutionary-ecology Vegetation Model*, an ambitious multinational research initiative that will attempt to develop the evolutionary foundations of dynamic global vegetation models.
5. Following a recommendation by the European Science Foundation, the Austrian Science Fund decided to support, until 2011, a research project on *The Adaptive Evolution of Mutualistic Interactions* as part of a multinational collaborative research project on Mutualisms, Contracts, Space, and Dispersal.
6. Funded by the Austrian Science Fund, the project *Evolution and Cooperation in Heterogeneous Spatial Games* is yielding new insights into how the heterogeneous allocation of resources in spatially distributed populations can be used to increase cooperation.
7. The European Research Training Network FishACE on *Fisheries-induced Adaptive Changes in Exploited Stocks* brings together 11 international research institutions coordinated by IIASA and, in 2007, reached the full breadth of its intended research agenda. Two young scientists from partner institutions successfully participated in IIASA's YSSP 2007.
8. The European Research Network FinE on *Fisheries-induced Evolution* started with a kick-off meeting in September 2007. The FinE project, which involves 18 international research institutions and operates until 2010, endeavors to unravel mechanisms underlying evolutionary change from the phenotypic to the genetic level, to evaluate their consequences for population and fisheries dynamics and to provide recommendations for evolutionarily enlightened management.
9. First research results are emerging from the project ADAPTFISH on *Adaptive Dynamics and Management of Coupled Socio-Ecological Systems Involving Recreational Fisheries*, for which EEP is partnering with the German Institute for Freshwater Ecology and Inland Fisheries to investigate the evolutionary consequences of freshwater angling.
10. In 2007 EEP made major progress in its contribution to the European Research Project UNCOVER on *Understanding the Mechanisms of Stock Recovery*, in close collaboration with the Norwegian Institute for Marine Research.

Among EEP's activities within IIASA, the following may be highlighted:

1. Participating in IIASA's international conference on *Global Development: Science and Policies for the Future*, EEP presented an overview on *The Global Fisheries Crisis: Acknowledged Causes and Elusive Cures*.
2. Collaboration with IIASA's Forestry Program led to the article *Adaptive Dynamics and Technological Change* (Dercole et al. 2008), which is currently in press in the journal *Technovation*. This work illustrates how the adaptive dynamics framework developed by EEP is readily applied to non-biological processes of adaptation.
3. Collaboration with IIASA's Dynamic Systems Program involved joint work on the efficient description of spatially distributed ecological dynamics in terms of moment equations and led to the joint supervision of a YSSP participant.

4. Through participation in the dialog preceding Korean accession to IIASA membership, EEP has been exploring options for joint research with Korean scientists on topics ranging from fisheries-induced evolution to modeling speciation.
5. EEP initiated IIASA's joining of the *Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities* and is contributing to discussions on how IIASA's practices can best be adjusted to foster open-access publication.
6. Edited by EEP and published by Cambridge University Press, the *Cambridge Studies in Adaptive Dynamics* series of books fosters the dissemination of methodological advances and innovative scientific perspectives developed at IIASA. Throughout 2007, work continued on Volumes 6 and 7, entitled *Fisheries-induced Adaptive Change* (Dieckmann et al., in preparation) *and Elements of Adaptive Dynamics* (Dieckmann and Metz, in preparation).
7. EEP's strong commitment to IIASA's YSSP was rewarded by YSSP Awards received by Daniel Falster (YSSP 2006, *An Evolutionary Model of Plant Succession*) and Andries Richter (YSSP 2007, *The Evolution of Social Norms for Renewable Resource Exploitation*).

The sections below briefly review EEP's research accomplishments in 2007, structured according to the Program's four main research projects as established in EEP's research plan for 2006–2010.

Adaptive Dynamics Theory

A backbone of EEP's research activities, adaptive dynamics theory provides versatile tools for analyzing the complex interplay between population ecology, phenotypic evolution, and environmental change. The EEP Program continues to develop the adaptive dynamics toolbox at the front line of international research, through a concerted line of mathematical and applied projects.

An overview of the theory of adaptive dynamics will be provided in a forthcoming book (Dieckmann and Metz, in preparation), which will also cover an extension of adaptive dynamics theory to Mendelian populations (Metz, submitted). Recent theoretical advances have already extended adaptive dynamics theory to physiologically structured populations (Dieckmann et al. 2007; Durinx et al. 2008). Additional research on bifurcation theory assists understanding of ecological transitions in realistically structured population models (Dercole et al. 2007a, 2007b).

In terms of applications, efforts have focused on multi-species models for examining the adaptive dynamics of community structure (Dieckmann et al. 2007), predator–prey evolution (Troost et al. 2008), and the evolutionary restorability of ecological communities (Johansson and Dieckmann 2008). Other applications have addressed the origin of biodiversity through speciation, investigating adaptive speciation in sexual models of quantitative genetics (Doebeli et al. 2007), a new mechanism for recurrent adaptive radiations (Ito and Dieckmann 2007), adaptive speciation along environmental gradients (Leimar et al. 2008), and the joint occurrence of adaptive speciation and dispersal evolution along environmental gradients (Heinz et al. 2008). Further applications have addressed the evolution of foraging strategies along resource gradients (Heino et al. 2008), the evolution of resource specialization through behavioral and morphological adaptations (Rueffler et al. 2007), the evolution of synchronization in metapopulations (Dercole et al. 2007c), and the adaptive dynamics of technological change (Dercole et al. 2008).

Evolutionary Fisheries Management

EEP's research on fisheries-induced evolution is designed to overcome a blind spot in the management of living aquatic resources: exploitation not only changes the abundance of fish, but also their traits. In pursuing this goal, EEP adopts a threefold approach.

A first element is the development of innovative methodological tools suitable for tackling the new research questions. To predict the future ecology and evolution of exploited fish stocks, to understand observed past changes, and to assess alternative management strategies, a novel class of eco-genetic models has been devised (Dunlop et al., submitted-a, submitted-b), and adaptive dynamics models have been extended (Ernande et al., submitted). To analyze trends in the maturation schedules of exploited fish stocks, so-called probabilistic maturation reaction norms have been introduced and estimated from data (Dieckmann and Heino 2007; Heino and Dieckmann 2007, 2008). To facilitate the comparison and interpretation of the ecological and evolutionary consequences of alternative management strategies, EEP has started to develop an integrative framework for deriving and assessing different utility components from dynamical models (Dankel et al. 2007).

As a second element, these new tools are applied to case studies on particular stocks. The steady pace of work along this line of research continued in 2007, with dedicated studies targeting smallmouth bass in Canadian lakes (Dunlop et al. 2007), brook charr in Canadian creeks (Thériault et al. 2008), Atlantic cod in the Gulf of St. Lawrence (Heino et al. 2007) and in the Barents Sea (Eikeset et al., submitted), North Sea herring (Enberg and Heino 2007), North Sea plaice (Grift et al. 2007; Mollet et al., in preparation), and sockeye salmon in Alaska (Kendall et al., in preparation).

A third element is provided by strategic studies designed to address basic open questions regarding fisheries-induced evolution. Recent progress includes an investigation of the propensity of marine reserves to slow the evolutionary effects of fishing (Dunlop et al., in preparation), new analyses of the practical implications of sex structure for fisheries-induced evolution (Mollet et al., in preparation; Urbach et al., in preparation), and systematic investigations of the ecological and evolutionary aspects of recovery in collapsed fish stocks (Enberg et al., in preparation). At a more fundamental level, investigations have examined parental care (Steinegger and Taborsky 2007; Taborsky et al. 2007), a process that may be disrupted by exploitation.

EEP's long-lasting research investment in elucidating the evolutionary implications of fishing (Dieckmann et al., in preparation) is attracting increasing attention among scientists in charge of providing advice to fisheries managers. The Study Group on Fisheries-induced Adaptive Change (SGFIAC), established in 2006 by the International Council for the Exploration of the Sea (ICES), addresses scientific and applied dimensions of

fisheries-induced evolution (Arlinghaus et al. 2007). The group jointly prepared an article in *Science*'s Policy Forum on *Managing Evolving Fish Stocks* (Jørgensen et al. 2007) that received wide attention and triggered lively debate.

Evolution of Cooperation

EEP's research on the evolution of cooperation strives to unravel the conditions required for engendering unselfish behavior in groups of unrelated agents. The basic question is how to avoid the "tragedy of the commons," through which selfish individual behavior jeopardizes public goods.

An article in *Science* entitled *Via Freedom to Coercion: The Emergence of Costly Punishment* (Hauert et al. 2007) examined the role of freedom and enforcement in public goods games. Not surprisingly, the possibility of punishing exploiters helps stabilize cooperation. However, if punishment is costly, it is difficult to conceive how punishment can emerge in the first place in a society dominated by punishers. Moreover, it is not evident how punishment can persist in the presence of "second-order exploiters," that is, players who do not punish exploiters but otherwise cooperate. A surprising escape from this dilemma opens up when the public goods game is voluntary rather than compulsory, so that players can opt not to participate in the game. The article shows, through analytic arguments and numerical simulations, that punishers will then emerge and persist in finite populations.

A comprehensive survey article on indirect reciprocity (Brandt et al. 2007), including new material on spatial games and cooperation experiments, was published in collaboration with Japanese researchers. Nowak and Sigmund (2007) highlighted overarching features bridging across the large variety of mechanisms stabilizing cooperation, including kin selection, direct and indirect reciprocity, cooperation on networks, and group selection. Reviewing the hotly debated contribution of punishment to the origin and maintenance of cooperation, Sigmund (2007) emphasized the role of incentives in promoting cooperative behavior in larger groups. Skubic (2007) reviewed the theory of cooperative breeding, Nakamaru and Dieckmann (submitted) investigated the natural emergence of strict-and-severe punishment in spatial games, and Kun and Dieckmann (submitted) showed how resource heterogeneity can greatly enhance cooperative behavior.

Evolving Biodiversity

Understanding the mechanisms underlying the emergence, maintenance, and loss of biodiversity remains a major challenge for evolutionary ecology and conservation science. EEP contributes to the resultant efforts in a variety of ways. First is the research on speciation and community evolution already mentioned above (Dieckmann et al. 2007; Doebeli et al. 2007; Heinz et al. 2008; Ito and Dieckmann 2007; Johansson and Dieckmann 2008; Leimar et al. 2008; Troost et al. 2008). Second is work on disease evolution addressing the often intricate interactions between pathogens and their hosts (Adams and Sasaki 2007; Mako et al. 2007; Yahara et al. 2007), including fundamental research on antigenic drift in influenza A (Kryazhimskiy et al. 2007) and on the incorporation of long-range correlations in models of disease spread (Peyrard et al. 2008). Third are three studies on evolutionary constraints (Galis and Metz 2007; Galis et al. 2007; Mazzucco and Mazzucco 2007). Fourth are novel insights into modeling species distributions using regression quantiles (Vaz et al. 2007), distinguishing quasi-cycles and limit cycles in ecological time series (Pineda-Krch et al. 2007), and into the unexpected non-monotonic effects of disturbances on the population size of species inhabiting fragmented landscapes (Kun et al., submitted).

Scientific Recognition

Editorships, Ulf Dieckmann

Theoretical Ecology

Invited lectures, Gergely Boza

1. International Centre for Theoretical Physics (ICTP), Trieste, Italy, Sixth European Conference on Ecological Modelling (ECEM07): Cooperation in n-player prisoner's dilemma threshold games

Invited lectures, Åke Brännström

1. Beijing, China, EcoSummit 2007: Evolutionary consequences of harvesting in size-structured food webs; and Evolution of maturation size in harvested predator–prey systems
2. Wuyishan, Fujian, China, Fourth International Conference on Mathematical Biology: Evolution of maturation size in harvested predator–prey systems
3. Umeå University, Umeå, Sweden, Workshop on Size-structured Population Models: An evolutionary model of plant succession

Invited lectures, Ulf Dieckmann

1. Portuguese Research Institute for Agriculture and Fisheries, Lisbon, Portugal, 2007 Meeting of the ICES Study Group on Fisheries-induced Adaptive Change (SGFIAC): Eco-genetic models for studying fisheries-induced evolution
2. Umeå University, Umeå, Sweden: The overlooked evolutionary dimension of modern fisheries

3. French Research Institute for Exploitation of the Sea (Ifremer), Port-en-Bessin, France, Annual Meeting of the European Research Training Network FishACE: Coordinator's overview for mid-term review and A family of generalized growth models
4. Snowbird, USA, SIAM Conference, Mini-symposium on Dynamics of Adaptive Coevolutionary Networks: The adaptive dynamics of coevolving communities
5. Collegium Budapest, Budapest, Hungary, Launch conference of the EUROCORES initiative TECT (The Evolution of Cooperation and Trading): The adaptive evolution of mutualistic interactions
6. San Jose, USA, Joint Annual Meetings of the Society for Mathematical Biology and the Japanese Society for Mathematical Biology, Mini-symposium on Adaptive Speciation, Theory Meets Population Genetics: Adaptive speciation, recent insights and future challenges
7. Korea University, Seoul, South Korea: Models of evolutionary dynamics, an integrative perspective
8. National Fisheries Research and Development Institute (NFRDI), Busan, South Korea: The overlooked evolutionary dimension of modern fisheries
9. Seoul, South Korea, KOSEF/IIASA Symposium: The overlooked evolutionary dimension of modern fisheries
10. Korea Center for Disease Control and Prevention (KCDC), Seoul, South Korea: Virulence evolution, beyond R0 maximization
11. Bergen, Norway, Opening Meeting of the European Research Network FinE (Fisheries-induced Evolution): Introduction to eco-genetic models and Task introductions (Fisheries-induced multi-trait evolution; Evolutionary vulnerability of prototypical life histories; Fisheries-induced evolution of specific stocks; Implications for stock stability and recovery potential; Evolutionarily enlightened stock management)
12. Umeå University, Umeå, Sweden, Workshop on Size-structured Population Models: Models of somatic and gonadic growth, an integrative perspective
13. Hofburg, Vienna, Austria, IIASA Conference on Global Development, Science and Policies for the Future: The global fisheries crisis, acknowledged causes and elusive cures
14. International Centre for Theoretical Physics (ICTP), Trieste, Italy, Sixth European Conference on Ecological Modelling: Modelling evolution, principles and applications
15. University of Tokyo, Tokyo, Japan: The adaptive dynamics of coevolving communities
16. The Graduate University for Advanced Studies, Hayama, Japan: Adaptive speciation, linking pattern and process

Invited lectures, Katja Enberg

1. Norwegian College of Fishery Science, Tromsø, Norway, ECONORTH Conference: Do fisheries-induced life-history changes influence stock recovery?

Invited lectures, Barbara Fischer

1. University of Bern, Bern, Switzerland: A model for energy allocation in a stochastic environment

Invited lectures, Ádám Kun

1. Free University of Barcelona, Barcelona, Spain, Workshop on Molecular Cooperation: Theoretical insights from multi-level public good games to enzymatization and protocell dynamics
2. International Centre for Theoretical Physics (ICTP), Trieste, Italy, Sixth European Conference on Ecological Modelling: The evolution of density-dependent dispersal in a noisy spatial population model

Invited lectures, Shuichi Matsumura

1. International Centre for Theoretical Physics (ICTP), Trieste, Italy, Sixth European Conference on Ecological Modelling: Non-ideal predators and resource dynamics: Implications for spatially structured fish-angler interactions

Invited lectures, Hans Metz

1. Umeå University, Umeå, Sweden, Workshop on Size-structured Population Models: Extending the canonical equation of adaptive dynamics to more realistic biological scenarios

Invited lectures, Axel Rossberg

1. Beijing, China, EcoSummit 2007, Symposium on Understanding Complex Food Webs: Understanding macroecology with the help of allometric stochastic food-web models
2. Edinburgh, United Kingdom: Meeting of the NANIA (Novel Approaches to Networks of Interacting Autonomes) Collaboration: Stochastic food-web theory
3. University of Fribourg, Fribourg, Switzerland: Size-structured evolutionary community models
4. Umeå University, Umeå, Sweden, Workshop on Size-structured Population Models: The top-down mechanism for body mass-abundance scaling

Invited lectures, Barbara Taborsky

1. Dalhousie University, Halifax, Canada, International Ethological Conference: Prudent habitat choice causes size-assortative mating in a monogamous cichlid

Personnel

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Forestry

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Objectives

The overall objective of the Forestry (FOR) Program is to address selected issues related to global change and forests with respect to the management of the forest sector and its interaction with other sectors, both environmental and non-environmental. The FOR Program is organized around three major themes. The first theme, *Greenhouse Gas Cycling and Terrestrial Ecosystems*, is itself divided into three projects and has the objective of contributing to a better understanding of the exchange of greenhouse gas (GHG) fluxes between terrestrial ecosystems and the atmosphere. The second theme is *Global Impacts of Forest Sector Development in Emerging Economies*, which is divided into two projects and aims to address the global impacts of the forest sectors in China and India, respectively. The third theme is *International Governance of Forests*, the objective of which is to contribute to the improvement of international practices in forestry and to bring the research results achieved in the Program into the sector's policy and governance processes.

Scientific Achievements

In 2007 FOR research involved activities in all three themes discussed above.

Greenhouse gas cycling and terrestrial ecosystems

This theme is divided into three projects: 1) *Global Terrestrial GHG Management*; 2) *Full GHG Analysis of Northern Eurasia's Terrestrial Biota*, and 3) *Constraining and Handling Uncertainties of GHG Fluxes*.

1) Global terrestrial GHG management

The objective of this project is to identify and quantify suitable measures of intervention in terrestrial GHG cycles in a consistent manner within forestry and agriculture and to relate these to the energy and industrial sectors.

The Integrated Sink Enhancement (INSEA) Project, funded by the European Union (EU), was officially finalized in 2006, although work and dissemination of results continued in 2007. Its objective is to assess the economic and environmental impacts of enhanced GHG sinks at the pan-EU level. Examples of this work are uncertainty analysis of climate change mitigation options in the forest sector (Böttcher et al. 2007) and global modeling of land use change and carbon sequestration (Rokityanskiy et al. 2007). FOR's work has also had substantial impacts on the issue of bioenergy and the links to climate change (e.g., Kraxner and Yamagata, 2007; Kraxner et al. 2007; Marland et al. 2007).

However, the major impact during 2007 was in terms of the European Commission-funded project "Global Earth Observation—Benefit Estimation: Now, Next and Emerging" (GEO-BENE), coordinated by FOR and following on from FOR's long-term involvement in earth observations linked to GHG/climate change. The objective of the project is to develop methods and tools to assess the socioeconomic and environmental benefits of the Global Earth Observation System of Systems (GEOSS), coordinated by the Group on Earth Observations (GEO: www.earthobservations.org).

These benefits are assessed in the nine Societal Benefit Areas (SBAs) of GEO: Disasters, Health, Energy, Weather, Climate, Water, Ecosystems, Agriculture, and Biodiversity. Phase I of the GEO-BENE project, "Development of Methods and Tools," ended during 2007 and FOR is now concentrating its work on phase II "Implementation and Application," which will be followed by the last phase III, "Global Aggregation and Integration across SBAs," in 2008.

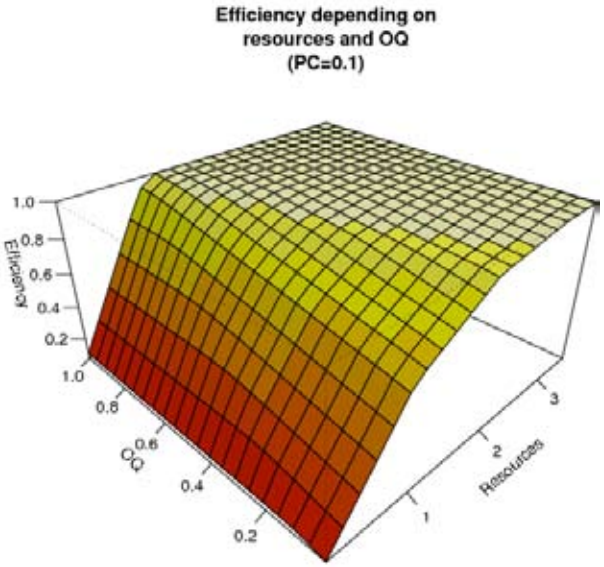

Figure 1. First result of FOR-based research on the Societal Benefit Areas (SBAs) of disasters: Rescue efficiency after an earthquake depending on available rescue resources and the density of an in situ sensor network.

Within the framework of GEO-BENE, FOR researchers participated in a number of international workshops and conferences. Inter alia, FOR exhibited at the GEO Ministerial Summit, which took place from 28 to 30 November 2007 in Cape Town (http://www.geo-bene.eu/?q=node/174) and held a side event on the political economy of avoided deforestation at the 13th Conference of Parties (COP 13) of the United Nations Framework Convention on Climate Change (UNFCCC) in Bali (3–14 December 2007) (http://unfccc.int/2860.php).

In November 2007 the FOR Program was invited to enter the negotiations for a new three-year research project sponsored by the European Commission (EC), "Climate Change– Terrestrial Adaptation and Mitigation in Europe" (CC-TAME). This 17-partner project is a continuation of the successfully finalized EC

project INSEA from 2006 and will also be coordinated by FOR. CC-TAME's primary objective is to build a strong science–policy interface. A major aim is to implement a "policy–model–data fusion" concept which will guarantee efficient and effective mitigation and adaptation policies in the land use sector and maximize benefits from policy coordination with other EU policies. The CC-TAME project will also augment FOR's contribution to the European Consortium for Modelling of Air pollution and Climate Strategies (EC4MACs) project coordinated by the Atmospheric Pollution and Economic Development (APD) Program of IIASA.

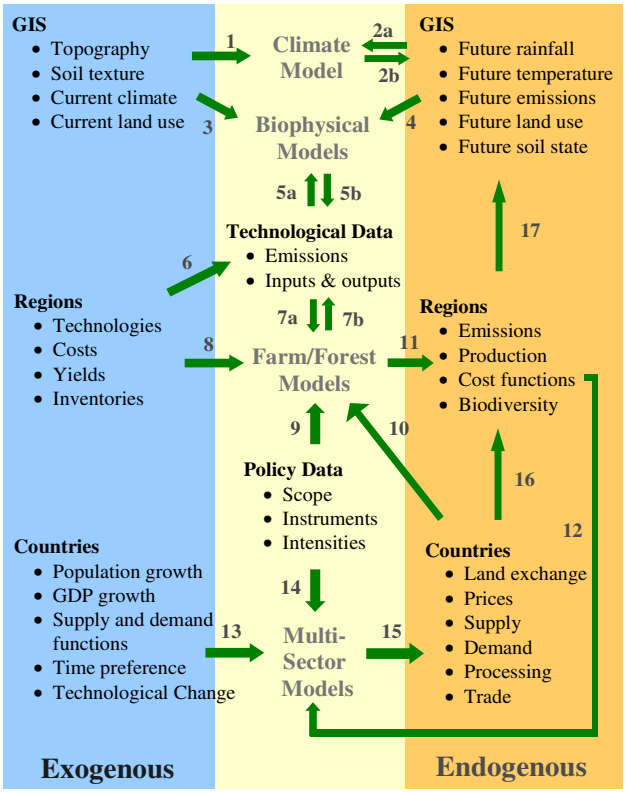

Figure 2: Data flow in CC-TAME

Along with CC-TAME, the FOR Program is also taking part in negotiations with the EC as consortium partners in two further FP7 projects:

- "Full Cost of Climate Change" (FCCC, with a 32-month duration) focuses on progressing the consideration of the economic costs of climate change damages. This includes the costs of inaction, mitigation, and adaptation.
- "Biomass Energy Europe" (BEE, with a 33-month duration) aims to improve the accuracy and comparability of future biomass resource assessments for energy by reducing heterogeneity, as well as to increase harmonization and exchange of knowledge.

2) Full GHG analysis of Northern Eurasia's terrestrial biota

The overall objective of this project is to contribute to a better understanding of the dynamics of the cycling of terrestrial carbon dioxide (CO_2) and non-CO_2 gases for improved full GHG terrestrial biota budgets.

The major elements of the work of the Project in 2007 were: 1) refinement of methodologies and development of models and algorithms of verified full greenhouse gas analysis (FGGA) of terrestrial biota at national/continental level; and 2) development of the information base that would satisfy the above methodology for providing the FGGA, including CO_2, carbon monoxide (CO), methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_X), volatile organic compounds (VOCs), and a number of other gases and aerosols, for northern Eurasia. The original FOR methodology is presented as a system integration of a number of relevant approaches of different natures (landscape–ecosystem method, process-based models, measurements of fluxes, inverse modeling) and allows a spatially and temporarily explicit verified FGGA to be provided of which the uncertainties are estimated in a comprehensive and reliable way. The information base includes up-to-date land cover of Russia produced using a multi-sensor remote sensing concept and different inventories and surveys (resolution 1 km), diverse databases of ground data, and sets of regionally distributed empirical models. A new approach for assessing uncertainties of the FGGA is introduced. Some of the major parameters of the FGGA (live biomass, net primary production etc.) have been estimated for the region of the study using the new methodology (an example is shown in *Figure 1*). The work was conducted in close cooperation with a number of national and international scientific institutions and international projects.

Among other things, during 2007 the project contributed to a better understanding of historical fire disturbances in carbon dynamics (Balshi et al. 2007) and of climate change and high latitude ecosystems (McGuire, Shvidenko et al, 2007). The project also contributed to the latest assessment of the Intergovernmental Panel on Climate Change (IPCC) (Alcamo et al. 2007) and to the debate on the implementation of the Kyoto Protocol (Schlamadinger et al. 2007).

Elements of the methodology of the FGGA being developed by the FOR Program are becoming visible in different scientific and policy-relevant publications and in international debates. The methodology is used by Russia and Ukraine for FGGA. Some FOR findings are implemented in forest management in Russia. In 2007 the Russian Federal Forest Service published a book based on this methodology that contains models and tables on the growth and productivity of Russian forests (Shvidenko et al. 2007a); the tables were approved as official documents for obligatory use in the planning of the Russian forest sector. FOR has also published a CD-ROM entitled "Forests and Forestry of Russia" (http://www.iiasa.ac.at/Research/FOR/forest_cdrom/index.html?sb=11) (Shvidenko A., Schepaschenko D., McCallum I., Nilsson S. [2007b]), produced jointly by IIASA and the Russian Academy of Sciences, which is used by scientific and management institutions worldwide: more than 1,100 users have visited the home page of the CD-ROM every month since the CD-ROM was made publicly available in the early summer of 2007.

The plans for 2008 are: 1) to finalize the nitrogen and VOC modules of the methodology and to provide full documentation of the FGGA including formal algorithms and software; 2) to finalize the required information base for the accounting; 3) to provide FGGA for the territories of Russia with a special empha-

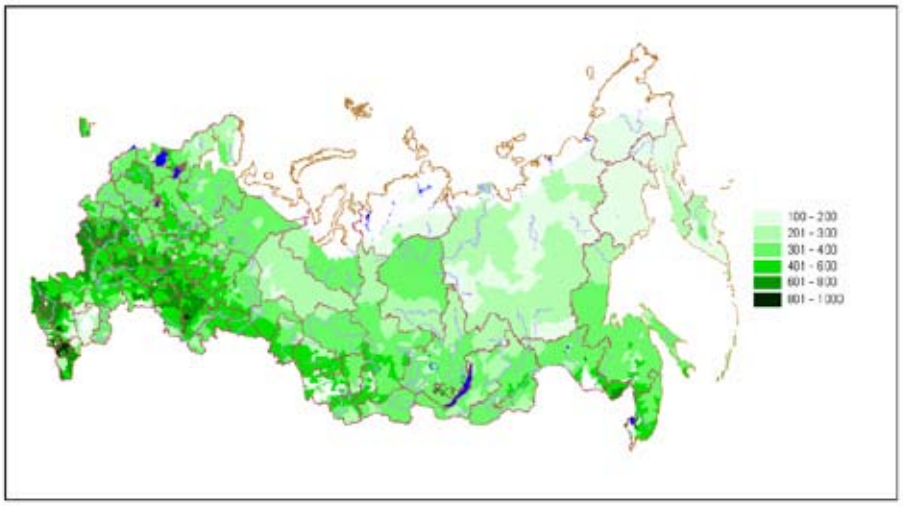

Figure 3. Net primary production of the forest ecosystems of Russia (g C m^{-2}).

sis on the nitrogen cycle (excluding assessment of VOC emissions and the impacts of technological cycles of vegetation products).

3) Constraining and handling uncertainties of GHG fluxes

The overall objective of this project is to constrain uncertainties of GHG fluxes to and from the atmosphere and to contribute to the handling of uncertainties in international climate negotiations.

FOR follows two scientific tracks with respect to uncertainties that are expected to emerge in the future.[1] The first addresses the need to close the gap between bottom-up and top-down accounting of net atmospheric carbon (and other) GHG *emissions*. Scientists are expected to overcome this accounting gap at the scale of continents in less than ten years from now and to even be able to downscale validated (dual-constrained) emissions to the scale of countries/groups of countries. The second track analyzes *emission change*s under the Kyoto Protocol, which have to take place in accordance with, not independently of, a scientifically solid bottom-up/top-down reference framework and taking uncertainty into account. The reference framework, once available, will enable scientists to instantaneously correct any politically driven (mis-)accounting reported on a bottom-up, annual basis under the Kyoto Protocol and its successor protocol.

Track I. Inversions place a substantial terrestrial carbon sink in the northern hemisphere. However, as recalled by the IPCC in its 4th Assessment Report, the longitudinal partitioning of the terrestrial carbon sink in the northern extra-tropical belt (NEB: 30–90°N) between North America, Europe, and northern Asia still exhibits large uncertainties (Denman et al. 2007: Section 7.3.2.2). We highlight Russia: 1) because of the important role of Russia's terrestrial biosphere in the global carbon cycle; and 2) to complement similar work executed for other regions in the NEB ("North American Carbon Program" and "CarboEurope"), thus allowing a consistent and complete bottom-up/top-down carbon flux coverage to be achieved; and last, but not least, 3) Russia is a signatory state to the Kyoto Protocol (KP) that is already large enough to be analyzed today in a bottom-up/top-down budgeting exercise. The focus is on Russia's CO_2-C fluxes between its terrestrial biosphere and the atmosphere, and their combined uncertainty. It is this direct flux-related knowledge that is relevant for estimating Russia's atmospheric balance. However, we made use of the overall change in its soil and vegetation pools (to the extent known) to check the plausibility, not validity, of our net flux estimate. We resolve Russia's atmospheric CO_2-C balance in terms of four major land use/cover types (arable land, forests, grasses and shrubs, and wetlands) and eight bioclimatic zones (BCZs).

For the whole of Russia during 1988–1992 we derive an atmospheric loss or net flux to Russia's terrestrial biosphere of about 957 Tg C/yr with an uncertainty of the order of 100% (90% CI). The uncertainty becomes considerably greater for individual BCZs. Russia's overall terrestrial sink strength turns out to be smaller (about 813 Tg C/yr) and its relative uncertainty somewhat greater (about 112%) if resolved by land use/cover (not shown here). While this difference can be explained, it falls beyond skillful resolution as it is outmatched by total uncertainty. Nonetheless, we are confident that we grasp the total uncertainty of Russia's terrestrial sink strength in the right order of magnitude (i.e., 907–956 Tg C/yr) and that it falls into the relative uncertainty class of 80–120% for the period 1988–1992.

Our terrestrial sink strength and its relative uncertainty deviate considerably from the 351 ± 176 Tg C/yr (90% CI) that Nilsson et al. (2003) report with reference to their earlier study (Nilsson et al. 2000). Among the reasons for this deviation range are: 1) a more rigorous treatment in view of limited data; 2) the elimination of biases and shortcomings in calculations; 3) an improved understanding of underground carbon cycling; and 4) the additional consideration of model-generated data (where appropriate).

Our results suggest that Figure 7.7 in Denman et al. (2007) should be revised. We find a less optimistic, although more realistic, bottom-up versus top-down match for northern Asia than the IPCC authors (see *Figure 1*), and this confronts us with

1 See also *FOR's Research Related to Uncertainty* at http://www.iiasa.ac.at/Research/FOR/uncert.html?.

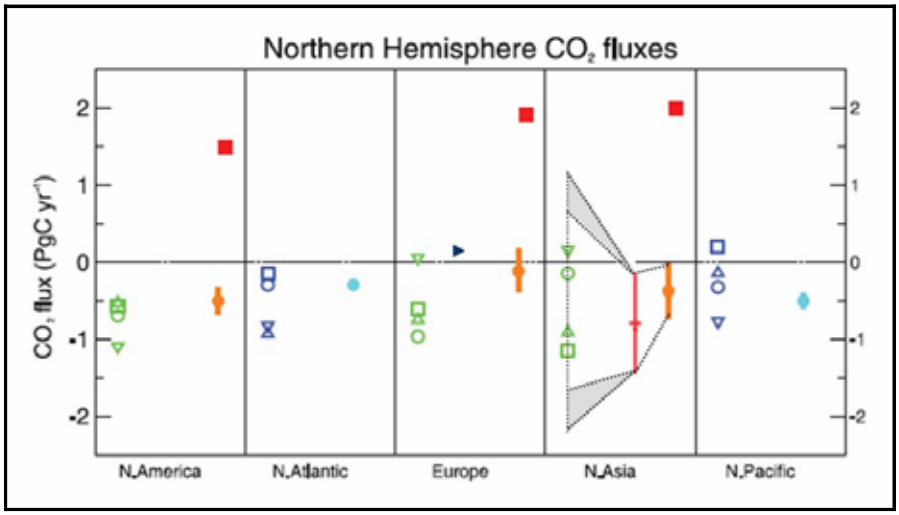

Figure 4: Regional ocean-atmosphere and land–atmosphere CO_2 fluxes for the northern hemisphere from inversion ensembles and bottom-up studies. Fluxes to the atmosphere: positive; uptake: negative. Inversion results correspond to the post-Pinatubo period 1992–1996. In the focus here: Northern Asia. Orange line: bottom-up terrestrial fluxes from Shvidenko and Nilsson (2003) for Asian Russia, and Fang et al. (2001) for China. Green symbols: terrestrial fluxes from inversion (Gurney et al. 2002, 2003; Peylin et al. 2005; Rödenbeck et al. 2003); their errors range between 0.5 and 1.0 Gt C yr-1. Red square: fossil fuel emissions. Source: Denman et al. (2007: Figure 7.7), modified. Additionally entered: red line—our revised bottom-up sink strength for the whole of Russia (68% CI) expanded by Fang et al.'s (2007) sink strength for China.

the crucial question: What is the added value of combining full carbon accounts bottom-up and top-down? It is correct to say that this question has been, and remains, subject to thorough research as each approach carries considerable uncertainties. Nonetheless, a first bottom-up/top-down linking exercise with LSCE (Laboratoire des Sciences du Climat et de l'Environnement; Gif-sur-Yvette, France) in 2007 based on our less optimistic, though more realistic, bottom-up uncertainty for Russia showed that an added value still seems to exist. Using a 12- and 77-station network as representative for ~1988 and ~2000 (Rayner et al. 1999, 2007) exhibit that our bottom-up uncertainty remains the main control for *a posteriori* error reduction over Russia. Thus, an increased need for atmospheric measurements over Russia continues to exist.

Track II. For almost all countries the emission changes (emission signals) agreed upon under the Kyoto Protocol are of the same order of magnitude as—or smaller than—the uncertainty that underlies their combined CO_2-equivalent emissions. Although much needed, techniques to analyze uncertain emission signals from various points of view, ranging from signal quality (defined adjustments, statistical significance, detectability, etc.) to the way uncertainty is addressed (trend uncertainty or total uncertainty) are not in place. This is astonishing, as any such technique, if implemented, would "make or break" compliance, especially in cases where countries claim fulfillment of their reduction commitments. Inventory uncertainty is only monitored, but not regulated, under the Protocol. It remains to be seen whether the declared status of negating or simply nullifying uncertainty by political decree will survive in the long term. We expect science eventually to take over and to help to put the post-Kyoto policy process on a solid basis.

During 2007 FOR: 1) finalized its Springer book entitled *Accounting for Climate Change. Uncertainty in Greenhouse Gas Inventories—Verification, Compliance, and Trading* (http://www.iiasa.ac.at/Admin/INF/recent-pubs/for/acc/index.html), which appeared in parallel as a special *WAFO* (Water, Air & Soil Pollution: Focus) issue; 2) organized, together with the Systems Research Institute of the Polish Academy of Sciences, the 2nd International Workshop on Uncertainty in Greenhouse Gas Inventories (27–28 September 2007, IIASA; http://www.ibspan.waw.pl/ghg2007/), which inaugurates the publication process for the follow-up book and/or special journal issue (to appear in 2009); and 3) produced, based on the Workshop's outcome, a summary for policymakers which became IIASA's *Policy Brief #01* (http://www.iiasa.ac.at/Publications/policy-briefs/pb01-web.pdf) and which also served the purpose of informing delegates on relevant scientific findings at the recent UNFCCC Conference in Bali, Indonesia (3–14 December 2007).

So far, the potential of Tracks I and II to impact the post-Kyoto policy process has, apart from the IIASA Policy Brief #01, only been tested on a few other occasions. In the same way, FOR's research and *Accounting for Climate Change* book impacted the 2007 Summary Report of the International Petroleum Industry Environmental Conservation Association (IPIECA) entitled Greenhouse Gas Emissions Estimation and Inventories (IPIECA, 2007). This report unanimously agrees with FOR's rationale for advancing and conducting uncertainty analyses.

FOR's activities related to constraining and handling uncertainties in 2008 will focus on two core activities:

Track I: Combining full carbon accounts bottom-up and top-down still needs to be put on a solid basis. The preliminary experiments carried out with LSCE need to be substantiated.

Track II: The analysis of uncertain emission changes requires more techniques to be developed. (To date, FOR has mainly focused on uncertainty analysis techniques that are applied with foresight or in a preparatory fashion. However, the analysis of uncertain emission changes also requires techniques to be studied that are applied mid-term and in retrospect.) In addition, the publication process for FOR's follow-up book and/or special journal issue has to be pursued.

Global impacts of forest sector development in emerging economies

This theme is organized within two projects in an attempt to gain a better understanding of the impacts of emerging economies on the global forest sector in China and India and how these developments will influence the global forest sector.

Moreover, work is being carried out on total global forest sector development per se to put the development of the Chinese and Indian forest sectors into perspective. Examples of this work are Nilsson (2007a, 2007b, and 2007c) and Rametsteiner et al. (2007).

Chinese forest sector development

China has become the world's workshop with respect to forest products. Consumption, imports, and exports are increasing dramatically because of rapid economic growth in the country. This development causes structural changes in the global forest sector as well as strong environmental and social footprints worldwide. FOR in cooperation with other organizations has made assessments regarding the Chinese forest sector development based on the available information in 2006 (http://www.forest-trends.org). One of the conclusions from this work is that analysis and conclusions about forest sector development in China are constrained by a lack of relevant inventory information of forest resources in China. A major effort in 2007 was to generate external funding to carry out this work. With the help of the Chinese NMO we now seem to be on our way to securing external funding in 2008 to make a start on this much needed work.

An important component with respect to the future development of the Chinese forest sector is the demographic development linked with consumption of forest products (Cao et al., 2007). Work on the link between demographic development and consumption of forest products will continue in 2008, mainly in terms of disseminating the work carried out in 2007.

Indian forest sector development

India has rapid population growth and strong economic growth. It is assumed that India will surpass China as an economic power within about 20 years. For decades, the forest resources of India have not been managed in a sustainable manner. Unfortunately, the forest inventory of India is unreliable, which means that we do not know the extent and qualities of the Indian forests. Currently, the most important forest product in India is wood fuel. The consumption of industrial forest products will increase with economic growth, and the Indian industry will be dependent on imported raw material.

In 2007 the work concentrated on a workshop on "The Contribution of the Forest Sector to Indian Society." The workshop was held in cooperation with the Technology Information Forecasting and Assessment Council (TIFAC, the Indian NMO to IIASA). The workshop was successful, with the participation of over 100 Indian and international experts (http://www.tifac.org.in/). Based on the workshop, some 25 papers were commissioned as state of the art on different features of the Indian forest sector. Again, this work has been conducted in cooperation with TIFAC. The papers will be published in 2008 in a special journal issue. The conclusions from these papers form the platform for the second workshop, taking place in India in the spring of 2008, dealing with important policy implementations and the required research tasks to move the Indian forest sector toward a sustainable path.

International governance of forests

The objective of this theme is to assess the relevance and effectiveness of international arrangements on forests and to bring the research results achieved by FOR to the international policy arena.

Globalization and the forest sector

In 2007 FOR implemented the "Study on the effects of globalization on the economic viability of EU forestry" in the context of contract work for the EU Commission.

The main objective of this study was to analyze the effects of globalization on the economic viability and global competitiveness of EU forestry. The study should improve the Commission's understanding of these aspects and should also lead to the identification of the main factors related to globalization that impact the functioning and development of forestry in the EU. Better knowledge of the nature and origin of the main factors affecting EU forestry should provide a basis for consideration of what actions need to be taken to adapt to and benefit from globalization and thereby enhance the economic viability and global competitiveness of forestry in different regions of the EU.

In addressing the objectives of this study, the following five tasks were performed:

- Identification of main trends and factors of globalization affecting forestry in the EU (literature review);
- Review of the relevant aspects of development of forestry and forest-based industry in the EU;
- Identification of how main trends and factors of globalization relevant to forestry are affecting different regions of the EU;
- Identification of threats and opportunities in adapting to and benefiting from the effects of globalization;
- Overview, conclusions, and possible recommendations.

The study was carried out in relation to a direct policy request and is a key contribution to the implementation of a core aspect of the EU Forest Action Plan. It was thus directly policy-relevant. The results of the study were presented at two events or forums for policymakers: the so-called Munich Conference (http://ww9186.wb09.de/cms/index.php), held in June 2007 and the meeting of the EC Standing Forestry Committee (http://ec.europa.eu/agriculture/minco/othco/forest/index.htm, held in December 2007. The results are available at http://www.iiasa.ac.at/Research/FOR/.

International governance of forests and policy impacts

In 2007 the work undertaken related to international arrangements mainly concerned four different international governance forums:

1. United Nations Forum on Forests (UNFF) (http://www.un.org/esa/forests/)
2. Ministerial Conference on the Protection of Forests (MCPFE) (http://www.mcpfe.org)
3. United Nations Food and Agriculture Organization (FAO) and UN Economic Commission for Europe (UNECE) (http://www.unece.org/trade/timber/)
4. Global climate change policy project, Comparing Climate Change Policy Networks (COMPON) (http://nicomedia.math.upatras.gr/cgi-bin/mailman/listinfo/compon)

a. FOR scientist, Dr. Ewald Rametsteiner, worked with and for the UNFF secretariat at UN Headquarters in 2007 to outline a strategic direction for better linking global policymaking and local/regional sustainable development needs. Dr. Rametsteiner was in charge of the scientific editing of the UNFF publication "Enabling sustainable forest management: A discussion on strategies for equitable development, for forests, for people" (http://www.un.org/esa/forests/) and wrote two of its five chapters, focusing on ways of better addressing the needs and conditions of local and regional development and sustainable forest management at this level in international forest policy. He also assisted the UNFF secretariat in an expert capacity during the final negotiations on the "Non-legally binding instrument on forests," adopted by UN General Assembly in 2007. This work, which is directly policy-relevant, is undertaken in direct cooperation with and according to the specifications of the UNFF, the highest global forest policy body and platform.

b. Dr. Rametsteiner also worked with and for the MCPFE and the UNECE/FAO to co-edit the authoritative scientific report "State of Europe's Forests, 2007" (http://www.mcpfe.org/files/u1/publications/pdf/FE_EN.pdf), which was presented to the ministers and representatives of the 46 signatory states of the MCPFE at the 5th Ministerial Conference in Warsaw, Poland, 5–7 November 2007 (http://5th.mcpfe.org/). According to the UNECE/FAO and the Ministerial Conference on the Protection of Forests in Europe (MCPFE) this is "the most comprehensive and balanced report ever produced on sustainable forest management in Europe." Dr. Rametsteiner was coordinating lead author of the chapters related to policies and institutions for sustainable forest management in Europe. These chapters, based on a national data collection he himself had designed and implemented, present the most comprehensive and up-to-date review of national forest policies in Europe. This work is directly policy-relevant and undertaken in direct cooperation with and according to specifications of the MCPFE, the highest European forest policy body and platform.

c. Dr. Rametsteiner, was invited to act as an expert to the FAO/UNECE/MCPFE Secretariat working group on policies, legal, and institutional frameworks on forests, which has met twice. He was invited to a specific meeting of FAO to advise on the design of its questionnaire for the FAO Forest Resource Assessment 2010, to be implemented in 2008–2009. This work is directly practice-relevant, aimed at substantially improving the availability and accuracy of global data related to forest policy and institutions. Professor Sten Nilsson, the Program Leader of FOR, was involved with the FAO/UNECE Secretariat on issues of policies for mobilizing wood and wood fuels (www.unece.org/trade/timber/docs/dp/dp-48.pdf).

d. Dr. Rametsteiner is involved in a global climate policy research network, COMPON: Effect of Advocacy Networks and Participation on Climate Change Policy Formation (Organizer: Jeffrey Broadbent, University of Minnesota, USA). The COMPON project will employ the logic of cross-national comparative analysis within the global context using the method of "policy network analysis." The cross-national comparison includes about 17 societal cases, currently: Austria, Brazil, Canada, China, England, Germany, Greece, India, Italy, Japan, Netherlands, New Zealand, Russia, South Korea, Sweden, Taiwan, and United States. Country investigators come from a variety of disciplinary backgrounds, including sociology, political science, anthropology, and mathematics.

In spring or summer 2008 a Globalization Workshop, "Globalization and the Forest Sector: Effects and Strategies," will be organized at IIASA. The objective of the Strategic Workshop is to elaborate new ideas, concepts, and solutions as well as key research issues in a workshop with highly experienced and open thinkers from both the decision-making and the science community. The workshop should be strongly forward-looking and discuss: 1) globalization issues affecting forest benefits to consumers; 2) forest-based industries and emerging opportunities; 3) emerging strategies on the part of companies and policymakers; and 4) response needs in the different global regions. The outcome will be in the form of workshop conclusions—"Globalization: Ten Key Issues to Address by the Forest Sector"—for decision makers. A separate document will specify "Ten Steps Needed for Strengthening the Contribution of Research in Effective Governance of Forests in a Globalized World."

For 2008 four main areas of activities are foreseen in the area of international governance of forests:

1. Design and (as far as requested by the MCPFE) help as regards implementation of the evaluation of the MCPFE. As a background: the Ministerial Conference on the Protection of Forests in Europe (MCPFE) was launched in 1990. Now, more than 15 years after its establishment, the MCPFE is a well established and well recognized body in the European and global forest policy arena. Over the years, the MCPFE has introduced a range of leading-edge concepts into forest policymaking. One of these is arguably the establishment of mechanisms for continuous improvement. This is an important building block of a quality assurance and improvement mechanism and already well accepted. The conducting of a more strategic review of the MCPFE, on a possibly periodic basis, could benefit the MCPFE. The mandate to conduct a review of the MCPFE within the work period of the Liaison Unit Oslo was agreed upon within the Warsaw Declaration, paragraph 40: "*Carry out a review of the MCPFE process by the Sixth Ministerial Conference, by assessing progress made and obstacles faced in the implementation of its com-*

mitments." Achieving such a mandate was due to the FOR scientists involved in the process.

2. Follow-up on the work related to the MCPFE and FAO in 2007 on policies and institutions to develop forest governance indicators and the design for a forest-related database. This should allow, based on existing international datasets on land use, a range of cross-factor and factor analyses and historical data series analyses to be undertaken to identify possible key factors and to verify these on the basis of existing data.

On the basis of these results, different methodical approaches or complementary combinations of approaches will be further developed in 2009 for the formalization of factors of analysis (policy factors) in land use decisions; the objective here would be to significantly improve the explanatory and, as far as possible, the predictive power of integrated land use change analysis models where these are applied in concrete cases (multi-method approach to further develop resource use policy explanatory models such as procedural, bargaining, and mixed models). This, inter alia, requires the formalization of parameters for more precise calculation of: 1) the likely characteristics and duration of policy processes; and 2) the probability and characteristics of certain policy decisions occurring and the duration and characteristics of subsequent implementation (instruments, effects). It will also comprise the development and testing of different formal analysis methods.

3. Co-develop and submit an EU FP7 project on policies to avoid deforestation and degradation in the context of UNFCCC and the post-Kyoto negotiations, in particular, to design the policy components (assessment of REDD policy options currently under discussion in the UNFCCC, assessment of alternative and emerging policy response options and their implementation conditions, and assessment of feasibility and implementation conditions).
4. To start implementing the surveys planned in the COMPON project.

Others

For a number of years FOR has been involved in biodiversity in forestry, and although this work has not taken the form of a specific project, this activity continued in 2007. Papers on this issue were published by Christensen et al. (2007), Hörnell-Willebrand (2007), and Newey et al. (2007a, 2007b). FOR started in 2007 the preparation of a major proposal on Biodiversity and Forestry to be submitted in 2008.

FOR has carried out substantial work on institutions earlier with some follow-up work on this issue still taking place (Olsson, 2007).

Scientific Recognition

Awards

In 2007 the Degree of Honorary Professor of the National Agricultural University of Ukraine was conferred on Anatoly Shvidenko. He was also elected Honorary Member of the Ukrainian Forestry Academy. Anatoly Shvidenko and Sten Nilsson were among the network of scientists who shared in the 2007 Nobel Peace Prize awarded to the IPCC.

Selected Invited Lectures/Presentations

In 2007 FOR staff were invited to give more than *100 papers/presentations* at scientific/policy meetings. Some of these are listed below.

Sten Nilsson

- Was invited to give a keynote address at the UN/ECE on "Wood Mobilization— What's the big deal" at the conference, Mobilizing Wood Resources, in Geneva, 11–12 January 2007.
- Was invited by Chatham House, London, to give a keynote speech on "Changing Patterns of Supply—Illegal Logging" at the workshop, Illegal Logging and Associated Trade, 24–25 January 2007, London.
- Gave a presentation at IIASA Days in South Africa on "The South African Forest Sector in an International Perspective: An Outsider's View," 11–12 April 2007.
- Was invited to give a keynote address on "Energy Technology Drivers" at the workshop, Mega-Trends and Surprises, organized by the European Environmental Agency, 14–15 April 2007, Copenhagen.
- Was invited by the German EU Presidency 2007 to give the keynote address on "Globalization and the European Forest Sector" at the conference, Strengthening the Competitiveness of the Forest-Based Sector, 20–21 June 2007, Munich.
- Gave a presentation at the IIASA Days in South Korea on "Biofuels – From Oil to Alcohol Addiction? Globalization and the European Forest Sector," 20–21 August 2007, Seoul.
- Was invited by MegaFlorestais to give a keynote on "The Boomerang—When will the Global Forest Sector Reallocate from the South to the North?" at MegaFlorestais biannual meeting, 16–18 October 2007, St. Petersburg, Russia.
- Was invited by the Swedish International Development Agency (SIDA) to give a keynote address on "Future Forestry" at the conference, Towards a New Global Forest Agenda, 29–30 October 2007, Stockholm.

- Was invited to give a keynote address by European Landowners Organization on "Bioenergy Demand" at the EUROFORENET conference, European Forest Energy Network, 20 November 2007, Brussels.

Hannes Böttcher

- Was invited to give a keynote speech on "Potential of Land Management for Climate Change Mitigation" by the European Environment and Sustainable Development Advisory Councils at the 15th Annual Conference of EEAC, 10–13 October 2007, Lisbon, Portugal.

Steffen Fritz

- Gave a presentation on "A Conceptual Framework for Assessment of the Benefits of a Global Earth Observation System of Systems" at the American Geophysical Union (AGU) Fall Meeting 2007, 9–16 December 2007, San Francisco, USA.

Petr Havlik

- Gave the presentation "Total land-use impacts of avoided deforestation" at the IIASA side event at UNFCCC-COP13, 5 December 2007, Bali.

Matthias Jonas

- Was invited to give a presentation on "How to Deal with Uncertainties under the Kyoto Protocol" by the International Petroleum Industry Environmental Conservation Association on Uncertainties and Greenhouse Gas Emissions, 9–10 January 2007, Brussels.

Nikolay Khabarov

- Gave two presentations: one on "Weather Observation Systems and Efficiency of Fighting Forest Fires," and one on "Global Partnership in Global Earth Observations" at the American Geophysical Union (AGU) Fall Meeting 2007, 9–16 December 2007, San Francisco, USA.

Florian Kraxner

- Gave a presentation on "The IIASA Long-Term Scenarios on Avoided Deforestation and Afforestation at the IIASA side event 'Political Economy of Avoided Deforestation' at UNFCCC-COP13, 5 December 2007, Bali.
- Was invited to give a keynote presentation on "Integrated Sink Enhancement Assessment" at the Sino–German Carbon Workshop in China, The Role of Eurasian Forest as a Pool for Carbon Dioxide Sequestration,' 22–25 May 2007, Beijing, China.

Michael Obersteiner

- Gave a presentation (co-authored with S. Fritz) on "Socioeconomic Benefits of Earth Observations" for the GEO-Ministerial Summit in Cape Town, South Africa, 28–30 November 2007.
- Conducted the IIASA side event at UNFCCC-COP13 on "Political Economy of Avoided Deforestation, 5 December 2007, Bali.
- Gave a presentation on "Costs of Mechanism Designs to Implement Avoided Deforestation" at the COP13 side event.
- Was invited to give a keynote presentation by the UN/Austrian Government/ESA on "Socioeconomic Benefit Assessment of Global Earth Observations" at the conference, Space Tools and Solutions for Monitoring the Atmosphere in Support of Sustainable Development, 11–14 August 2007, Graz.
- Was invited by London Energy Forum to give a keynote presentation on "Real Options and Investment Portfolios" at the conference, Risk, Policy Uncertainty, and Energy Investments, 23–25 October 2007, London.

Ewald Rametsteiner

- Gave two presentations: "Improving Governance of SFM on the Local and Regional Levels" and 2) "Promoting Forest-Based Economic Development on Local Levels" at the UNFF Secretariat side event, Selling the Framework for Sustainable Forest Management, of the Seventh Session of the United Nations Forum on Forests, 16 April 2007, New York.
- Gave a presentation on the report "State of Europe's Forests 2007" to the ministers and representatives of the 46 signatory states of the MCPFE at the 5th Ministerial Conference, 5–7 November 2007, Warsaw, Poland.
- Gave a presentation on the report "Effects of Globalisation on the Economic Viability of EU Forestry" to the European Union Standing Forestry Committee, 14 December 2007, Brussels.

Editorships

- Sten Nilsson is on the editorial board of the journal *Carbon Balance and Management*.
- Michael Obersteiner is coordinator of the journal *Carbon Balance and Management*.
- Anatoly Shvidenko is on the editorial board of Forest Inventory and Forest Planning, the International *Journal of Applied Earth Observation, and Geoinformation and Mitigation and Adaptation Strategies for Global Change*, as well as a member of the Science Advisory Committee of the *Eurasian Journal of Forest Research.* In 2007 he served as Editor of *Forest Encyclopedia.*
- Gui-Ying Cao is on the editorial board of the journal *African and Asian Studies*.
- Ewald Rametsteiner is on the editorial board of *Forestry: An International Journal of Forest Research*.

Workshops

FOR organized and hosted five conferences and workshops during 2007 and played a crucial role in organizing IIASA's 35th Anniversary Conference.

Publications and Web Site

FOR published a total of 75 publications, of which 40 are in the category of books, book chapters, and journal articles.

FOR's Web site is an important tool for the dissemination of information and results of FOR work. The statistics are illustrated in the table below.

	2006	2007
Visitors	140,000	150,000
Hits	265,000	300,000
Bandwidth (GB)	28	45

Personnel

Scientific Staff

Sten Nilsson (Sweden), *Program Leader*
Kentaro Aoki (Japan)
Per Bodin (Sweden)
Hannes Böttcher (Germany)
Gui-Ying Cao (China)
Oskar Franklin (Sweden)
Steffen Fritz (Germany)
Sabine Fuß (Germany)
Alberto Gappmayer Biscaia (Brazil)
Mykola Gusti (Ukraine)
Petr Havlik (Czech Republic)
Joanna Horabik (Poland)
Daniel Johansson (Sweden)
Matthias Jonas (Germany)
Nikolay Khabarov (Russia)
Georg Kindermann (Austria)
Daniela Knorr (Germany)
Florian Kraxner (Austria)
Sylvain Leduc (France)
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Ian McCallum (Canada)
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Michael Obersteiner (Austria)
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Land Use Change and Agriculture Program

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Objectives

The strategic goal of the Land Use Change and Agriculture (LUC) Program is to support policymakers in developing realistic, rational, science-based strategies at the national, regional, and global level for the production of food, animal feed, fiber, bioenergy, and other services that achieve long-term sustainability of land and water resources while promoting rural development.

To achieve this goal, the LUC Program aims to advance applied science with a focus on the following strategic research objectives:

- Develop new and improved tools and databases in order to provide a spatially detailed understanding of alternative land and rural development options and strategies, against the background of global change.
- Analyze synergies and trade-offs of alternative uses of agro-resources (land, water, technology) for producing food and energy, while preserving environmental quality.
- Identify hot spots of significant environmental and rural social risks, and clarify their relation to global change.
- Verify methodologies and tools in applications for regional/national case studies needed to improve global scenarios and links with region-specific conditions, issues, and policy options.

Three areas of research, outlined below, are identified for the period 2006–2010. These cover key issues of importance for understanding the interactions between society, land use, agriculture, and climate over the coming decades.

Research Areas

The first area provides a common thread for the program's global research through a "Food and Agriculture to 2100" project that unifies the themes of climate and anthropogenic impacts on soil and water resources, adaptation and mitigation strategies, and rural development. The second area analyzes subsets of these issues in regional case studies in Europe, China, South Asia, sub-Saharan Africa, and Latin America. The third area includes activities aimed at developing new methodologies that advance our ability to derive and manipulate spatially explicit data and provide better integration of socioeconomic and biophysical analyses.

Global level research:

- Food and Agriculture to 2100;
- Climate change, impacts, mitigation, and adaptation;
- Water and agriculture;
- Biofuel production and land competition.

Policy support for sustainable development of regional agricultural and rural sectors:

- Agriculture and rural development in transition economies;
- Multi-functionality of land and sustainable socioeconomic and environmental development;
- Environmental impacts of agriculture;
- Regional biofuel roadmap.

Methodology development:

- Sequential rebalancing methods for spatial allocation and downscaling;
- Framework for spatial ecological–economic analysis;
- Methodologies for spatial global and regional land cover change scenarios.

Scientific Achievements

In 2007 LUC scientific activities and advanced research projects were carried out in all three thematic areas listed above.

Agriculture in the 21st Century

IIASA's integrated modeling framework comprises a global spatial Agro-ecological Zone (AEZ) model and a regionalized general equilibrium model of the world food economy. The two models form the basis of scenario evaluation and policy analysis of food and agriculture in the 21st century at the national, regional, and global levels. The study includes analyses related to future demographic and economic development pathways and to the potential impacts of climate change on, for example, natural resources and the environment, agricultural science and technology research priorities, food and agricultural systems, population and demographic changes and consumption, international agricultural trade reforms and globalization, and assessment of the scale and location of risks of hunger and malnutrition.

Food Security and Bioenergy Production

The role of bioenergy has been strongly enhanced by its inclusion in the climate change debate, as well as through the opportunities it may create for rural development and improved energy security. Land use competition with food and feed production is considered a potential key barrier to exploiting the regional and global bioenergy production potential. LUC activities aim to assess the potential role of biofuel production under different scenarios of projected food and feed demand, severity of land use restrictions, yields of food crops and bioenergy feedstocks, and availability of biofuel conversion technologies. In this area of research the following activities and projects are currently under way:

Renewable Fuels for a Sustainable Europe (REFUEL): In early 2006 the EU-commissioned REFUEL Project began forming a long-term vision for biofuels. The REFUEL project was designed to encourage a greater market penetration of biofuels, consistent with European Union (EU) biofuel policies and supported by stakeholders involved in the biofuels field. The two-year project

involved seven renowned European partners. LUC was a major contributor to this study, providing:

- A pan-European assessment of the bio-physical production potentials of all main biofuel feedstocks, and
- Alternative scenarios for quantifying the land that could be used for domestic biofuel feedstock production without compromising food/feed production or affecting nature conservation.

As an important finding in 2007 the REFUEL project concluded that the EU biofuels target for 2020 can be met with conventional feedstocks and current technology without major agricultural land use changes, and with moderate imports. Biofuels potential can become available without compromising food and feed supply. Furthermore, it does not require conversion of forestland, grassland, and nature conservation areas into arable land. The latter is essential as recent studies indicate that such land use changes may lead to losses of soil carbon that would turn any greenhouse gas emission reductions achieved by fossil fuel substitution into net increases of emissions. In the new EU member states and Ukraine, agriculture has ample opportunities for increasing crop and livestock yields, thereby freeing up agricultural land for biofuel feedstocks cultivation.

Yet, only advanced, second generation biofuels are expected to provide a substantial contribution to reducing greenhouse gas emissions and increasing energy security. These biofuels, produced from residues and woody or grassy plants, show substantially higher yields per hectare of land and provide far better opportunities for EU industry to develop an innovative sector. Any biofuels policy promoting these benefits leads to improved opportunities for second-generation biofuels, the REFUEL analyses show. In comparison, conventional biofuels (biodiesel from oil crops and bioethanol from sugar crops, cereals) perform less adequately, according to the most commonly used arguments for increasing advanced biofuels use. The introduction of advanced biofuels requires supporting measures on several policy levels, and various obstacles will need to be tackled. The required production technology needs to be further developed and deployed, as do new supply chains for agricultural and forestry residues and crops. Overcoming these hurdles will require a favorable and stable investment climate. Furthermore, REFUEL showed that cross-sector strategies can help reduce these barriers. Examples are the initial development of biomass supply chains for power generation and integration of biofuel plants in district heating systems.

Global Assessment of Bioenergy Potentials: This activity comprises a spatially detailed global estimation of agro-bioenergy potentials and, building on this, spatially detailed understanding of agrobioenergy sources, an assessment of development options, synergies, and land use competition among food and bioenergy plants.

Acknowledging the significant advantages of second generation ligno-cellulosic biofuel feedstocks over conventional agricultural feedstocks both in terms of environmental performance and also reduced land competition, LUC employed its detailed geographical resource databases to estimate land potentially available for bioenergy production under a "food and environment first" paradigm (i.e., excluding land currently used for food and feed production as well as current forests).

Excluding from a total land area (excluding Antarctica and Greenland) of 13.1 billion hectares all current cultivated land, forests, built-up land, water and unvegetated land (desert, rocks, etc.) resulted in some 4.5 billion hectares remaining land area (35 percent of total; see *Figure 2*). Excluding from these lands the very low and unproductive areas (e.g. tundra, arid land) a remaining area of 2.1 billion hectares is estimated (currently grassland and pastures, shrubs and woodland). Constructing detailed country-level livestock feed balances, we estimated that in the year 2000 about 60–70 percent of the available grassland biomass was needed for animal feeding. Hence, for current use levels, the land potentially available for bioenergy production

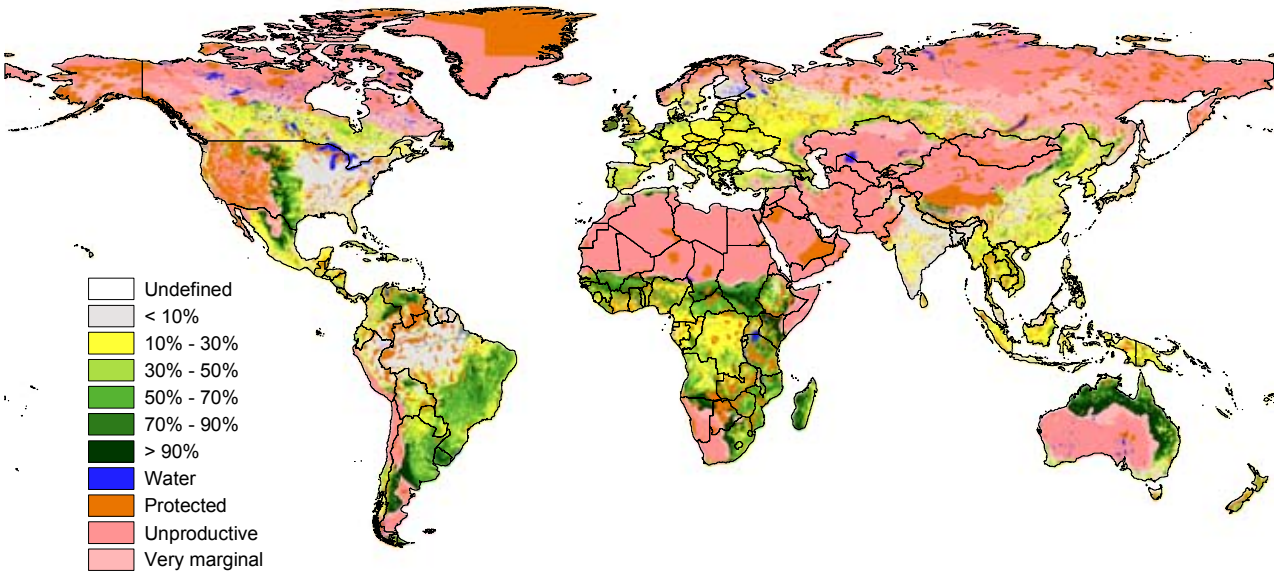


Figure 1. Spatial distribution and share of land by 5' latitude/longitude grid cell currently classified as grassland, scrubs, or woodlands potentially usable for ligno-cellulosic biofuel feedstock production

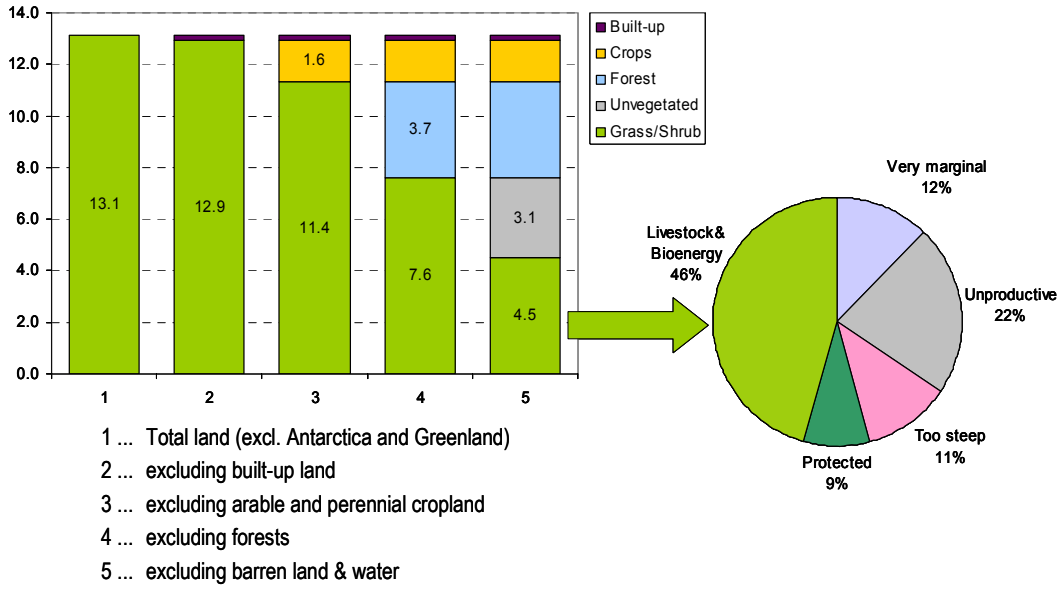


Figure 2. Balance of land currently classified as grassland, scrubs, or woodlands potentially usable for ligno-cellulosic biofuel feedstock production

was estimated in the order of 600–800 million hectares, with a rather wide range of land productivity levels.

Effective and Low-disturbing Biofuel Policies (ELOBIO): The inception workshop for the ELOBIO project, funded by the European Commission's 7th Framework Programme, took place in Brussels on 23 November 2007. This three-year project seeks to identify integrated policy measures that are suitable for the promotion of biofuels while at the same time avoiding or minimizing negative effects on other policy goals and markets. LUC's role in ELOBIO is to model impacts of increased demand for biofuel feedstocks on food and feed commodity markets and to assess the effects of different policies and measures aiming to reduce this disturbance. ELOBIO research and recommendations are serving the Intelligent Energy Executive Agency of the European Commission.

Water and Agriculture

Water is a key driver of agricultural production. The area under irrigation worldwide has expanded to over 270 million ha, about 18 percent of total cultivated land. Agriculture is the largest user of water of all human activities: irrigation water withdrawals represent 70 percent of the total anthropogenic use of renewable water resources. This has brought agriculture into competition with other water users and has impacted negatively on the environment. The research in this thematic cluster undertakes a comprehensive, spatially detailed quantification of water needs for agriculture, based on the integrated ecological–economic evaluation of food system changes against the background of future global change.

Water and Global Change (WATCH): The Water and Global Change (WATCH) start-up meeting took place March 2007 in Oxford, England. This four-year integrated project, which is being funded under the European Commission's 6th Framework Programme, brings together more than 25 institutions in the hydrological, water resources, and climate communities to analyze, quantify, and predict the components of the current and future states of the global water cycles and related water resources, to evaluate their uncertainties and to clarify the overall vulnerability of global water resources related to the main societal and economic sectors. LUC's task is to provide global spatial data on key components of the water cycle from 1900 to 2100 regarding agricultural, industrial, and domestic uses. This involves scenario projections of agriculture development and land use change as well as the provision of modeling techniques and methodologies for scaling and analyzing the data.

Water Scenarios for Europe and for Neighboring States (SCENES): SCENES is a four-year EU Integrated Project with 23 partner institutions that includes stakeholders in the development and analysis of a set of comprehensive scenarios of Europe's freshwater futures up to 2025. The involvement of the Land Use and Agriculture Program within SCENES centers around driving forces. Specifically, LUC has been working to produce spatial databases of land use, soil, agricultural cropping patterns, and agricultural water demand in Europe. LUC is also responsible for delivering spatial population, GDP, and energy data, applying knowledge from other IIASA programs. All these datasets will be used to quantify spatial water demand and use for agriculture, industry, energy, and households and to inform the SCENES participatory scenario-building process.

Land Resources and Agro-ecological Zoning

The Food and Agriculture Organization (FAO) of the United Nations, with the collaboration of IIASA, has developed a spatial analysis system that enables rational land use planning on the basis of an inventory of land resources and evaluation of biophysical limitations and production potentials of land. This, referred to as the AEZ methodology, follows an environmental approach; it provides a standardized framework for the characterization of climate, soil, and terrain conditions for analyzing

synergies and trade-offs of alternative uses of agro-resources (land, water, technology) for producing food and energy while preserving environmental quality.

Global Agro-ecological Zones Assessment (GAEZ 2007): This FAO-sponsored agro-ecological zones project includes practical applications and a novel methodology for spatial downscaling of agricultural production statistics to produce a detailed global gridded inventory of year 2000 agricultural yields and production. Using this information in conjunction with estimated attainable yield potentials, yield gaps are estimated and production opportunities worldwide are quantified. Examples of applications are: 1) quantification of land productivity; 2) estimation of extents of land with quantified rain-fed or irrigated cultivation potential for respectively food, feed, fiber, and bioenergy production; 3) occurrences of environmental constraints to agricultural production; and 4) identification of potential hot spots of agricultural conversion and the possible geographical shifts of agricultural land potentials as a result of changing climate.

The current revision provides results for an expanded number of crops and management techniques. The tasks included:

- Creation of an updated and expanded global database with a number of additional crops including citrus, cocoa, coffee, tea, tobacco, yam, and selected vegetables;
- Creation of a grassland-suitability classification and its application worldwide;
- The introduction of new input/management classifications reflecting dryland management for the main crops grown in these conditions;
- The creation of GIS layers that reflect actual land use/land cover and crop distribution and production levels for both rain-fed and irrigated conditions; and
- The comparison of potentially attainable yields with actual yields and interpretation in terms of yield gaps;
- Construction of agricultural land balances.

As part of the GAEZ 2007 update, LUC has developed improved soil evaluation procedures, which make use of the soil attributes stored in the harmonized world soil database (HWSD; see below) and replace the expert-based soil unit ratings used in earlier versions of AEZ. In the newly developed GAEZ soil evaluation approach, land qualities are assessed in steps involving several land qualities related to climate and climate–soil interactions (flood hazards, soil erosion hazards, and natural soil nutrient maintenance) as well as land qualities related to soil properties. Seven soil qualities important for crop production have been selected for consideration in soil/crop evaluation, namely: nutrient availability, nutrient retention capacity, rooting conditions, oxygen availability to roots, excess salts, toxicities, and workability.

Harmonized World Soil Database (HWSD): In the context of GAEZ 2007, FAO and IIASA recognized that there was an urgent need to combine existing regional and national updates of soil information worldwide and incorporate these into the information contained within the FAO–UNESCO Soil Map of the World which, in large parts, no longer reflected the actual state of the soil resource. To do this, partnerships were sought with the International Soil Resources Information Centre (ISRIC) which had been largely responsible for the development of regional soil and terrain databases and with the European Soil Bureau Network (ESBN) which had undertaken a major update of soil information for Europe and northern Eurasia in recent years. The incorporation of the 1:1 million scale Soil Map of China was an essential addition obtained through the cooperation with the Academia Sinica. There are four source databases used in this harmonized soil database: the European Soil Map (ESDB), the CHINA 1:1 million soil map, various soil and terrain (SOTER) databases, and for the remainder the FAO74 digital soil map of the world.

To estimate soil properties in a harmonized way, the use of actual soil profile data and the development of pedotransfer rules was undertaken in cooperation with ISRIC and ESBN draw-

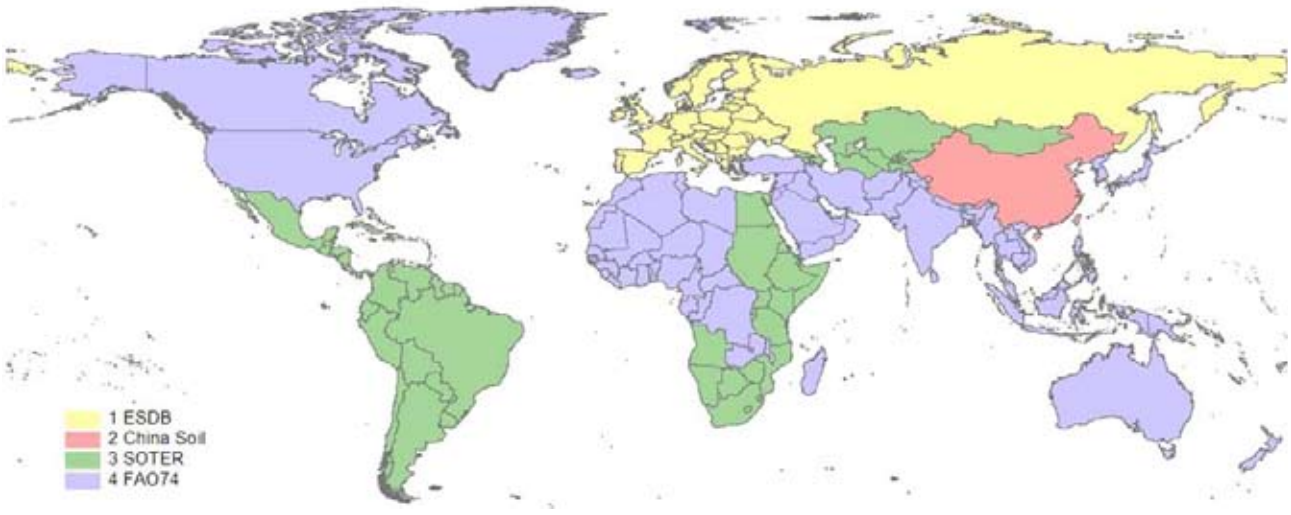


Figure 3. Source of information used in this harmonized soil database

ing on the WISE soil profile database and earlier work at ISRIC. The resulting global database uses 30 arc-second latitude/longitude rater grids of 21,600 rows and 43,200 columns which are linked to a harmonized attribute database with a standardized structure that allows via a link with GIS to display or query the composition in terms of soil units and the characterization of many soil parameters (organic Carbon, pH, water storage capacity, soil depth, cation exchange capacity of the soil and the clay fraction, total exchangeable nutrients, lime and gypsum contents, sodium exchange percentage, salinity, textural class and granulometry).

Exploiting Information on Global Environmental Risks—Agriculture (EIGER-Agri): The objective of this project is to enhance available knowledge and data on yield and land suitability of key agricultural crops under climate change conditions. Improved spatially referenced datasets of crop yield and land use for different climate change scenarios were compiled and integrated to assist decision making and environmental risk assessments. The principal goal of the project's postdoctoral research component is to develop crop damage modules (pest/disease, yield damage due to extreme thermal conditions, ozone damage) for use in global/regional agroecological assessments. EIGER-Agri is a joint effort of the LUC Program at IIASA, the Plant Production System Group at Wageningen University (PPS-WU), the Netherlands, and the Sustainable Agriculture Research Division of Unilever.

Policy Support for Sustainable Development of Agriculture and Rural Sectors

In support of and complementing the global studies, LUC has been conducting or initiating a number of regional projects, for example: in Ukraine on agriculture and rural transformation in transition economies; in Europe on land use issues related to sustainability and biofuel production; and in China on water scarcity and agroenvironmental impacts in the context of rapid growth, globalization, and global change. These projects consider a time horizon of 25 to 50 years and are carried out at the regional/national scales in close collaboration with local research partners. The studies address critical policy issues of land stewardship, based on spatially detailed assessments of policy alternatives with specific consideration of social development in rural areas and implications for the resource base and ecosystems.

China Agricultural Transition: Social and Environmental Impacts (CATSEI): This EU-funded project, implemented by six prominent European, Chinese and US-based partners, investigates the impact of China's rapid economic transition on its agricultural economy with special reference to the consequences of trade liberalization and to changing trade flows. The research focuses on three themes: trade, social conditions, and environment.

LUC carries out the agronomic and environmental assessment in CATSEI WP 4, which requires a state-of-the-art land resources database. The database includes layers of climate, soil, terrain and land cover. Development started from the CHINAGRO database compiled during 2001–2005. The current datasets represent a major update and improvement. The spatial resolution of the gridded database has been enhanced from a 5 by 5 km grid to 1 by 1 km. The update and refinement of the geographical database concerned the grids of monthly climate attributes, the geographic distribution and physical/chemical characteristics of soils, a detailed inventory of elevation, terrain slopes and aspect, and a detailed land cover characterization to link agricultural activities, as observed in the statistical sources with physical and environmental factors of the resource database.

Climatic grids for average conditions and year-by-year data for 1990 to 2000 were obtained from Chinese sources and included in the resource inventory. Data layers with monthly values characterizing average climate conditions were obtained for seven attributes: mean maximum temperature, mean minimum temperature, precipitation, sunshine duration, wind speed, relative humidity, and number of rainfall days. For mean monthly temperature and precipitation time series of 1 by 1 km grids were also included in the database, currently for 1990 to 2000.

A new soil database was compiled on the basis of the Soil Map of China at 1:1 Million scale (China Academy of Sciences). The soil map is distributed by the Resources and Environment Spatial Data Center in Beijing and the Soil Data Centre of the Institute of Soil Science in Nanjing. To make these data sources compatible and usable within the agronomic assessment models used to estimate county-level crop production potentials (required for the Chinagro model production functions) and to quantify crop water requirements and water scarcity indexes, the Chinese soil classification was correlated to a FAO classification system and soil properties were estimated in a harmonized way using actual soil profile data and pedotransfer rules drawing on the WISE soil profile database. The information contained in the soil attribute database includes soil texture, sand/silt/clay volume percentages, bulk density, organic carbon content, pH, cation exchange capacity, calcium carbonate and gypsum content, exchangeable sodium content, electrical conductivity, and an indication of additional physical chemical limitation (expressed as soil phases). The detailed information is a significant improvement over information previously available for China. It not only enhances the agronomic assessment underpinning CATSEI but is essential for the environmental component, both the quantification of emissions and the water analysis.

The update of the land resources database also included creation of a detailed terrain database for China. Data of the NASA Shuttle Radar Topographic Mission (SRTM) were processed with a resolution of 3 arc-second (approximately 90m at the equator), that is, 6,000 rows by 6,000 columns for each 5° x 5° tile, were used at IIASA for calculating a global database of: 1) terrain slope gradients for each 3 arc-sec latitude/longitude grid cell; 2) aspect of terrain slopes for each 3 arc-sec grid cell; 3) terrain slope class by 3 arc-sec grid cell; and 4) aspect class of terrain slope by 3 arc-sec grid cell.

The work specifically carried out for CATSEI was to: 1) extract elevation, terrain slopes and terrain aspects from the global latitude/longitude database; 2) project to a 100m by 100m grid for the equal-area geographical projection used for China; and 3) aggregate results to provide distributions of slope gradient

and slope aspect classes for the 1 by 1 km grids used for the resource database. The data have also been combined to produce a detailed characterization of agricultural land in terms of eight standardized slope classes and to aggregate grid-cell data to county and province level.

Sustainable Livestock Production in China: Among the research objectives of the CATSEI project is to investigate the impacts of current economic transition in China on the agricultural production of the country, in particular, on the developments in the livestock production sector. Meeting the needs for agricultural products boosted the development of industrial input–intensive agriculture. To provide sufficient food, China has been following a trend of agricultural production intensification characterized by high N fertilization rates and rapid introduction of industrial livestock production units in the vicinity of urbanized areas. This trend profoundly disturbs the natural nitrogen and carbon balance, because of either leaching of excess N compounds into ground water and river systems or volatilization into the atmosphere of greenhouse gases and other pollutants.

To analyze these problems in their complexity and accounting for interdependencies, LUC developed an innovative stochastic and dynamic livestock and crop production model for the analysis of agricultural production planning in China under risks and uncertainties. The model integrates demographic, economic, agricultural, and environmental modeling components. The model is spatially detailed and runs for a time horizon of 30 years, with a 5-year time step. It performs analyses at county and province levels, for which it employs specific down- and upscaling procedures, permitting maximum use of the available data.

The purpose of the model is to guide decisions regarding the future expansion of livestock production and to ensure their sustainability by characterizing environmental, social, and economic conditions of locations in terms of location-specific sustainability indicators reflecting economic–environmental risks and constraints. Suitable indicators of sustainability may, in fact, depend on various factors including, for instance, the spatial distribution of people and incomes, the current levels of livestock production and intensification, and the characteristics and current use of land and water resources.

The results obtained with this simulation tool show that spatially explicit treatment of risks and uncertainties in agricultural production planning may considerably alter decision making to achieve sustainable agricultural development. In a report entitled "Risk-Adjusted Approaches for Planning Sustainable Agricultural Development," two key scenarios are simulated. The intensification scenario (i) implicitly minimizes the transportation costs as production concentrates in the vicinity of urban areas with high demand. In the alternative scenario (ii), the production is shifted to more distant locations characterized by availability of cultivated land and lower livestock and population density, but at the expense of additional transportation. Environmental sustainability aspects of the two scenarios were compared with respect to the share of people in China's regions exposed to different severity classes of environmental risks. Environmental risks are measured in terms of environmental pressure in relation to the coincidence of three factors: density of confined livestock, human population density, and availability of cultivated land. For year 2000, the estimates suggest that about 20 percent of China's population lives in counties characterized as having high or extreme severity of environmental pressure from intensive livestock production. In the "intensification" scenario, by 2030 this population share increases to 37 percent, while in the second, more environmentally friendly scenario, it stays below 30 percent. To finally compare the two scenarios, it is necessary to "normalize" gains due to improved life conditions with expenses of additional transportation.

The outcomes of the project were presented at several conferences and received favorable responses. For example, at a conference in Shanghai, (Risk Analysis and Crisis Response, 25–26 September 2007, China), devoted to methodological and modeling challenges for management risks and crisis response, LUC methodology for agricultural production planning under health and environmental risks was recognized as an operation tool to be used in the decision making and negotiation processes of agricultural production policies.

At the IFIP/IIASA/GAMM conference held at IIASA (IFIP/IIASA/GAMM Workshop on Coping with Uncertainty: Robust Decisions, 10–12 December 2007, Laxenburg, Austria), the China model for agricultural production planning was identified as a novel methodology for the design of strategies that mitigate risks and minimize the potential negative consequences that are likely to occur under rapid production expansion, intensification, urbanization processes typical for China.

Presented at the joint IIASA–Peking University Institute for Population Research roundtable "Pandemic Influenza in China—Challenges, Responses, Needs" (held at Peking University on 22 October 2007), the IIASA LUC work was recognized as a novel and sophisticated methodology to identify and evaluate hot spots of potential livestock-related disease risks characterized by a high density of livestock production and human population, with consequent implications for emergent zoonoses. Positive reviews of the presentation came from experts on human and animal health from IIASA, Peking University, the Chinese Centre for Disease Control, the Agriculture Academy, the Ministry of Agriculture, Chinese Centre for Animal Disease Control, and the Natural Science Foundation of China. A scientific cooperation network between these organizations is foreseen as an outcome of the presentation.

Assessment of Agro-ecological Zones for the Transition of the Agricultural Sector in Ukraine: This activity aims to gain a better understanding of land use change and its effect on the transition agriculture of Ukraine, to estimate the agricultural potential of Ukraine's natural resources, and to assess the impacts of climate change on crop suitability and yields in Ukraine. As part of a cooperative agreement between the Land Use Change Program and Ukraine's Institute of Economics and Forecasting of the National Academy of Sciences, program leader Günther Fischer visited Kiev in May, where he presented the methodology and results of a detailed resource potential and climate change impact analysis for Ukraine. His talk on ongoing LUC research toward a European "Biofuel Roadmap" (project REFUEL) highlighted recent findings for Ukraine.

Scientific Recognition

Awards

Ferenc Toth and Francesco Tubiello were among the network of scientists who shared in the 2007 Nobel Peace Prize awarded to the IPCC.

Selected Invited Lectures/Presentations and Scientific Networking

Günther Fischer

- Attended the EU-funded project "CATSEI" (Chinese Agricultural Transition: Trade, Social and Environmental Impacts) kick-off meeting at SOW-VU in Amsterdam, the Netherlands on behalf of the LUC program, 19–21 January.
- Participated in "IIASA Days" at the National Research Foundation (NRF), CSIR Convention Center in Pretoria, South Africa, 11–13 March.
- Attended expert meeting on "Common Biophysical Criteria for defining areas that are constrained for agriculture in Europe" at the Joint Research Centre of the European Commission, in Ispra Varese, Italy, 19–20 March.
- Attended discussions on collaboration between IEF and LUC on agro-ecological assessment of Ukraine at the Institute for Economic Forecasting, (IEF) NAS, Kiev, Ukraine. Presentation 1 (pdf): "Ukraine resource potential assessment and the impacts of climate change." Presentation 2 (pdf): "Biofuels for Europe – Ukrainian prospects," 23–24 May.
- Invited speaker at the Agri Benchmark Cash Crop Conference 2007, held at the Institut fuer Betriebswirtschaft, Bundesforschungsanstalt fuer Landwirtschaft, (Federal Agricultural Research Centre, FAL) in Braunschweig, Germany. Presentation: Agro-ecological Impacts of Global Climate Change (pdf), 11–12 July.
- Attended IPCC expert meeting: Toward new scenarios for analysis of greenhouse gas emissions, climate change, impacts, and response strategies, in Noordwijkerhout, the Netherlands, 18–21 September.
- Attended conference on Risk for Rural Communities organized by the Swiss Reinsurance Centre for Global Dialogue in Rueschlikon/Zurich, Switzerland. Presentation (pdf): "Outlook for the next 20 years – risky for agro," 7–8 October.
- Attended a workshop on Strategies and Priorities for Agricultural Data Systems, organized by the Bill & Melinda Gates Foundation in Rome, Italy, 8–9 October.
- Discussions on possible collaboration was held with the Planning Commission and TIFAC in New Delhi, India, 29 October – 2 November.
- Attended the start up meeting of the EU-funded project "ELOBIO" at EACI, Place Madou, Brussels, Belgium. Brochure (pdf), 23 November.
- Attended a workshop on bioenergy and food organized by the Federal Agricultural Research Centre, Institute of Farm Economics, Braunschweig, Germany, 4–5 December.

Tatiana Ermolieva

- Attended conference on Framing Land Use Dynamics II at University of Utrecht and Netherlands Environmental Assessment Agency in Utrecht, the Netherlands and gave a presentation entitled "Agricultural Production Intensification under Risks and Uncertainties," 17–20 April.
- Attend 1st Int. Conf. on Risk Analysis & Crisis Response - at the College of Information Engineering, Shanghai Maritime University, Shanghai, China and gave a presentation entitled "Catastrophic risks, vulnerability and land use" and "Integrated risk management approaches for planning sustainable agriculture." 25–26 September.

Kateryna Gumeniuk

- Discussions on collaboration between IEF and LUC on agro-ecological assessment of Ukraine at the Institute for Economic Forecasting, (IEF) NAS, Kiev, Ukraine, 27 May–3 June.

Sylvia Prieler

- Attended the EU-funded project Renewable Fuels for a Sustainable Europe, "REFUEL" Partners meeting on behalf of the LUC Program, Kongens Lyngby, Denmark, 22–27 February.
- Attended an EU-funded project "REFUEL" meeting and 15th European Biomass Conference & Exhibition - From Research to Market Deployment organized by ETA-Renewable Energies, Florence and WIP-Renewable Energies, Munich, held at the CC International Congress Center Berlin, Germany, and gave a presentation entitled "Europe's land resource potential for biofuel production" (Fischer, Prieler, van Velthuizen), 7–11 May.
- Attended an EU-funded project "REFUEL" progress meeting at the EC BREC/IEO in Warsaw, Poland, 20–22 September.
- Attended an EU-funded project "REFUEL" policy workshop at EC BREC/IEO in Warsaw, Poland, 25–27 October.
- Attended the start up meeting of the EU-funded project "ELOBIO" at EACI, Place Madou, Brussels, Belgium, 23 November.

Mahendrakumar Shah

- Mankind, Agriculture and Ecosystem Symposium at the Universita Cattolica del Sacro Cuore in Rome, Italy, Food Security, Human Health and Climate Change: The 21st Century Challenges (pdf). Abstract, 22–24 June.
- Discussions on possible collaboration was held with the Planning Commission and TIFAC in New Delhi, India, 29 October – 2 November.

Edmar Teixeira

- Visited JRC in connection with the LUC-Unilever "EIGER" project, 12–14 June.
- Did modeling work on Ozone for the LUC-Unilever "EIGER" project, 6–24 August.

Francesco Tubiello

- Attended workshop at UNFCCC to discuss potential for development of joint implementation projects, including afforestation/ reforestation, United Nations Framework Convention on Climate Change UNFCCC, Bonn, Germany, 11–15 February.
- Attended IPCC Author meeting for the Technical Paper on Water and Climate Change (IPCC Technical Support Unit, Met. Office, Hadley Centre, Exeter, UK), 19–23 February.
- Attended Experts meeting on Climate Change Impacts on European Agriculture at the Institute for the Protection and Security of the Citizens (IPSC), EC, JRC Ispra - MARS unit, in Ispra Varese, Italy, 7–9 March.
- Attended follow up meeting on Workshop at UNFCCC to discuss potential for development of Joint Implementation projects, including afforestation/ reforestation - invited to make a presentation at the UNFCCC–CDM executive board on inputs to topics for "additionality" of CDM projects. United Nations Framework Convention on Climate Change UNFCCC, Bonn, Germany, 22–25 March.
- Attend annual Northern Eurasian Earth Science Partnership Initiative "NEESPI" PI meeting at the University of Maryland, NASA LCLUC academic HQs, Maryland, USA, 3–6 April.
- Attended IPCC WGII side-event presentation at FAO to Ministries of Agriculture at IPCC meeting held at FAO, Rome, Italy, 26–27 April.
- Attended annual mtg. of Italian Society of Agriculture & Horticulture, at the University of Sassari, Italy, and gave a presentation entitled "Climate Change and Agriculture: Challenges for Coming Decades," 7–11 May.
- Attended Ist Italian National Workshop on Climate Change in Alghero, Italy and gave and invited lecture, "Soils, water and agriculture in the IPCC report," 20–22 June.
- Participated in a panel for selection of EU FP7 proposals in land use, climate change impacts, adaptation and mitigation at the EU in Brussels, Belgium, 9–10 July.
- Was a member of panel review for the sub-activity ENV.2007.6.1.3 Pressures on environment and climate at the European Commission, DG Research, Directorate Environment, Unit "Climate change and environmental risks," Brussels, Belgium, 18 July.
- Attended the Cambiamenti Climatici - Conf. National. 2007 in Rome as a speaker, 11–14 September.
- Attended a workshop on joint implementations - mechanisms of UNFCCC, at UNFCCC in Bonn, Germany, 19–21 September.
- Attended one-day seminar on Climate Change and Food Security at FAO-NRC (Environment, Climate Change and Bioenergy Division), Rome, Italy, 10–12 October.

Harrij van Velthuizen

- Attended an Exploiting Information on Global Environmental Risks – Agriculture (EIGER-Ag) meeting at Wageningen University, The Netherlands, 18–21 January.
- Discussions on Global Agro-ecological Zones Assessment "GAEZ 2007" and Harmonized World Soil Database "HWSD." Food and Agriculture Organization (FAO) of the UN, Rome, Italy, 28–29 March.
- Attended expert meeting on "Common Biophysical Criteria for defining areas that are constrained for agriculture in 22–26 Aug. Visited FAO to work on Global Soil Resources Database Project and GAEZ 2007 project. FAO, Rome, Italy, 19–22 April.
- Attended a restricted expert-meeting "Common Biophysical criteria (soil and climate) for the delimitation of areas by significant natural handicaps - Revision of the EU Less Favoured Areas" at IES, Rural, Water and Ecosystem Resources Unit, Joint Research Council, Ispra, Varese, Italy, 6–7 December.

Luc Verelst

- Visited FAO to work on Global Soil Resources Database Project and GAEZ 2007 project. FAO, Rome, Italy, 22–26 August.

David Wiberg

- Attended the IA2 Meeting of the EU-funded project Water Scenarios for Europe and for Neighbouring States "SCENES," at the Central European Center for Communication, Consultation and Land Issues, in Budapest Hungary, 8–9 March.
- Attended the EU-funded project Water and Global Change "WATCH" start-up meeting on behalf of the LUC program at the Centre for Ecology and Hydrology in Wallingford, UK, 18–21 March.
- Attended EU-funded project "SCENES" meeting with Frank Farquharsen, CEH Wallingford, UK, 22 March.

- Attended expert meeting on Sustainable Water Management for Crops at the International Life Sciences Institute - ILSI Europe, Brussels, Belgium, 10 September.
- Attended all-partner meeting EU-funded project "SCENES" in Granada, Spain, 2–29 September.
- Attended the annual science meeting and general assembly of the EU-funded project "WATCH" at UPC in Barcelona, Spain, 4–9 November.
- Attended a meeting related to the EU-funded project "SCENES" at the Center for Environmental Systems Research (CESR), Univ. of Kassel, Germany, 20–22 November.

Personnel

Scientific Staff

Günther Fischer (Austria), *Program Leader*
Erfu Dai (China)
Tatiana Ermolieva (Austria)
Daniel Garcia Galindo (Spain)
Kateryna Gumeniuk (Ukraine)
Sylvia Prieler (Austria)
Mahendrakumar Shah (United Kingdom)
Laixiang Sun (China)
Zhan Tian (China)
Ferenc Toth (Hungary)
Eva Tothne Hizsnyik (Hungary)
Francesco Tubiello (USA)
Harrij van Velthuizen (Netherlands)
Luc Verelst (Belgium)
David Wiberg (USA)

Postdoctoral Research Scholars

Edmar Teixeira (Brazil)

YSSP

Muhammad Goheer (Pakistan)
Sepo Hachigonta (Zimbabwe)
Jing Li (China)
Vivek Voora (Canada)

Administrative Support

Cynthia Enzlberger-Vaughan (Austria)

Part II

Population and Society

Processes of International Negotiation Network

pin@iiasa.ac.at

The Processes of International Negotiation (PIN) Program develops and disseminates knowledge through research on international decision making, especially negotiation, that includes subjects of relevance to IIASA. The overall goal of the PIN Program is to develop knowledge about negotiation to promote: 1) solutions to specific problems; 2) regimes for international governance and cooperation; and 3) new concepts and techniques to support decision making in the international context. The PIN Group seeks to complement substantive solutions developed in other IIASA research programs with a better understanding of the processes by which they can be implemented.

Cooperation Between PIN and Other IIASA Programs

Dialog session on Caspian Sea issues (CaspiLog)

CaspiLog I, Istanbul, Turkey

In May 2006 the PIN Program organized CaspiLog I in Istanbul, a Dialog among representatives of the five littoral states of the Caspian Sea (Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan). The Dialog related not to the contentious issues that have proved divisive in the region but to environmental matters such as pollution, land use, and water. Collaborating with PIN and giving presentations at the Dialog were scientists from other IIASA programs: David Wiberg (LUC), Fabian Wagner (APD/GGI), Ulf Dieckmann (EEP) and Yaroslav Minnulin (DVN).

CaspiLog II in Baku, Azerbajian

A second Dialog, Caspilog II, was held in Baku, Azerbaijan, from 6 to 10 May 2007. Caspilog II, organized by PIN in cooperation with both the Caspian Partnership for the Future Public Union (CPF) and the Association for Civil Society Development in Azerbaijan (ACSDA), brought together over 40 academics, policymakers, and NGO representatives to discuss issues facing the Caspian Sea/Lake and to look for potential areas for cooperation. The CaspiLog II participants focused their discussion on issues of common concern such as water management, maritime emergency management, fisheries, and energy transport. IIASA scientists again provided input, while government and NGO representatives from Azerbaijan, Iran, and Russia, presented and explained the economic and political implications of their policies.

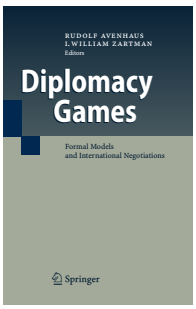
Book projects

There was collaboration between PIN and other IIASA projecrts on three recent book projects. Markus Amann (APD/GGI) contributed a chapter in *Diplomacy Games: Formal Models and International Negotiation*. Joanne Linnerooth-Bayer (RAV) contributed a chapter to *Overcoming Obstacles to Climate Change Negotiation*, and Keith Compton (RAV) contributed a chapter to the *Negotiating Risks* book project.

Scientific Achievements and Policy Impacts in 2007

PIN publications

Diplomacy Games

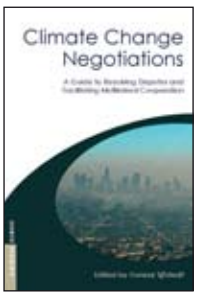


The PIN Book *Diplomacy Games: Formal Models and International Negotiation*, edited by Rudolf Avenhaus and I. William Zartman, was published by Springer in July 2007. In this book, leading international experts in the field evaluate formal models *in*, *of*, and *for* negotiation. The book tackles a number of questions: How can the abstract concepts and results of rational choice theorists be made more understandable and plausible to political and social scientists not trained to work with formal models? What can be done to encourage practitioners (e.g., politicians and diplomats) to use not only simple but also mathematically advanced approaches in their analysis of real world negotiation problems? How can practitioners become familiar with, take account of, and apply formal models of their more important problems?

SAGE Handbook of Conflict Resolution

The *SAGE Handbook of Conflict Resolution* brings together 36 international authors under the editorship of Jacob Bercovitch (Canterbury University, New Zealand), a new PIN associate member, and PIN members I. William Zartman and Victor Kremenyuk, with the PIN Steering Committee acting as associate editors. The *Handbook* provides a deeper understanding of the field of conflict resolution, its evolution, future, and areas of application, presenting an up-to-date summary and evaluation of the various areas of knowledge in a form useful to both analysts and practitioners. The book, the subject of a 2007 June workshop, will be published in 2008.

Book Project: Climate Change Negotiations: A Guide to Resolving Disputes and Facilitating Multilateral Cooperation



The overall objective of this PIN book project is to design and assess approaches to and concrete methods for the *facilitation* of climate talks. *One task* of the project is to specify the meaning of facilitation, particularly for those measures with a long-term impact—an innovative approach. The *second task* is to analyze

how facilitation measures can be designed, how they can be communicated from designer to user, how they can affect the negotiation process, and what results they can attain and why. The objective of facilitation is explicitly or implicitly inherent in much of negotiation theory. However, most concrete facilitation measures suggested in the literature can be described as "smart fixes" to cope with an immediate negotiation problem such as an impasse. Usually, proposals about "smart fixes" and other ways of facilitating a negotiation pertain to a bilateral situation. Little has been written about facilitation of multilateral negotiation in a strategic, long-term perspective.

The reasons for producing a book on this topic are the high and increasing complexity of the international negotiations on climate talks and the urgency of their agendas. The negotiation on climate warming has made little progress in recent years and the U.S. refusal to ratify the 1997 Kyoto Protocol threatened to undermine the whole process. Post-Kyoto negotiations are likely to be more cumbersome than the pre-Kyoto talks. The complexity of the negotiation process reflects the technical difficulty of the issue, the political circumstances under which the negotiations are conducted, and the great and increasing number of participants: state delegations as well as NGOs and other representatives of civil society. Although a large number of actors hamper informal discussions and problem solving, broad participation in international negotiation is beneficial from a "democratic" point of view and a pre-condition for a wide commitment to a negotiated agreement.

Gunnar Sjöstedt is the editor of the book project.

Book project: Negotiating with Terrorists

The project on Negotiating with Terrorists focuses on when, how, and why negotiations take place between governments and terrorists, given governments' public stance against doing business with terrorists. Two workshops were held in June 2006 and June 2007 to provide a final manuscript for publication, which may be ready by the end of 2008. The project is supported by the United States Institute of Peace (USIP) and the Smith Richardson Foundation. The book addresses a topic that has hitherto received little systematic attention and will provide an important guide to both analysis and practice. It has already given rise to a *Handbook on Mediation: Negotiating with Terrorists*, by Guy Olivier Faure and I. William Zartman, prepared in conjunction with USIP for the UN Mediation Support Unit.

Book project: Negotiated Risk. Issues Framed as Risks in International Negotiation

The purpose of the project is to assess if, and how, issues framed as risks are addressed and treated in a special way at the negotiation table. The project particularly focuses on the perception and the communication of risk and aims to identify various stumbling blocks and appropriate ways of coping with them. The project is organized as a comparative case study looking at different types of negotiated risks, including business joint ventures, environmental issues, and chemical weapons. Edited by Rudolf Avenhaus and Gunnar Sjöstedt, the book will be published in 2008.

Book Project: Unfinished Business: Negotiations that Did Not End in Agreement

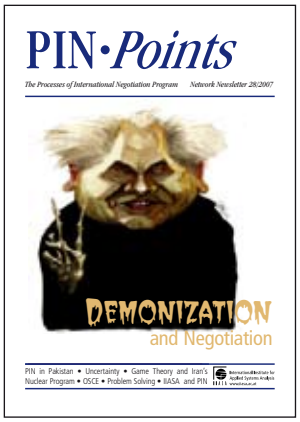
The project on failed negotiations, which began with a workshop in June 2005, presents lessons from incomplete negotiation encounters, analyzed both from the point of view of particular conceptual approaches and through case studies. The approach avoids a search for a single cause and allows the presentation of multiple reasons for failure and lessons in avoiding them. The project is funded by the United States Institute of Peace (USIP), and a summary research report by Guy Olivier Faure and I. William Zartman is with USIP for publication.

Participation at the 3rd International Negotiations Biennale in Paris

PIN members Guy Olivier Faure, Paul Meerts, I.William Zartman, and Victor Kremenyuk participated at the 3rd International Negotiations Biennale held in Negocia in Paris from 13–15 November 2007, attended by over 250 researchers and practitioners from around 15 different countries. The 3rd Biennale examined and analyzed the risks implicit in negotiation, whether "external" (the consequence of an unstable environment) or "internal" (reflecting on the participants and their behavior). PIN Steering Committee members, Kremenyuk, Sjöstedt, and Zartman presented their contributions during the round table on *La Prise de Risque en Négociation et la Négociation sur des Enjeux à Risque*, with Guy Olivier Faure acting as moderator. Victor Kremenyuk delivered a report on "International Negotiations on Security Risks" and "Negotiations on the National Security Risks: The Soviet-American Case." Paul Meerts discussed "Risking War or Words. Is Negotiation War by Other Means?" I. William Zartman presented a paper on Risk and Preventive Negotiation in Identity-Related Negotiations. Professor Zartman made the final selection of the winner of the Negocia Prize, Achim Wennmann (Switzerland).

PINPoints newsletter/magazine

PINPoints, published twice yearly by the Processes of International Negotiation, was redesigned in 2006 to turn it from a newsletter into a full-color magazine. It is clear from the comments received regarding the redesign that the negotiations community approves of the transformation and that PINPoints is now seen as a leading contributor to the dissemination of state-



of-the-art knowledge about international negotiations and the theory pertinent to this field. The PIN Steering Committee are the main contributors to the magazine, but contributions are also sought and published from the wider negotiations community.

PIN Roadshow in Lahore, Pakistan

The PIN Roadshow in Lahore, Pakistan from 11 to 12 February 2007 was organized and hosted by the Forman Christian College (FCC). PIN members led discussions on the following topics: Game Theoretical Considerations on Nuclear Negotiations between Iran and the West (Rudolf Avenhaus); Negotiating with Terrorists (I William Zartman); Water Negotiations (Gunnar Sjoestedt); Is Negotiation War by Other Means? (Paul Meerts); Negotiations on the Resolution of Military Confrontations (Victor Kremenyuk); Negotiation and the Demonization Process (Guy Olivier Faure).

The retired governor of Punjab province, Shahid Hamid, addressed the practical lessons drawn from his negotiating experience, while Dr Imtiaz Bokhari, host of the Roadshow and chair of the Political Science Department at FCC, compared Indian and Pakistani negotiating styles. Following the presentations there was a lively discussion with the audience. The PIN workshop had a significant impact on the Forman Christian College, which is currently in the process of establishing a Policy Studies Institute, and including courses on negotiation in its curriculum.

PIN in Pakistan

PIN Roadshow in Nanjing, China

Approximately 80 students, staff, and other participants gathered on 27 October 2007 at the Johns Hopkins and Nanjing University Center in for the PIN Roadshow. Professor Jacob Bercovitch of the University of Canterbury, New Zealand, gave a presentation on international mediation. I. William Zartman spoke on negotiation and conflict resolution with a special focus on negotiation tactics and the value of trust building. Victor Kremenyuk gave a talk on negotiation methodology, joining Franz Cede in the later breakout session to discuss the topic of law between East and West, the consequences of the fall of the Berlin Wall, and the role of multipower players. Rudolf Avenhaus

Pin in China

gave a presentation on some of the topics covered in PIN's latest book: *Formal Models of, in, and for International Negotiations*, explaining the problem of Prisoner's Dilemma and other formal games. Paul Meerts, in a close look at negotiating security in Asia, discussed how the sensitive subject of human rights is handled within the negotiation process. Prof Huang and Prof Jan Kiely, the two co-Directors of the Center, warmly welcomed the group and hosted several events, including traditional Chinese dinners, where the visitors enjoyed the company of enthusiastic scientific staff and students.

YSSP 2007

The PIN Program selected two students for the 2007 Young Scientists Summer Program: Joshua Smilovitz from the United States and Maiko Sakamoto from Japan, who applied their research to two current PIN projects. Joshua Smilovitz contributed a chapter on the topic of mediation from the psychological perspective. Maiko Sakamoto, whose main field of interest includes conflict analysis and management of water resources, applied her research to the ongoing Caspian Dialog project.

Future projects

PIN roadshow in Geneva

Hosted by the Geneva Center for Security Policy (GGSP), the first Roadshow of the year on 11 February 2008, also called "Geneva Negotiating Day," adheres to the objective of the Geneva Center to "promote the building and maintenance of peace, security and stability." The road show promises to be a significant collaboration between PIN and the GGSP, as GGSP is a prestigious academic institution whose main activity is to provide training in comprehensive international security policy for mid-career diplomats, military officers, and civil servants from foreign, defense, and other relevant ministries. Overall, the GGSP trains over 200 participants from more than 40 countries each year, with training programs ranging from new dimensions of security policy, including human rights and human security, to crisis management and conflict mitigation.

At the PIN Roadshow, PIN members will give lectures on topics such as: "Basic Elements of Negotiation Analysis" (Victor Kre-

menyuk); "Why States Cooperate: Negotiation and Cooperation" (I. William Zartman); "Formal Models and International Negotiation" (Rudolf Avenhaus), "EU–NATO Relations as a Negotiation Experience" (Franz Cede); "Demonization and Negotiation" (Guy Olivier Faure); "Negotiating Sustainable Development. The Case of Environmental Goods and Services in the Doha Round" (Gunnar Sjoestedt);"Negotiating Conflict: External Interventions in African Conflicts" (Mark Anstey); and "Negotiations on Disaster Relief " (Paul Meerts). The lectures will be followed by individual seminars on the topics, giving the chance for questions and deeper discussion with the PIN members.

PIN fall roadshow

Arrangements are being made for a Roadshow in October 2008 at either Jawaharlal Nehru University in New Delhi or the University of Warsaw.

CaspiLog III in Kazakhstan or Iran

CaspiLog III has been difficult to arrange but possibilities of a meeting in spring 2008 in either Atirau, Kazakhstan, or Tehran, Iran, are being pursued.

The Workshop on Negotiation in Theory and Practice

At the summer workshop at IIASA there will be a day of discussions (20 June 2008) between practitioners (diplomats) and analysts, linking theory and practice, on a variety of topics: comparing PIN conceptual writings on Iranian nuclear options; the Rambouillet negotiation on Kosovo; trade negotiations in the Doha Round; and negotiations with terrorists. The project is led by Franz Cede and Rudolf Avenhaus.

The Workshop on External Efforts to Promote Negotiation in Internal Identity Conflicts (ExIn)

The focus of this 2008 PIN project is on the role of external parties in promoting negotiations in internal conflicts involving identity, based on the assumption that the parties are unable to break the stalemate by themselves. How does an external party bring parties in an internal identity-based conflict to negotiation and thus bring the conflict to an end? Sixteen papers will be presented at the workshop on 21–22 June at IIASA. The project is supported by the Smith Richardson Foundation. The project is led by Paul Meerts, I. William Zartman, and Victor Kremenyuk, with new associate member Mark Anstey of the University of Port Elizabeth, South Africa.

PIN Steering Committee Members

Rudolf Avenhaus, Germany
Franz Cede, Austria
Guy Olivier Faure, France
Victor Kremenyuk, Russia
Paul Meerts, the Netherlands
Gunnar Sjöstedt, Sweden
I. William Zartman, USA

PIN Associates

Mark Anstey, South Africa
William Donohue, USA
Jacob Bercovitch, New Zealand

PIN coordinator/in-house staff

Ariel Macaspac Penetrante has replaced Tanja Huber as PIN Coordinator. Also an IIASA Research Assistant, he is currently writing his PhD dissertation at the University of Vienna with the title "International Mediation as Intervention—Effective Mediation in Fragile States."

Scientific Recognition

Rudolf Avenhaus presented "A Critical Evaluation of the Critical Time Concept in Nuclear Material Safeguards" at the European Safeguards Research and Development Association (ESARDA) Symposium on Safeguards and Nuclear Material Management in Aix-en-Provence on 23 May 2007. He was also invited, together with Dr. Thomas Krieger, to cooperate with The Joint Research Center of the European Union in Ispra, Italy, in the area of quantitative analyses of verification measures for the nuclear non-proliferation treaty. The joint work will start in 2008; its first phase should be finished around mid-2009.

Franz Cede, after his retirement from the Austrian diplomatic service in December 2007, is pursuing his academic activities. Dr. Cede has accepted a teaching position at the Salzburg University of Applied Science where he will offer a course on European Union Law in spring 2008. He is also scheduled to become a visiting professor at the German-language Andrassy University in Budapest beginning in fall 2008. In 2007 Dr. Cede published two articles, one dealing with Austrian neutrality and the State Treaty, the other related to the teaching of EU law within the framework of the Austrian education system.

Guy Olivier Faure's publications in 2007 included: *Négociation internationale et pratique des affaires en Chine* (with Philippe Beraud and Jean-Louis Perrault, Paris, Maisonneauve et Larose), "*Les négociations en Chine*" (In Philippe Beraud, Guy Olivier Faure et Jean-Louis Perrault, *Négociation internationale et pratique des affaires en Chine*. Paris, Maisonneuve et Larose, 2007, 31- 53) and *Les stratégies déescaladent en situation hyperconflictuelle*. Agir, Revue Générale de Stratégie, n° 32, 2007.

Victor Kremenyuk, Deputy Director of the USA and Canada Studies Institute of the Russian Academy of Sciences, published an article entitled "Russian–U.S. Relations: The Time of Trial" in the Institute's monthly *USA–Canada: Economics, Politics, Culture* [in Russian]. He also published a forecast of U.S. foreign policy for the year 2008 in the aggregated world policy forecast for 2008

published by the Institute of World Economy and International Relations of the Russian Academy. He continues to teach as the chair of the World Policy at the Moscow University of the Human Sciences on the topics: Basics of the Political Science, Conflict Management, Negotiation, World Policy. He continues to teach at the NATO Defense College in Rome "NATO and Russia" and "Russian Security Perspective." Professor Kremenyuk participated in the work of the American–Russian group of top-level experts headed by Henry Kissinger and the former Russian Prime Minister Primakov on global and bilateral issues, one in Moscow (July 2007) attended by Vladimir Putin and the other in Washington (January, 2008) attended by George W. Bush. He received an Excellence Award for the contribution in the political science from the International Biographical Centre, Cambridge, England.

Paul Meerts organized two international conferences, one on 'Culture and International Law' for The Hague Academic Coalition and another one for the tenth anniversary of the Organisation for the Prohibition of Chemical Weapons. He published an article on war and negotiation in the Dutch academic journal *Vrede en Veiligheid*. He spent half of his time teaching international negotiation processes in 20 countries. He is guest lecturer at the University of Leiden and guest professor at the College of Europe in Bruges and the Charles University in Prague.

Gunnar Sjöstedt was project coordinator in two projects at the Swedish Institute of international Affairs in 2007. One of the projects made a quantitative assessment of how the non-military power distribution in the world has changed since 1973. The results were presented in maps (geographical information systems software) in a report from the Swedish Institute of international Affairs: *Neglected Conditions for International Influence: Non-Military Power Configurations*. Another project concerned environmental issues and international trade and was carried out in collaboration with a research team in China. A report from the project was titled *Negotiation for Sustainable Development*. The Case of Environmental Goods and Services. In 2008 Gunnar Sjöstedt started a new project on *the role of non-governmental organizations in peace and reconciliation processes* supported by a research grant from the Norwegian Foreign Ministry.

I. William Zartman presided over a one-day celebration of the 25th anniversary of his Conflict Management Program at the School of Advanced International Studies, The Johns Hopkins University, involving 15 speakers. He was honored with the publication by Routledge of 16 of his past writings on *Negotiation and Conflict Management: Essays on Theory and Practice*. In May he was one of a small group invited to discuss conflict management at the White House with President Bush and National Security Advisor Hadley. He was appointed the foreign (American) member of the Canadian Social Sciences and Humanities Research Council, and was reelected president of the Tangier American Legation Museum Society.

Personnel

Scientific Staff

Rudolf Avenhaus (Germany)
Franz Cede (Austria)
Guy Olivier Faure (France)
Victor Kremenyuk (Russia)
Paul Meerts (Netherlands)
Gunnar Sjöstedt (Sweden)
William Zartmann (USA)

YSSP

Maiko Sakamoto (Japan)
Joshua Smilovitz (USA)

Administrative Support

Tanja Huber (Austria)

Population and Climate Change Program

Brian O'Neill
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Objectives

The Population and Climate Change (PCC) Program was established in January 2005, primarily funded by a five-year European Young Investigator (EURYI) Award to Program Leader, Brian O'Neill. The PCC program aims to develop new approaches to interdisciplinary analysis of the climate change issue. Given the disparate aspects of the climate problem—from socioeconomic drivers of greenhouse gas emissions, to changes in the climate system, to political and economic response strategies—there is a strong need for integrative studies. PCC seeks to address this need by advancing integrated assessments of climate change in three areas: 1) understanding links between demography, energy and emissions; 2) developing approaches to better account for uncertainty and learning (i.e., changes in uncertainty over time); and 3) analyzing medium-term strategies that keep open long-term policy options while uncertainties are reduced. While research necessarily includes advances in methodology, the primary aim is to provide better information to the climate policy community to support the development of appropriate responses to the climate issue.

Scientific Achievements and Policy Impact in 2007

In 2007 we built on earlier work to make progress and produce new results in each of our three main projects.

Demography and emissions

The demography, energy, and emissions project aims to explicitly model links between the major demographic trends of aging, urbanization, and changes in living arrangements on the one hand, and energy consumption, land use, and associated emissions on the other. These links include not only how demographic changes might affect future energy demand and emissions but also how different energy futures would affect aspects of well-being such as access to affordable energy sources in developing countries.

Earlier work, in a case study of the United States, assessed how aging might affect projected energy use and carbon emissions. In 2007 we extended this work by producing a first set of results for case studies of India and China that focus not only on aging but also on urbanization. Model results, described in a paper presented at the Annual Meeting of the Population Association of America, indicate that explicitly accounting for urbanization could lead to emissions projections that are nearly 50 percent higher than projections made without considering the influence of urbanization.

An important methodological issue raised by the case studies of the USA, India, and China is the best way to incorporate household heterogeneity into the model employed, a general equilibrium growth model of the global economy (the Population–Environment–Technology or PET model. To this end, we initiated a study of the general problem of grouping economic agents according to their preferences. With a model similar to PET, we are investigating the level of aggregation that is sufficient to capture the impact of heterogeneity on total consumption of energy in a model region.

The modeling work supporting emissions scenario development draws heavily on analysis of data describing the economic and energy use behavior of different types of households (for example, old versus young, urban versus rural, low- versus high-income). In 2007 Research Scholar Shonali Pachauri published a book detailing her work in this area: *An Energy Analysis of Household Consumption: Changing Patterns of Direct and Indirect Use in India*. The book elucidates the underlying drivers of growing energy use in India by adopting a household perspective. It estimates the direct and indirect energy requirements of household consumption by combining aggregate economic and energy data for various sectors of the economy with disaggregated data from household expenditure surveys. Statistical analyses identify changing patterns and trends over time and determine how demographic and socioeconomic factors affect variations in total energy requirements across households. This work provides a basis for better understanding the distribution of energy use and access within India and the relationship of energy with different dimensions of human well-being.

Our work on demography, energy, and emissions also requires the development of new urbanization projections. Existing projections from institutions such as the United Nations provide a useful starting point, but are insufficient for our purposes because they produce only single scenarios rather than a range of plausible outcomes, and they do not indicate how much migration from rural to urban areas would need to occur in order to

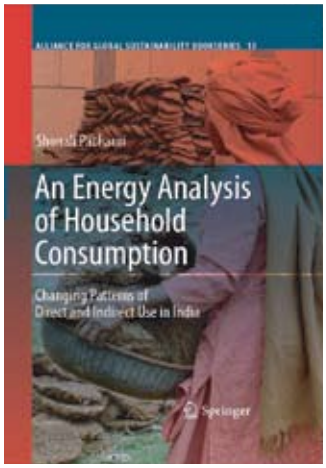

Figure 1. Shonali Pachauri, *An Energy Analysis of Household Consumption: Changing Patterns of Direct and Indirect Use in India.*

produce the anticipated degree of urbanization over the coming decades. In collaboration with the World Population Program, we produced a first analysis of the UN projections that, for India, imply a rapid take-off in rural–urban migration over the next 30 years, while, for China, they indicate the opposite. We then used this insight to produce a first set of new urbanization projections for China and India that explore a wider range of possibilities, and used them in our emissions scenario modeling.

Uncertainty and learning

The *uncertainty and learning* project examines the implications of learning (or changes in uncertainty over time) for climate change policy. The anticipation that we will learn more over time plays a key role in climate policy debates, particularly over the appropriate timing of emission reduction policies. For example, some argue that we should postpone substantial emission reductions until we learn more about possible climate change impacts. Others argue that we should make larger, precautionary reductions now because waiting would risk committing the world to climate impacts that that we might later learn will be more severe than anticipated. Research has not yet provided definitive answers to this question.

Our 2007 work on this project was highlighted by a paper published in *Science* arguing that, with the general credibility of the science of climate change established, it is important that policymakers understand the more extreme possibilities that consensus may exclude or downplay. PCC Program Leader Brian O'Neill, along with colleagues from MIT and Princeton, pointed out several ways in which the most recent scientific assessments by the Intergovernmental Panel on Climate Change fell short in how they characterized uncertainty, especially regarding the potential for extreme outcomes. They made several recommendations for ways in which assessment processes could be revised in order to avoid such problems in the future.

The program also initiated a new joint research activity within this project focused on The *Practice and Politics of Scenarios*, which aims to better understand the strengths and weaknesses of one of the key approaches to uncertainty in anticipating future change. The activity was launched at a meeting titled *Global Environmental Futures* co-organized with collaborators at the Watson Institute for International Studies at Brown University. The conference brought together 20 of the leading scholars and practitioners in the scenario development field. Scenarios have become a standard tool in the portfolio of techniques that scientists and policymakers use to envision and plan for an uncertain future. Yet, despite their prevalence, systematic analysis of scenarios as scientific and social processes is in its beginning stages. The meeting sought to better understand how scenarios are used in the scientific and policy communities, to draw on the experience with scenarios in other issue domains, such as security and energy, and to identify key research questions and needs for improvement. It resulted in an agreement with the journal *Environmental Research Letters* to produce a special issue on *Where Next with Global Environmental Scenarios?* to be published in 2008.

At the same time, over the past year we nearly completed the process of producing a special issue in the journal *Climatic Change* based on the 2006 PCC conference on Learning and Climate Change. That meeting brought together leading climate change economists, climate scientists, energy analysts, and demographers to discuss recent work on learning, assess its policy relevance, and identify promising areas of future research. In addition to editing other contributions to the journal, PCC completed three of its own papers on learning as it relates to population projections and to the carbon cycle, which will be included in the issue.

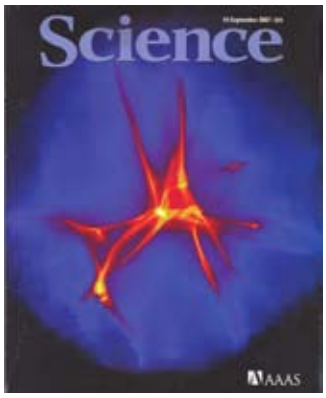

Figure 2. Science, September 2007.

In 2007 we also finalized a research activity on the early prediction of a potential threshold response in the meridional overturning circulation (MOC), a large-scale ocean circulation with important implications for climate. Current predictions about the fate of the North Atlantic MOC as climate changes are deeply uncertain, but can be improved by the understanding of a potential bifurcation response. We investigated mechanisms of abrupt change in conceptual box-models used to study the MOC. Self-sustained oscillations in a simple model of density-driven circulation, maintained by heat and salt diffusion, were proven to exist for a wide class of transfer functions. A limit cycle was shown to occur either through the classical Andronov-Hopf bifurcation or its analog, observed when a jump function is smoothed by transfer functions from the introduced class. The bifurcation may possibly capture certain features of a transition in ocean circulation to inter-decadal oscillations.

Medium-term climate strategies

The *medium-term strategies* project investigates options for climate policy strategies over the next 30–50 years that help link potential long-term climate change targets to short-term actions. The UN Framework Convention on Climate Change (FCCC) sets the ultimate objective of international climate policy as a long-term (century scale) goal of stabilizing atmospheric concentrations of greenhouse gases at a level that is not dangerous. Agreement on such a goal is unlikely to occur soon given the substantial uncertainties in long-term climate change outcomes and political differences among parties to the FCCC. Therefore, strategies for the interim period are needed that keep long-term options open while uncertainties are reduced through learning. Research in this project aims to inform such strategies, drawing on results and tools from the other research areas within the program.

In 2006 an initial paper was published in *Climate Policy* proposing that international climate policy would benefit from the development and adoption of interim concentration targets—that is, a multi-gas target that would limit atmospheric concentrations to a particular level at mid-century. Agreeing to such a target could help limit the rate of climate change over the next several decades, provide more policy certainty for decision makers considering long-term investments, and help keep open the option of achieving a range of long-term climate change targets that we might later decide are necessary to meet. In 2007 PCC presented results of an atmospheric analysis of mid-century targets at an event organized by the Greenhouse Gas Initiative (GGI) at a preparatory meeting for the Conference of Parties to the UN Framework Convention on Climate Change. We are currently collaborating with GGI on a further analysis of emission reduction scenarios consistent with mid-century targets.

Personnel

Scientific Staff

Brian O'Neill (USA), *Program Leader*
Regina Fuchs (Austria)
Karl Gmeiner (Austria)
Nikolay Melnikov (Russia)
Shonali Pachauri (India)
Isolde Prommer (Austria)
Katarina Zigova (Slovakia)

Postdoctoral Research Scholar

Katsumasa Tanaka (Japan)

YSSP

Ivan Medvedev (Russia)
Carolyn Snyder (USA)

Administrative Support

Ekaterina Smirnova-Scherbov (Netherlands)

Scientific Recognition

Selected Invited lectures

Michael Dalton

- Annual Meeting of the Population Association of America, New York, NY: Demographic change and future carbon emissions in China and India

Leiwen Jiang

- Annual Meeting of the Population Association of America, New York, NY: *Projecting U.S. household changes with a new household model*
- Third Annual Symposium of the Population, Work and Family Policy Research Collaboration, Policy Research Initiative, Government of Canada: *Population/household dynamics, energy consumption and carbon emissions in the USA, China and India*

Nikolai Melnikov

- EquaDiff '07, Vienna University of Technology, Vienna: *Limit cycle oscillations in thermohaline circulation box model with turbulent fluxes*
- Lecture series on Dynamical Systems and Differential Equations, Department of mathematics and statistics, Georgia State University, Atlanta: *Instability mechanisms of thermohaline circulation box models*

Brian O'Neill

- Energy Modeling Forum, Snowmass, Colorado: *Downscaling demographic drivers from SRES*
- Joint Program on the Science and Policy of Global Change, Massachusetts Institute for Technology (MIT): *Demographic change and future carbon emissions in China and India*

Shonali Pachauri

- International Energy Agency (IEA), Paris, France: *Demographic and socio-economic dimensions of energy transitions in India and China*
- Conference on InputOutput Analysis for Indian and the World Economy, New Delhi: *Energy balancing and an energy analysis of Indian input-output accounts: assessing sectoral energy intensities over two decades*

Selected Editorships

Brian O'Neill

- Editorial Board, *Environmental Research Letters*.
- International Editorial Board, *Global Environmental Change*.
- Associate Editor, Population and *Environment*.

Activities for 2008

Demography and Emissions Project

In this project we aim to finalize and publish our case studies of the influence of urbanization on future emissions in China and India and also to complete a first global analysis of population effects on emissions. In addition, we are developing a user interface to provide a relatively simple means of using the integrated set of population, economic, and carbon/climate models used in our scenario development. We plan to have a functioning prototype completed in 2008.

Uncertainty and Learning Project

We plan to complete the special issue of Environmental Research Letters based on our 2007 conference on Global Environmental Futures and to undertake a new analysis of the effect of learning about multiple uncertainties simultaneously within an integrated carbon cycle and climate model. We anticipate both of these activities to produce results relevant to policy questions.

Medium-Term Strategies Project

We aim to complete a more comprehensive and detailed analysis of mid-century targets for climate change policy, in collaboration with other programs at IIASA.

Risk and Vulnerability Program

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Objectives

In its second year the Risk and Vulnerability Program (RAV) continued progress toward meeting its objective, namely, *advancing scientific inquiry and assisting the development of policy strategies that promote adaptation and resilience of societies and ecosystems to stresses imposed or aggravated by global-change phenomena*. Emphasis was on the science–policy interface, in other words, moving beyond frameworks to contribute to the design and implementation of adaptation policies. Interdisciplinary research concentrated mainly, but not exclusively, on developing countries.

RAV's scientific achievements and policy impacts within its applied projects are described below as they contributed to the Program's four strategic goals: 1) conceptual and methodological development; 2) assessing risk, vulnerability, and adaptive capacity; 3) integrative case studies of vulnerability and governance; and 4) building capacity at the local, national, and international levels.

Scientific Achievements and Policy Impacts in 2007

Conceptual and methodological development

As demonstrated in the Nobel Prize–winning Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate change is already taking place. This raises the question: to what extent are increasing losses from floods, windstorms, and other weather extremes already the result of a changing climate or, alternatively, of changing land use practices or greater-than-ever population and assets? A major conceptual question, especially within IIASA's Greenhouse Gas (GHG) Initiative, thus concerns *how socioeconomic and natural systems drive potential extreme event impacts and risks, now and in the future?* RAV staff members, Georg Pflug, Stefan Hochrainer, and Reinhard Mechler, contributed to this question and to the GHG Initiative's emerging focus on adaptation research by carrying out an exemplary analysis of current and future financial and economic impacts of climate-related extreme events in Bangladesh consistent with downscaled IIASA SRES population and GDP scenarios. Although data are scarce, this report showed that projected changes in socioeconomic variables (exposure of people and assets, vulnerability) are as important as possible changes in the hazards due to climate change.

Climate change is increasingly framed in terms of risk management rather than optimization and, as such, the communication of probabilities and uncertainties is another difficult methodological challenge. Contributing to the IPCC's Fourth Assessment Report on this topic, Anthony Patt built on his extensive empirical research aimed at characterizing, describing, and framing uncertainty. His most recent study published in *Global Environmental Change* shows how people interpret climate change uncertainty differently, depending on whether it is the result of stochastic modeling or expert disagreement. RAV also contributed to the U.S. State of the Carbon Cycle Assessment on this topic.

RAV research continues to be at the forefront of methodological development in support of risk and vulnerability analyses. Within the integrated project on Adaptation and Mitigation (ADAM) of the European Union (EU), Reinhard Mechler is leading research that is, for the first time, providing consistent, probability-based and spatially explicit digital maps of risks from natural extremes at continental (i.e., European) scale and identifying monetary economic losses. A first deliverable with drought and flood maps is now available. Building on these probability-based maps, RAV is estimating the economic vulnerability of European households, businesses, and governments to the extremes of adverse weather. The analysis demonstrates that, even in Europe, disasters can have dire fiscal consequences today and in a future world and that early financial planning can make a positive difference.

More generally, RAV continues its focus on methodological development with the publication of the book *Modeling, Measuring, and Managing Risk* edited by Georg Pflug and W. Römisch.

Assessing risk, vulnerability, and adaptive capacity

Finding practical ways to promote climate change adaptation is a challenge facing many governmental and nongovernmental organizations, especially in Africa where adaptation will clearly be necessary and yet where poverty means that people often cannot afford to think beyond the next harvest. RAV is conducting research on the issue of adaptation in Africa, looking in particular at the role that adapting to interannual climate variability can play. In Malawi a RAV team examined the implementation of an innovative crop insurance system designed to be affordable and practical for subsistence farmers. Based in field work conducted by RAV associate Pablo Suarez and in collaboration with the Climate Systems Analysis Group in Cape Town, South Africa, this research demonstrates the important role of local institutions for insurance system credibility and the need for insurers to take climate change into account. If they do not, they risk being seriously undercapitalized.

In Mozambique RAV carried out a second World Bank study on people's perceptions of climate change and increased weather variability. The work revealed a serious mismatch between the perceptions of farmers and of policymakers, leading to the failed implementation of adaptation policies. RAV also completed an assessment commissioned by the United States National Oceanic and Atmospheric Administration on the use of seasonal climate forecasts throughout Africa. The major finding, that greater use of forecasts for adaptation is constrained by the lack of interorganizational partnerships, appeared in a paper that Anthony

The photo shows representatives from the African Centre for Meteorological Applications for Development (ACMAD), visiting a community radio station in Niamey, Niger, which has started broadcasting seasonal climate forecasts for local farmers. The station accesses the forecasts from ACMAD using a satellite transceiver that is part of the Radio and Internet (RANET) network. This programme represents an important way to bring an important technology, locally specific climate and weather information, to the people who can use it to reduce their vulnerability to climate variability.

Patt and colleagues from Africa and the United States published in the journal *Science*.

Moving from Africa, RAV staff, coordinated by Daniel Kull, participated in projects on the climate screening of donor development assistance portfolios in Bangladesh, China, and India. The projects developed and applied climate screening frameworks for assessing climate change impacts and the integration of adaptation into development projects. Although the frameworks have been applied after the fact rather than as an integral part of the design process, they have proven to provide a clear framework for prioritizing, analyzing impacts, and examining adaptation effectiveness.

Integrative case studies of vulnerability and governance

Neither the public nor the private sector, acting alone or in partnership, has provided the security needed to developing country households and communities at risk from major shocks to their lives and livelihoods caused by natural disasters. In most developed countries, the state and private insurers, often in partnership, provide safety nets for victims by providing post-disaster assistance and monetary compensation. Public–private partnerships, however, are neither available nor affordable in many highly exposed developing countries. In a paper appearing in a RAV special issue of *Environmental Hazards*, Joanne Bayer and Reinhard Mechler examine recent innovations in financial management regimes that extend beyond traditional public–private partnerships to include nongovernmental organizations (NGOs), international financial institutions, and other donors. Importantly, these innovative partnerships provide secure financial arrangements to low-income communities *before* disasters strike and thus relieve the uncertainty and anxiety of depending on ad hoc post-disaster aid for recovery and even survival. The paper examines three examples: the Turkish Catastrophe Insurance Pool; the Andhra Pradesh micro-insurance program and the index-based weather derivative for farmers facing drought in Malawi. RAV is recognized as a neutral broker in discussing these recent systems and, at the request of the United Kingdom Department for International Development (DFID), prepared a work plan that merged the interests of their humanitarian assistance and financial team departments in supporting insurance and other market instruments as a supplement to post-disaster aid.

The complexity of governance regimes for responding to climate-related extremes is dwarfed by the complexity of integrating policy responses to both economic and ecological problems. Building on RAV's history of developing participatory processes to manage flood risks in Hungary's River Tisza basin, RAV staff broadened its research agenda to consider the ecology along with the economics of the region. Initial successes in flood control have repeatedly given way to surprising and catastrophic reversals. In a paper appearing in *Environmental Modeling* and Software Jan Sendzimir and Piotr Magnuszewski with Hungarian collaborators maintain that recurrent economic and ecological crises suggest systemic linkages far broader than imagined in the economic paradigms that drove the engineered systems. Typical of "policy resistance," these problems have resisted repeated efforts for their solution. The authors applied an innovative systems modeling technique, causal loop diagramming, integrating the economic with the ecological, as a means of examining what aspects of system structure might generate these surprising and counterintuitive reversals.

Building capacity at the local, national, and international levels

RAV's Catastrophe Simulation Model (CATSIM), which assesses risks, financial vulnerability, and adaptive capacity of governments to extreme events, has found many successful applications with regard to building the capacity of policymakers to carry out financial disaster planning. One case in point, Mexico, has recently become the first transition country to transfer part of its public-sector natural catastrophe risk to the international reinsurance and capital markets, in part with an innovative catastrophe bond. This decision was examined by IIASA's CATSIM model in a joint paper with Victor Cardenas of the Mexican Fi-

nance Ministry. As the costs of financial instruments can greatly exceed expected losses, the paper examines the benefits and alternatives of the Mexican transaction by setting it within the context of a public investment decision. The Mexican case is of considerable interest to highly exposed transition and developing countries, many of which are considering similar transactions. This is the second RAV paper to appear in the special issue of Environmental Hazards, edited by RAV staff along with collaborators in Japan and China.

Most recently, RAV has made use of CATSIM to help policymakers in Madagascar manage their increasing risk from tropical cyclones. Based on future scenarios of cyclone tracks generated by the Massachusetts Institute of Technology (MIT) and taking into account potential increases in hazard frequency and intensity, Stefan Hochrainer and Reinhard Mechler assessed country-wide economic risks and the Madagascar Government's vulnerability to these risks. Research findings and advice on proactive financial policy measures were presented at a workshop in Madagascar, co-facilitated by RAV, which was sponsored by the Provention Consortium and the World Bank. Key policymakers from the finance ministry and the prime minister's office found the advice helpful for better preparing for cyclones and helping to mainstream risk into fiscal and development planning. A follow-up workshop will be held early in 2008 at IIASA.

Building capacity at the international scale, RAV, together with Munich Re, the German Agency for Technical Cooperation (GTZ), and the World Bank, organized an expert workshop on *Insurance Instruments for Adaptation to Climate Risks* that took place at IIASA. This exploratory meeting identified opportunities and constraints for supporting risk pooling and transfer in the developing world both within and outside the post-Kyoto process. The meeting contributed to RAV's ongoing efforts to place insurance instruments squarely on the Bali roadmap, beginning with a RAV presentation at a special session on this topic at COP 13 in Bali. More generally, as the IIASA focal point, RAV is participating in the United Nations Framework Convention on Climate Change (UNFCCC) Nairobi Work Program on impacts and adaptation.

RAV is also informing the emerging EU strategy on adaptation, which will culminate in the publication of an EU White Paper late 2008. At a number of meetings and a policy workshop in Brussels with key policymakers and stakeholders, RAV offered policy advice and assessments conducted within the ADAM project.

Finally, RAV designed the World Bank distance-learning course on "Financial Strategies for Managing the Economic Impact of Disasters." In 2007 Reinhard Mechler was the online instructor for well-attended training courses in Latin America, India, and the Philippines.

Activities for 2008

RAV plans to continue these activities in 2008 with funding from its EU projects (ADAM, NeWater, SCENES, and CAVES). In addition, RAV staff with RAV associates Fawad Khan in Pakistan and Unmesh Patnaik in India, in collaboration with the Institute for Social and Environmental Transition (ISET) and local partners in Nepal, India, and Pakistan, have started research with the aim of contributing to sustainable reductions of poverty and vulnerability by identifying effective mechanisms for reducing disaster risk, including those likely to emerge under different climate-change scenarios.

Personnel

Scientific Staff

Joanne Bayer (USA), *Program Leader*
Aniello Amendola (Italy)
Stefan Hochrainer (Austria)
Juha Kämäri (Finland)
Mohammad Khan (Pakistan)
Daniel Kull (USA)
Anna Lasut (Poland)
Piotr Magnuszewski (Poland)
Reinhard Mechler (Germany)
Kunihiro Oishi (Japan)
Unmesh Patnaik (India)
Anthony Patt (USA)
Georg Pflug (Austria)
Sergio Saldana Zorrilla (Mexico)
Jan Sendzimir (USA)
Michael Thompson (United Kingdom)

YSSP

Marko Ahteensuu (Finland)
Dietmar Borst (Germany)
Jing Liu (China)
Iwona Markiewicz (Poland)
Elisabeth Meze-Hausken (Austria)
Marta Vicarelli (Italy)

Administrative Support

Celeste Lhombreaud (United Kingdom)
Helene Pankl (Austria)
Jun Watabe (Japan)

Scientific Recognition

Awards

Anthony Patt and Reinhard Mechler were co-recipients of the Nobel Peace Prize, having been contributing authors and reviewers to Working Group II of the IPCC Fourth Assessment Report.

Selected Invited Lectures

- Joanne Linnerooth-Bayer, "Climate change, extreme weather and insurance," *Oxford MBA Capstone Conference*, SAID Business School, Oxford.
- Reinhard Mechler, "Insurance for adaptation," *Workshop on Finance and Investment Flows to Address Climate Change: The Way Forward*, UNFCCC Secretariat, Bonn, 31 October 2007.
- Reinhard Mechler, "Financial and economic consequences of natural disaster risk and development," World Bank Workshop, *Financial Strategies for Disaster Risks,* Santiago de Chile, May 31st, 2007
- Anthony Patt, "Communicating uncertainty as consensus or conflict," presented at *NATO Advanced Studies Institute on Uncertainty in Environmental Modeling*, Vrsar, Croatia, October 2007.
- Anthony Patt, "Reducing vulnerability to climate change and variability," *NCCR Climate Summer School*, Grindelwald, Switzerland, August 2007.

Selected Editorships

- Jan Sendzimir, *Ecology and Society* (guest editor); Environmental Modelling and Software (guest editor).
- Anthony Patt, Global Environmental Change (editorial board; *Regional Environmental Change* (editor); *Climate and Development* (forthcoming; editor).
- Joanne Linnerooth-Bayer, Journal of Risk Research (associate editor); *Risk Analysis* (associate editor); *Journal of Natural Resources Policy Research* (editorial board).
- Georg Pflug, *Computational Management Science* (associate editor); *Mathematical Methods of OR, Computational Optimizations and Application* (associate editor).

World Population Program

Wolfgang Lutz
lutz@iiasa.ac.at

Objectives

The main research objective of the World Population Program (POP), as stated in the Research Plan 2006–2010, is to analyze and forecast the dynamics of global population change in its interactions with changing social, economic, and environmental conditions. Special emphasis is being placed on the modeling of the dynamics of human capital formation, which includes the reconstruction of population data for the period 1970–2000 for 120 countries in terms of age, sex, and levels of educational attainment. Based on the new data it is possible to carry out analyses of the economic, social, and health returns of investments in education. With this research objective, POP continues to function as the world's only group that is primarily dedicated to the scientific analysis of global population dynamics with human capital added as an extension. POP is also conducting pioneering work in the field of modeling future improvements in educational attainment. The Program aims to combine innovative work at the highest scientific standards (publishing in top journals) with relevance to other research programs at IIASA and to the global policy community. To meet these ambitious aspirations, POP utilizes an extensive global network of regional population centers, for which it functions as the scientific node.

Scientific Achievements

Production of the 2007 IIASA probabilistic world population projections

In 2007 POP produced its third update of probabilistic world population projections for 13 world regions. As with the two previous sets of projections, these results were also published in *Nature*. The first-ever global probabilistic population projections were produced in 1996 by POP, published in Lutz (1996) and summarized in *Nature* (Lutz, 1997). In 2001 a new assessment based on newer data and improved methodology was published in *Nature* (Lutz, 2001), which resulted in extremely wide international media coverage. A more detailed description of these projections was published in Lutz (2004). The results of the 2007 projections will be published in *Nature* under the title "The coming acceleration of global population ageing."

These new projections use the same methodology and essentially the same long-term assumptions as the 2001 projections, but the focus now is on the expected speed of population aging rather than population growth. The new projections also reflect the most recent demographic trends up to 2006. Given the great sensitivity of long-term demographic trends to starting conditions and initial trends, this reflection of the most recent empirical trends changes the regional population outlook to some extent. As fertility in China has declined faster and to a lower level than previously assumed, the long-term population

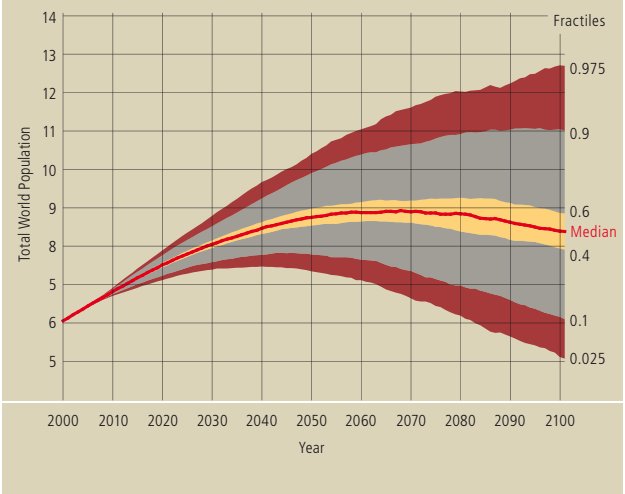

Figure 1. Uncertainty distribution of total world population to 2100, in billions.

of China comes out lower than before and aging occurs more rapidly. In sub-Saharan Africa, on the other hand, fertility declined more slowly than had been assumed, and the decline actually showed a stagnation in some countries which translated into more rapid population growth in that region. On the global level, the higher growth in Africa and the lower growth in China almost compensate for each other, so that our previous estimate of an 88 percent probability of the world population peaking before the end of the century remains virtually unchanged.

The new focus on population aging shows that over the coming decades, the world as a whole, as well as almost all individual world regions,will experience an acceleration in the speed of aging which, after the middle of the century, is likely to be followed by continued aging but at a slower speed. In the West this is a consequence of the strong cohorts of the baby boom passing through the age pyramid, whereas in developing countries, it is a consequence of the fertility declines that many countries experienced around the 1970s. This trend holds for various different indicators of aging. In this context we introduced indicators that not only reflect the traditional age as measured by time since birth, but also the average time remaining until death. Hence, the traditional proportion above the age of 60 is complemented by the proportion of the population that is at an age with an average remaining life expectancy of less than 15 years. These new measures of age are a highly innovative element that follows up on earlier work in this field by Sanderson and Scherbov (2005).

Probabilistic population projections for individual EU member countries

As part of the EU FP6 project, PLUREL, POP in collaboration with the Vienna Institute of Demography produced the first consistent probabilistic population projections for all EU member states. These projections are largely based on the Eurostat projections and convert the high and low Eurostat variants into

probabilistic ranges for future fertility, mortality, and migration trends in all countries. This work has been carried out in close collaboration with Eurostat to ensure that the Eurostat Baseline Scenario coincides with the median of the probabilistic population projections.

Collaboration with Africa

The year 2007 saw intensive collaboration with Africa at different levels. In January the final results of a POP study (in collaboration with the Cairo Demographic Center) on "Future Human Capital in Egypt: Projections at the Level of Governorates" was presented and discussed with government representatives, academics, and the media in Cairo. In February, Wolfgang Lutz spent three weeks in South Africa mainly to strengthen collaboration with researchers at the University of Cape Town on the effects of AIDS on population projections and on the issue of human capital and economic growth. Throughout the year, collaboration with the African Population and Health Research Center in Nairobi continued at various levels. Finally, in December, a study on the returns to education in selected African countries was presented at the African Population Conference in Arusha (Tanzania). Also in December, POP played an active role in the high level EU–Mediterranean Population Forum which focused on North Africa.

Human capital reconstruction

The task of reconstructing the population by age and sex and for levels of educational attainment for 120 countries in the world for the period 1970–2000 using demographic multistate techniques was completed in 2007. The dataset was made publicly available on the IIASA Web site. The method was published in a peer-reviewed journal, and several papers based on these new data have been submitted for publication. As this new database is superior to all previous datasets (including, for example, the often-used Barro and Lee data) in that it gives a complete cross-classification of the four educational attainment categories by age and sex for a large number of countries over three decades, it has been received with great interest, particularly among economists.

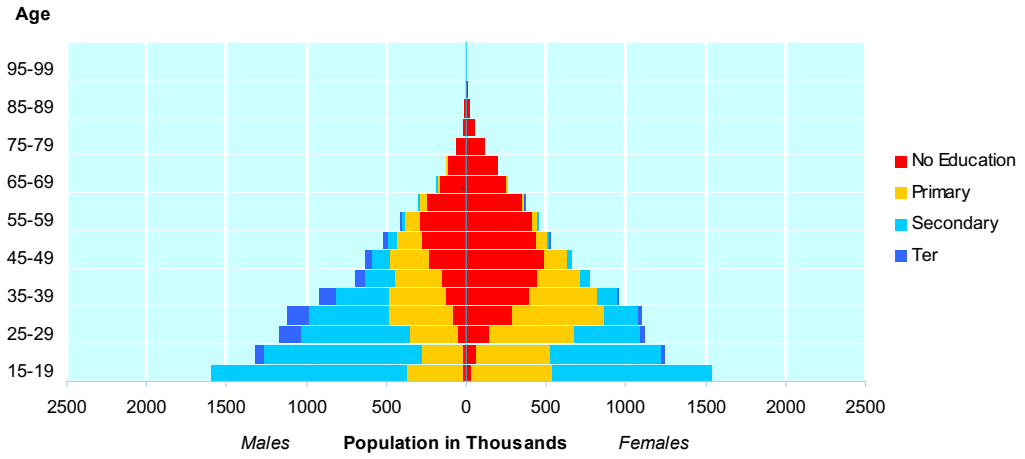

Figure 2a. Republic of Korea - Population by Age, Sex and Educational Attainment in 1970

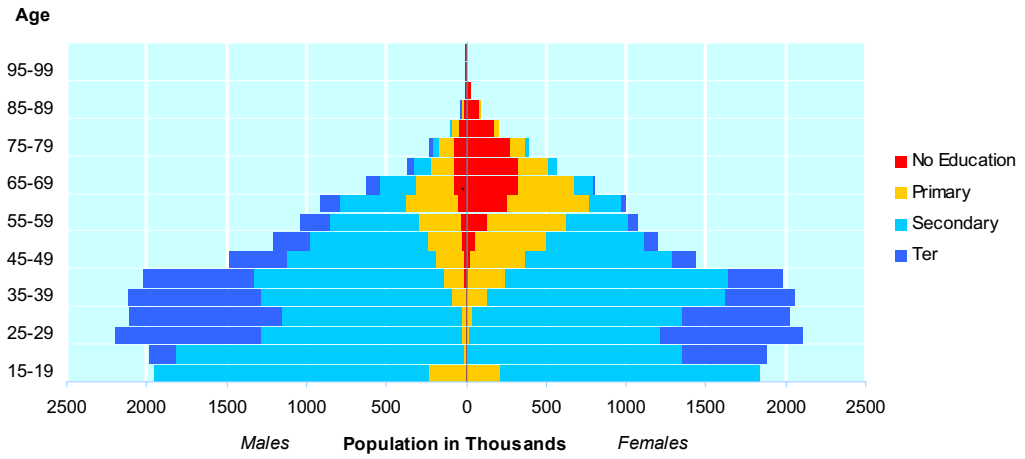

Figure 2b. Republic of Korea - Population by Age, Sex and Educational Attainment in 2000

Fertility by eduation and social status

Vegard Skirbekk assembled and published the most comprehensive database to date on differential fertility by level of education or other indicators of social stratification. It aimed to include all publicly available empirical data on these issues from around the world for all times. It is expected to become an important source for analyses in this field, which is essential for a better understanding of population–development interactions.

Human capital and economic growth

Late in 2006 a new project on "Human Capital and Economic Growth" was established under the umbrella of the World Population Program. The main task of the project, under the leadership of Jesus Crespo Cuaresma, was to reestimate major economic growth models using the new data. It was felt that IIASA should capitalize on the great potential of this new data and not leave it to other groups to derive important new findings while using IIASA's data. The year 2007 was very productive in this field and even resulted in the acceptance of a paper to be published as a Policy Forum in *Science* on "The demography of educational attainment and economic growth." The study finds that the current Millennium Development Goal of universal primary education is not sufficient and should be complemented by the goal of secondary education over broad segments of the population. This is necessary for the desired development push that would bring countries out of poverty. In the industrialized countries, tertiary education for the younger adult population turns out to be of utmost importance.

Activities for 2008

In 2008 POP will continue to pursue the research agenda as described in the Research Plan 2006–2010. Special emphasis will be given to disseminating our exciting results on human capital and economic growth. In addition we will explore new methods in the field of small area population projections.

References

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Sanderson W and Scherbov S, 2005. Average remaining lifetimes can increase as human populations age. *Nature*, 435, pp.811–813.

Scientific Recognition

Selected Invited Lectures

Wolfgang Lutz

In 2007, Wolfgang Lutz gave 31 lectures in 20 different countries.

- Lecture on "The dynamics of education, health and economic growth in a global perspective" at the Economic Research Institute (ETLA), Helsinki, Finland, 12 January.
- Public lecture on "How education affects future health and development in Africa" at the University of Cape Town Main Lecture Hall, Cape Town, South Africa, 16 February.
- Lecture on "The future of human reproduction: Biological, social and economic factors shaping an uncertain future course" at the University of Oxford, Oxford, UK, 11 May.
- Lecture on "Global population trends in the 21st century and the role of education and health for development" at the Annual Meeting of Scottish and Northumbrian Academic Statisticians, Edinburgh, UK, 25 May.
- Lecture on "Long term consequences of very low fertility in some European countries" at the Policy Dialogue Forum, James Martin Institute for 21st Century Studies, Oxford, UK, 28 June.
- Plenary panel address on "The consequences of living longer and healthier lives" at the 3rd World Ageing and Generations Congress, World Demographic Association, St. Gallen, Switzerland, 9 September.

Wolfgang Lutz and Sergei Scherbov

- Opening keynote speech on "Future aging in Southeast Asia: Demographic trends, human capital and health status" at the Conference on Financing Issues for an Ageing Society in Southeast Asia, Institute of Southeast Asian Studies, Singapore, 3 September.

Sergei Scherbov

- Keynote lecture on "Demographic outlook" at the Round Table on Perspectives of Demographic Policy Implementation in the Republic of Belarus, Parliament of Belarus, Minsk, Belarus, 7 February.
- Lecture on "A new way of looking at population ageing" at the European Congress on Gerontology, St. Petersburg, Russia, 4 July.
- Lecture on "Probabilistic household projections for Russia" at the International Conference on Family Policy, Moscow, Russia, 28 November.

Vegard Skirbekk

- Lecture on "Fertility during tertiary education" at a public hearing held by the Committee on Women's Rights and Gender Equality of the European Parliament, Brussels, Belgium, 27 February.

Anne Goujon

- Lecture on "Women's level of educational attainment in North Africa, 1970–2050" at the Mediterranean Population Forum on Demographic Transitions, Inequalities and Development, Barcelona, Spain, 10 December.

Samir K.C.

- Lecture on "Future returns to education in Ethiopia, Kenya and Nigeria" at the 5th African Population Conference: Emerging Issues on Population and Development in Africa, Arusha, Tanzania, 10 December.

Personnel

Scientific Staff

Wolfgang Lutz (Austria), *Program Leader*
Jesus Crespo Cuaresma (Spain)
Victor Garcia Guerrero (Mexico)
Anne Goujon (France)
Samir K.C. (Nepal)
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Warren Sanderson (USA)
Serguei Scherbov (Netherlands)
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Administrative Support

Marilyn Brandl (USA)

Part III

Energy and Technology

Dynamic Systems Program

Arkady Kryazhimskiy
kryazhim@iiasa.ac.at

Objectives

The Dynamic Systems (DYN) Program develops methods for assessment and control of large-scale dynamical systems in the economy and environment and applies these methods to IIASA's research into global change. In 2007 DYN also developed two Institute-wide initiatives involving both IIASA researchers and external experts and suggesting strong methodological agendas: *Driving Forces of Economic Growth*[1] and *The Fragility of Critical Infrastructures*[2].

Scientific Achievements and Policy Impacts in 2007

Methodology Development Area: *Methods of Dynamic Optimization in Management Sciences Project***.** The question "How to bring a dynamical system to its optimal path?" arises in numerous applied studies. One of the greatest challenges comes from the economy. The extended report by Sergey Aseev and Arkady Kryazhimskiy[3] summarizes DYN's recent achievements in linking the endogenous economic growth theory and mathematical theory of optimal control. Large-scale processes of economic growth have no definite time horizons. Their mathematical analogs have, accordingly, infinite time horizons. This natural mathematical idealization leads to a strong uncertainty in the analytic characterization of the desired optimal paths. More specifically, the so-called adjoint variables, also known as "shadow prices," may exhibit highly irregular behavior as time grows to infinity. The DYN researchers suggested a novel finite-horizon approximation approach that allowed them to eliminate the "irregularity at infinity" and to characterize, in result, the optimal paths for a broad class of models of the economic growth processes. Next, this theory was used to explore key features of optimal growth of a technological follower, a country that absorbs, in its technology sector, part of the knowledge produced by an autarkic technological leader. *Figure 1* illustrates one of the principal results of this study.

Technology Development Area: *Optimal Control of Technological Innovation Project***.** The control-theoretic framework that resulted from the above methodological studies was employed in a new phase of research on optimal growth of the economies described by non-classical linear-exponential production functions. In 2007 the basic technological growth model developed in 2006 was analyzed under the additional assumption that the fraction of the economy's GDP, which is annually invested in consumption, never falls below a prescribed non-zero minimum value. This constraint aims to better reflect investment practice. The simulated optimal technological growth trajectories agreed with the time series for Japan. Through model calibration, the minimum value for Japan's fractional investment in consumption was estimated.

Technology Development Area: *Competing Innovators—Models of Equilibrium Behavior Project*. In 2007 DYN researches continued to study mathematical models of repeated interactions between technological innovators. The models assume that new technological products appear repeatedly, infinitely many times, at random points in time. Two types of innovators are considered: leaders and followers. The leaders develop new technologies to produce new products, and the followers assimilate the leaders' technologies and use these to produce the blueprints. This classification gives rise to the leader–follower and leader–leader innovation processes treated

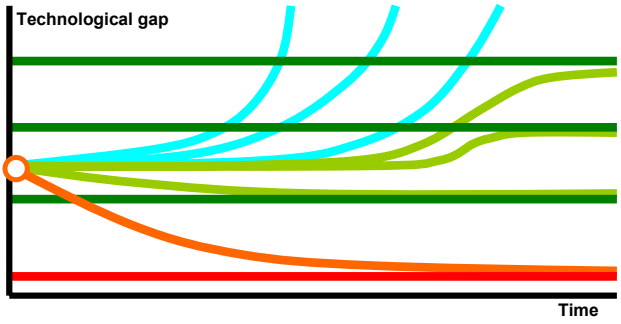

Figure 1: The results of a sensitivity analysis of the optimal long-term development of the technological gap—the ratio of the follower's and leader's accumulated technology stocks—in the case where the size of the educated labor in the follower country is considerably higher than in the leader country. The curves show the optimal trajectories for the technological gap and the horizontal lines show their limit values. The light blue curves correspond to the follower's "forward-looking" labor allocation policy (the discount coefficient in the follower's integrated consumption index is low); the technological ratio goes to infinity; the follower overtakes the leader. The light green curves correspond to the follower's "rational" labor allocation policy (the follower has a medium-size discount coefficient); the technological ratio tends to a reasonably high limit value; the follower catches up the leader. The orange curve corresponds to the follower's "myopic" labor allocation policy (the follower's discount coefficient is high); the technological ratio nearly vanishes in the end; the follower stays far behind the leader. Thus, as the follower's labor allocation policy varies from "forward-looking" to "rationality" and finally to "lack of foresight," the follower's technological development, in relation to the leader's, passes through three radically different phases: overtaking—catching up—losing.

1 http://www.iiasa.ac.at/Research/ECG/index.html?sb=9
2 http://www.iiasa.ac.at/Research/FCI/index.html?sb=8
3 S.M. Aseev and A.V. Kryazhimskiy, The Pontryagin maximum principle and optimal economic growth problems, Proceedings of the Steklov Institute of Mathematics, 257 (2007), 1-255; http://www.iiasa.ac.at/Admin/INF/recent-pubs/dyn/pont.html

as dynamic games, in which the innovators' R&D investment policies act as the players' strategies (understood as in game theory). The analysis, carried out in 2007, led to the understanding of a strong difference between the two innovation games: the leader–follower game suggests a mutually acceptable mode of behavior—an equilibrium collection of strategies, whereas the leader–leader game may have no equilibrium and may thus never lead to a resolution of the conflict.

Technology Development Area: *Building Efficient Technological Portfolios for Electricity Generation*. Returns from the use a new technology are contingent on various factors of risk. The implementation of a portfolio of technologies, within a given branch of industry, can diversify and reduce risk. The new Transition to new Technologies (TNT)/DYN project launched as part of the 2007 Young Scientists Summer Program (YSSP) aims to apply methods of the modern portfolio theory to assessing sets of technologies. In 2007 a model of electricity generation technological portfolios was developed. The model suggests efficient portfolio structures that take into account three types of risk, associated with three types of uncertainty: uncertainty in technology costs, uncertainty in energy prices, and uncertainty in carbon prices. The model was tested using data from the MESSAGE scenarios.

Environmental Dynamics Area: *Negative Learning and Value of Information*. This exploratory Population and Climate Change (PCC)/DYN YSSP-based methodological project focused on the widespread phenomenon of negative learning, implying that a new piece of information may guide the observer away from an understanding of the real situation. For a stylized climate-economy model, the cases were described, in which the probability of negative learning tends to one (alternatively, tends to a value of less than one) as the number of observation points goes to infinity. Situations in which negative learning is equivalent to receiving a negative value of information were also examined.

Environmental Dynamics Area: *Methods for Coastal Area Management Project*. This project is motivated by the issue of harmonizing feedback between the food industry and the environment. Research focuses on the development of bivalve shellfish agriculture, which is a rapidly growing resource sector nowadays. In 2007 DYN continued analysis of an offshore bivalve shellfish farm model. The focus was on the impact of the spatial distribution of rearing density on the water quality within the licensed area. The methodology was based on the mathematical theory of control of distributed systems, and the rearing density was treated as a distributed control. It was shown how the farm can redistribute the rearing density so as to simultaneously increase its carrying capacity and reduce its negative impact on the water quality.

Environmental Dynamics Area: *Analysis of Moment-Based Models of Spatial Distribution of Species*. A joint Evolution and Ecology Program (EEP)/DYN group analyzed a moment-based model of a one-dimensional spatial distribution of a single-specie community. Conditions necessary for the existence of the distribution in question were suggested, and cases in which this distribution is unique were described. A numerical method for finding the distribution was proposed and tested.

Economic Growth Area: *Optimal Management of Economies under Effect of Random Natural Hazards Project*. This new Forestry (FOR)/DYN project proposes an approach to optimizing investment in a global earth observation system aimed at lowering economic losses from future natural disasters. The analysis is based on an explicit characterization of the optimal management strategy for an economy affected by random natural hazards over the period subsequent to the implementation of the observation system. It was shown that the propensity to invest increases with the economy's affluence and degree of vulnerability to natural disasters. The case of two economies was analyzed using a game-theoretic framework. The equilibrium investment solutions obtained demonstrate that equally developed economies tend to cooperate, whereas a strong gap in economic development leads to free riding.

Economic Growth Area: *Optimal Economic Development in Relation to Pollution and Population Project*. This study addressed the issue of a trade-off between consumption and population growth. Increasing consumption calls for production growth, which may, in turn, lead to the raising of environmental mortality and, finally, to the lowering of population growth. Can it then be optimal for an economy to end up with negative population growth?(Can the economy sacrifice demographic sustainability in favor of consumption?) A stylized economic growth model analyzed using a DYN-elaborated control-theoretic technique gave a preliminary answer to this question (see *Figure 2*).

Economic Growth Area: *Analysis of Optimal Economic Development in Relation to Greenhouse Gas (GHG) Emissions*. This new GGI/DYN project focused on the design and analysis of a new simplified stochastic DICE-type model of global economic development in relation to GHG emissions. The model assumes that growth in the accumulated GHG emissions raises economic losses from random environmental shocks. The optimal investment policy was characterized using the mathematical control theory.

Economic Growth Area: *Accounting for Household Heterogeneity in Economic Growth Models Project*. This new PCC/DYN project aims at understanding key features of the equilibrium development of a group of different interacting economic agents. The case of multisector production with a common discount factor was studied. The uniqueness of the equilibrium regime was stated. It was shown that even in the one-sector production model, investment is contingent on both the production and consumption sides.

The Fragility of Critical Infrastructures Project. This new DYN-initiated project is expected to develop into an Institute-wide activity. The key motivation is that the existence of modern societies relies critically upon the timely and reliable delivery of numerous goods and services. These processes rely on infrastructures that are extremely complex and fragile. The project aims at understanding key approaches to the design and management of infrastructures in the face of various types of uncertainty and disruptions. In 2007 DYN undertook two research efforts to support the project. The first focused on natural prototypes of human-made infrastructures—the ecological networks. Adopting the premise that energy flow is a primary organizing principle in ecological systems, the DYN researchers

explored an ecological goal function based on the net energy flow between system compartments. It was shown that simple networks exhibit relations that are fixed for that particular structure, whereas for more complex cases the system may be classified into utility regimes depending on the energy flow values in the system. A network structure, for which the most probable regime has the highest utility value, was described, and candidate structural configurations having the least and greatest utility values were presented. The second research effort focused on the exploration of an approach to evaluating an infrastructure's nodes, drawing upon the theory of probabilistic evidence-based reasoning and its application to assessing the state of a natural gas infrastructure, as well as the alternatives for its further development.

Activities for 2008

In the methodology development area, DYN will develop the theory of infinite-horizon optimal control, game-theoretic approaches and optimization techniques for random processes, and will extend the spectrum of applications, with emphasis on economic growth and critical infrastructures.

In the technology development area, DYN will finalize the study of the innovators' game in both leader–follower and leader–leader settings, and will expand the ecological network analysis into application to technology datasets.

In the environmental dynamics area, DYN will continue studies of coastal area management through raising the complexity of the underlying model, and will extend the contribution to the EEP/DYN project on models of spatial distribution of species.

In 2008 DYN expects to set up a new research project with the World Population Program (POP) in the area of social mood and collective social events.

In the economic growth area, DYN will continue the study of: optimal management of economies under effect of random natural hazards (jointly with FOR); optimal economic development in relation to pollution and population; and accounting for household heterogeneity in economic growth models (jointly with PCC). DYN will also explore possibilities for 1) extending the joint GGI/DYN project on analysis of optimal economic development in relation to GHG emissions and 2) setting up new cross-program projects in the area of economic growth in the context of the environment.

In 2008 DYN will continue developing The Fragility of Critical Infrastructures (FCI) initiative.

This will include preparation of a proposal to the IIASA Council in May for formalizing the initiative as an IIASA Special Project, leading to the development of a full-scale proposal for a Research Program on Critical Infrastructures in the next five-year IIASA research plan. In addition, the DYN group together with other interested IIASA scientists plan to form an FCI-related Business Consortium of firms interested in critical infrastructures. The activities of this Consortium will include special programs for Consortium members, joint work with researchers by the firms, distribution of IIASA publications to the members, and networking between IIASA researchers and Consortium members. DYN will extend FCI-oriented research on ecological networks and assessment of critical infrastructures.

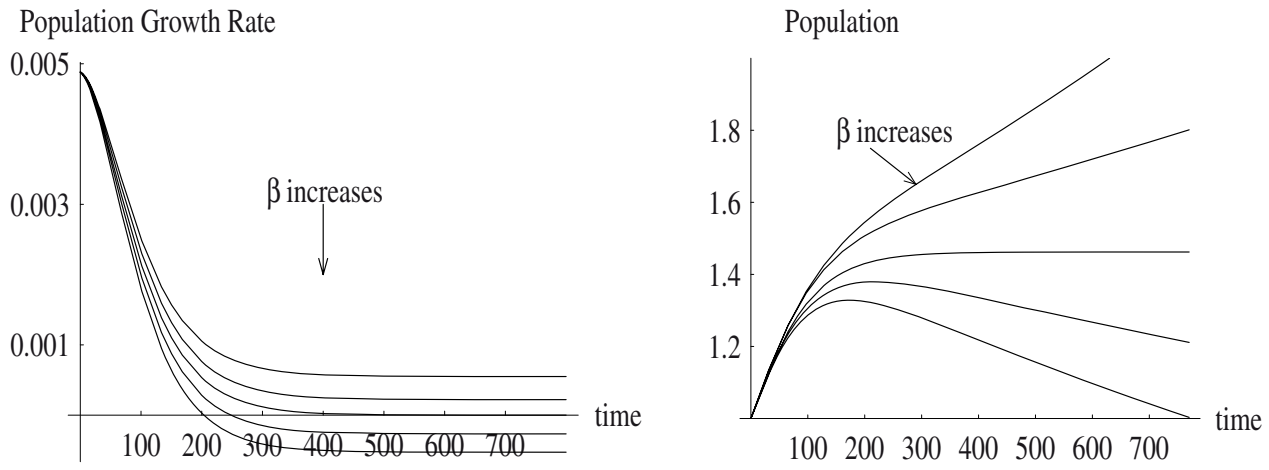

Figure 2: Allowable European future population growth rate senarios simulated using a stylized optimal economic growth model capturing a trade-off between consumption and population growth. The horizontal axis shows the time increment in years. The optimal scenarios are found using the mathematical theory of optimal control. The different scenarios correspond to different values of a parameter characterizing the strength of the negative impact of industrial growth on the population growth rate. It is interesting that the scenario that ends up at the zero level (the central scenario in the bundle) corresponds to a benchmark value for ß , which is identified using European air pollution data.

Scientific Recognition

Sergey Aseev

Selected invited lectures

- *A dynamic model of optimal capital accumulation for an enterprise*. IIASA–Tokyotech Workshop on Hybrid Management of Technology in the 21st Century, IIASA, 8–9 September 2007 (coauthored with Arkady Kryazhimskiy).
- *Optimal labor allocation policy for technological followers*. IIASA–Tokyotech Workshop on Hybrid Management of Technology in the 21st Century, IIASA, 8–9 September 2007 (coauthored with Arkady Kryazhimskiy).
- *On optimal labor allocation policy for technological followers*. Viennese Vintage Workshop on Structured Models in Population and Economic Dynamics, Vienna, 26–27 November 2007 (coauthored with Arkady Kryazhimskiy).

Editorships, memberships

- Deputy Editor-in-Chief, Proceedings of the Steklov Mathematical Institute.
- IFAC Technical Committee 2.4 "Optimal Control" (TC 2.4)

John Casti

Selected invited lectures

- *Social mood and globalization*. Global Futures Forum Conference I, Zurich, 16 January 2007.
- *Agent-based modeling in agriculture*. Agricultural Research Center, Hamilton, New Zealand, 25 January 2007.
- *Complex systems*. Lecture series. Harbin Institute of Technology, Harbin, China, 29 January–2 February 2007.
- *The decline and fall of globalization*. Finnish Futures Forum, Workshop on the Future of Globalization, Helsinki, 10 April 2007.
- *BizSim: Agent-based modeling for business*. Toyota Workshop on Agent-Based Modeling, Baden, Austria, 25 September 2007.
- *Complex systems and simulation*. CSI Piemonte Days, Torino, Italy, 22 November 2007.

Editorships

- Editor-in-Chief, *Applied Mathematics and Computation*.

Alexey Davydov

Selected invited lectures

- *Controllability: Its stability and bifurcations*. Workshop on Control, Optimization and Stability of Non-linear Systems: Geometric and Analytic Methods, SISSA/ISAS, Trieste, Italy, May 30-June 1, 2007.
- *Soft loss of stability in an ocean circulation box-model*. Centro de Matematica da Universidade do Porto, General Seminar, 2 February 2007.
- *Limit cycle bifurcation in thermohaline convection box-model*. International Conference "Analysis and Singularities," Moscow, Russia, 20–24 August 2007 (coauthored with Nikolai Melnikov).

Editorships

- Editorial Board, *Journal of Dynamical and Control Systems*.
- Coeditor, Abstracts Volume, International Conference on Analysis and Singularities, Moscow, Russia, 20–24August 2007.
- Coeditor, Abstracts Volume, International Conference on Mathematical Control Theory and Mechanics, Suzdal, Russia, 22–27 June 2007.

Brian Fath

Selected invited lectures

- *Cyclic energy pathways in ecological food webs*. European Conference on Ecological Modelling, Trieste, Italy, 27–30 November 2007.
- *Marine ecological modelling and assessment of the Baltic Sea region*. Symposium on Socio-environmental Modelling of Baltic Sea, Uppsala, Sweden, 10 November 2007.
- *Complex ecological networks: structural and functional regimes*. Center for Complexity Research, University of Vermont, Burlington, Vermont, 29 October 2007.
- *Ecological network analysis: Measuring cycling and indirect mutualism*. Environmental Science Department, University of Maryland, College Park, Maryland, 7 September 2007.
- *Identifying ecological-economic relations using network analysis*. EcoSummit, Beijing, China, 25 May 2007.

Editorships, memberships

- President, North American Chapter of International Society for Ecological Modelling
- Associate Editor-in-Chief, Elsevier, Encyclopedia of Ecology.

- Associate Editor, *Ecological Modelling Journal*.
- Editorial Board, *The Scientific World Journal*.
- Editorial Board, *International Journal of Ecodynamics*.
- Board of Directors, International Environmental Modelling and Software Society.
- Baltimore County Commission on Environmental Quality (CEQ).
- International Scientific Advisory Committee, The Sustainable City Conference, Skiathos, Greece, 24–26 September 2008.
- Scientific Advisory Committee, 6th European Conference on Ecological Modelling, Trieste, Italy, 27–30 November 2007.
- International Scientific Advisory Committee, 6th International Conference on Ecosystems and Sustainable Development, Coimbra, Portugal, 5–7 September 2007.

Andrey Krasovskii

Selected invited lectures

- *Optimization of investment dynamics in economic growth modeling*. International Workshop on Dynamics and Control, Zvenigorod, Russia, 25–27 May 2007 (coauthored with Alexander Tarasyev).
- *Optimal control design in models of economic growth.* The 7th International EUROGEN Conference, Evolutionary and Deterministic Methods for Design, Optimization and Control with Applications to Industrial and Societal Problems, Jyväskylä, Finland, 13 June 2007 (coauthored with Arkady Kryazhimskiy and Alexander Tarasyev).
- *Dynamics of investments to efficiency factors in the growth model with the LINEX production function*. IIASA–Tokyotech Workshop on Hybrid Management of Technology in the 21st Century, IIASA, 8–9 September 2007.

Arkady Kryazhimskiy

Selected invited lectures

- *Optimal paths for technological followers*. UNIDO, 13 June 2007.
- *On optimal labor allocation policy for technological followers*. Viennese Vintage Workshop on Structured Models in Population and Economic Dynamics, Vienna, 26–27 November 2007 (coauthored with Sergey Aseev).

Editorships, memberships

- Editorial Board, *Journal of Computational Mathematics and Mathematical Physics*.
- Editorial Board, *International Journal of Applied Mathematics and Computer Science*.
- Editorial Board, *International Game Theory Review*.
- Program Committee, International Conference "Differential Equations and Topology" dedicated to the 100 Annivesary of L.S.Pontryagin, Moscow, 17–22 June 2008.
- Russian Academy of Sciences.

Yaroslav Minullin

Selected invited lectures

- *Energy cooperation in the Caspian Region: Current status and challenges*. CASPILOG-II Baku, Azerbaijan, 7–9 May 2007.
- *Energy security cooperation in APR: China gas market and a dialogue between producers and consumers*. Workshop on Energy Security Cooperation in the Asia Pacific, Japan's Institute for International Affairs, Tokyo, Japan, 17–19 April 2007.

Nikolai Melnikov (PCC/DYN)

Selected invited lectures

- Instability mechanisms of thermohaline circulation box models. Lecture series on dynamical systems and differential equations, Department of Mathematics and Statistics, Georgia State University, Atlanta, USA, May–June, 2007.
- Limit cycle bifurcation in thermohaline convection box-model. International Conference, Analysis and Singularities, Moscow, Russia, 20–24August 2007 (coauthored with Alexey Davydov).

Tapio Palokangas

Selected invited lectures

- *Competition and product cycles with non-diversifiable risk*. IIASA Seminars on Economic Growth, IIASA, 24 July 2007.
- *Immaterial property rights, product cycles and non-diversifiable risk*. IIASA Seminars on Economic Growth, IIASA, 25 July 2007.

Editorships

- Coeditor, Stochastic Economic Dynamics, CBS Press, 2007.
- Associate Editor, *European Economic Review*.
- Associate Editor, *E-Economics*.

Elena Rovenskaya

Selected invited lectures

- *Integrated socio-environmental assessment model for the Baltic region*. The 7th International EUROGEN Conference, Evolutionary and Deterministic Methods for Design, Optimization and Control with Applications to Industrial and Societal Problems, Jyväskylä, Finland, 13 June 2007.
- *Air pollution mortality and sustainable economic development: an approach to integrate environmental impact on population*. Symposium on Socio-environmental Modelling of Baltic Sea, Uppsala, Sweden, 10 November 2007.

Alexander Tarasyev

Selected invited lectures

- *Optimization of investment dynamics in economic growth modeling*. International Workshop on Dynamics and Control, Zvenigorod, Russia, 25–27 May 2007 (coauthored with Andrey Krasovskii).
- *The impact of investment restrictions on growth dynamics*. IIASA–Tokyotech Workshop on Hybrid Management of Technology in the 21st Century, IIASA, 8–9 September 2007.
- *Optimal control design in models of economic growth*. The 7th International EUROGEN Conference, Evolutionary and Deterministic Methods for Design, Optimization and Control with Applications to Industrial and Societal Problems, Jyväskylä, Finland, 13 June 2007 (coauthored with Andrey Krasovskii and Arkady Kryazhimskiy).

Editorships, memberships

- Guest Editor of a Special Volume, *Applied Mathematics and Computation*.
- IFAC Technical Committee 2.1 "Control Design" (TC 2.1) http://icat2.snu.ac.kr/ifac-tc/members.html?tc_id=201

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Alexander Tarasiev (Russia)

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Valentin Nikonov (Russia)
Simon-Erik Ollus (Finland)
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Transition to New Technologies Program

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Objectives

The objective of the Transitions to New Technologies (TNT) Program is to analyze the patterns and drivers of technological change across sectors, over time, and across space. In terms of systems hierarchy, technological change arises from the spatial and temporal diffusion of individual innovations all the way up to the emergence of new technological combinations that could lead to fundamentally new human activities. TNT's research aims at an improved understanding and modeling of technological change with an emphasis on the treatment of technological uncertainties as well as assessments of the potential economic and societal impacts that could result from pervasive diffusion and adoption of new technologies. The research focuses particularly on new communication, information, mobility, and energy and climate-friendly technologies. Research is based on a blend of both basic research, including conceptual as well as theoretical modeling work inspired by empirical case studies, and applied research informing technology policy choices through sectoral case studies, uncertainty and scenario robustness analysis, and inputs to major international assessments.

Scientific Achievements/Projects in 2007

The cyclical nature of research is always characterized by interlaced periods of planning, research work, and publication/dissemination. The year 2007 was particularly one of scientific *harvest*, in terms of both dissemination through the final publication of altogether four major international, collaborative scientific assessments, and wide international recognition.

First and foremost, 2007 saw the final publication of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). Three TNT staff members (Arnulf Grübler, Nebojsa Nakicenovic, and Keywan Riahi) served as Convening Lead and Lead Authors with TNT staff member Peter Kolp serving as Reviewer. TNT's contribution to the IPCC AR4 not only reflects both the Program's research focus but also synthesizes the findings of its multi-year research efforts.

Nebojsa Nakicenovic served as convening Lead Author and Keywan Riahi as Lead Author of Chapter 3 of Working Group III on *Issues Related to Mitigation in a Long-term Context*. The chapter included a comprehensive review of technological change scenarios as well as a detailed assessment of their impacts in terms of greenhouse gas emissions. Peter Kolp developed a comprehensive scenario database that helped in the scenario assessment both in this chapter and within other IPCC writing teams. Arnulf Grübler served as Lead Author in Chapter 2 of Working Group III on *Framing Issues*, which contains a comprehensive section on technology that reviews our current understanding of the drivers of technological change as well as of technology policy and inducement instruments. Finally, Keywan Riahi also served as Lead Author for the IPCC AR4 *Synthesis Report* that was approved at the IPCC Plenary in Valencia, Spain, on 17 November 2007 and will be available in printed form early 2008. Work within the IPCC will continue, in particular under the auspices of the newly formed IPCC Scenario Consortium (see the ENE Progress Report).

The exceptional commitment of TNT staff members who contributed to the IPCC also explains the delight with which Program members received the news that the 2007 Peace Nobel price had been awarded to the IPCC jointly with Al Gore "*for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change*." As such, the Prize represents an important recognition of the scientific work of the IPCC, as well explicitly recognizing for the first time the contribution science that science can make to a more peaceful world (Figure 1).

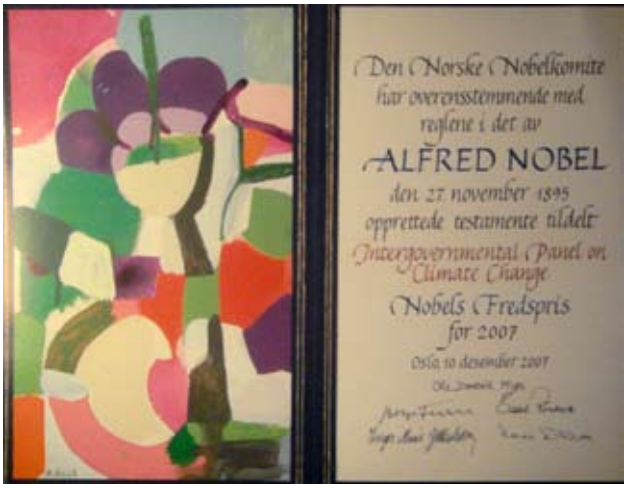

Figure 1: Nobel Peace Prize 2007 for IPCC

Next to the IPCC AR4, the results of three additional major collaborative projects were also published in 2007: the UN Foundation/Sigma Xi report, *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*, the InterAcademy Council report, *Lighting the Way: Toward a Sustainable Energy Future* (with Nebojsa Nakicenovic as co-author), as well as the IIASA-GGI integrated assessment/scenario study that appeared in print as a special issue of *Technological Forecasting and Social Change* (74[7], September 2007) with articles (co-)authored by Nakicenovic, Grübler, Riahi, and Kolp among other IIASA colleagues in this exemplary interdisciplinary and collaborative study across IIASA Programs.

It is finally also worth mentioning that two TNT staff members (Nakicenovic and Grübler) presented papers and talks at the highly successful conference commemorating IIASA's 35th anniversary *Global Development: Science and Policies for the Future* held at the Vienna Hofburg 14–15 November, 2007. TNT

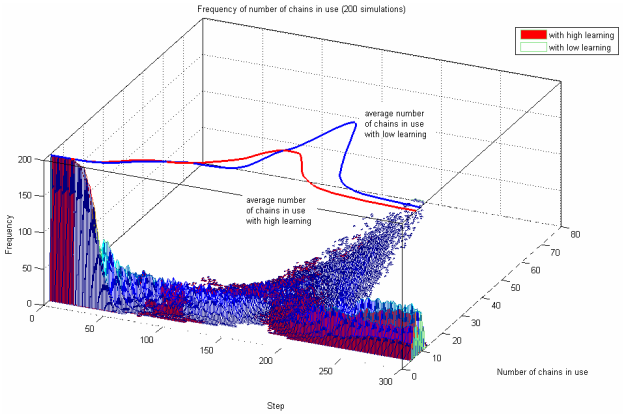

Figure 2: Evolution of technological complexity (number of resource processing chains in use) from a sample of 200 simulations and sample mean under scenarios of high and low increasing returns to adoption. Note in particular the lower degree of complexity in the high learning case (red sample and mean).

was in fact the only IIASA Program that received the distinction of having two speakers at this important IIASA event.

Modeling Technological Complexity

The three TNT core research topics comprise the following areas: *technology policy and inducement instruments; technology for development and climate protection*; and *methodology and modeling*. Whereas the focus in the first two research areas was on the completion and dissemination of the major international assessment reports highlighted above, in-house research focused heavily on a new generation of an *agent-based model of the evolution of technological complexity*. An initial model emulating a stylized energy system was substantially revised/improved during 2007 by Tieju Ma with contributions from Brian Arthur, Arnulf Grübler, and Nebojsa Nakicenovic. With the new model, hundreds of simulations were performed and the resulting alternative technology "histories" generated were sampled statistically (*Figure 2)*. The simulations invariably confirm a nonlinear process of technological complexification. It is interesting to note that under presence of increasing returns to adoption there is, in fact less complexity (i.e., systems lock-in into a few dominant technology combinations; compare the differences in the means and distributions for the "low" and "high learning" case simulations in *Figure 3*). Running the simulations over a very long time (>300 steps, akin to years) also reveals an invariable pattern: with onsetting resource depletion, technological complexity declines substantially, a feature that the late Harrison Brown referred to as "technological denudation." An interesting new result also obtained is that the distribution of the "survival time" of technologies (akin to the Δt in technological diffusion/substitution) indicates that technological combinations, once in existence remain in use for well over a century (*Figure 4*). These results suggest that it might not be possible to accelerate pervasive changes in technology systems unless an explicit policy mechanism of Schumpeterian "gales of creative destruction" can be found.

In addition to this more basic-research-oriented modeling work, there was also noticeable progress in applied modeling and software development, including an update and extension of the popular online *LSM software* package for the analysis of competing technologies as well as in continued maintenance and improvements in the *GGI scenario database* that has become an extremely successful tool for disseminating IIASA's research results with some 70,000 page hits, 28,000 data retrievals, and close to 3,000 data downloads in 2007.

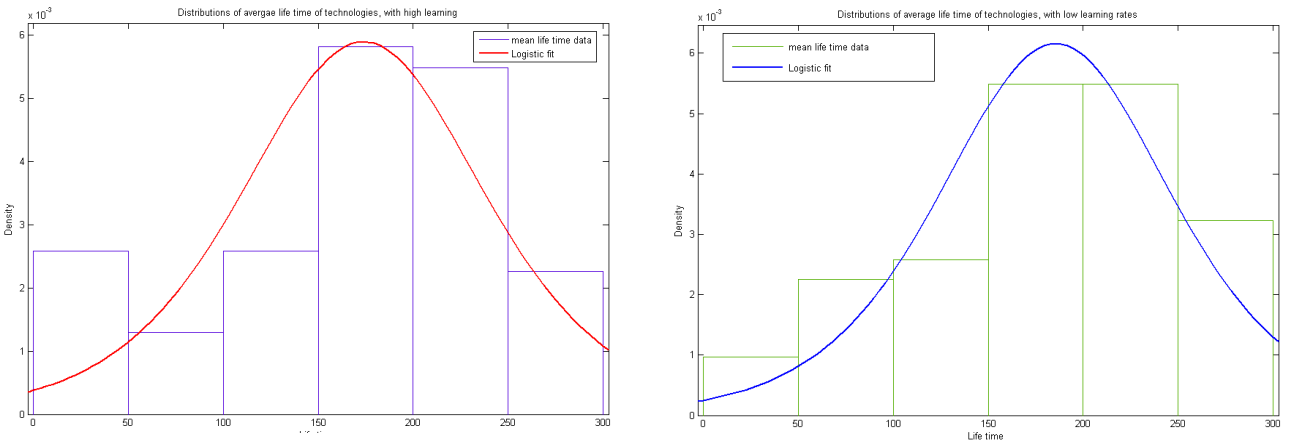

Figure 3: Time in use (survival time) of technologies in a sample of 200 simulations and under high (left) and low (right) learning. Note in particular the dominance of technologies with a lifetime of more than 100 periods (years) indicating extreme longevity and hence barriers for rapid change

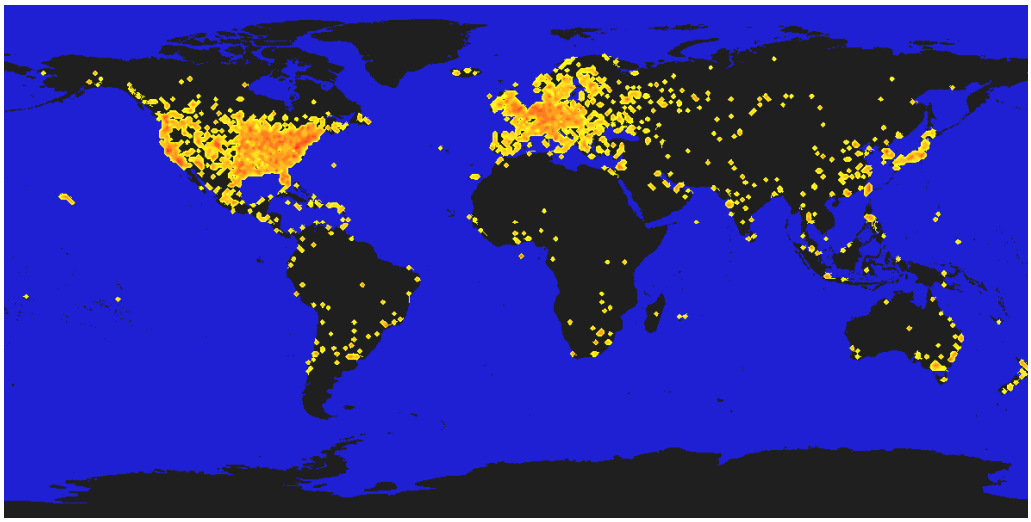

Figure 4: Density of a sample of 564,521 Internet routers. Note in particular the extreme low density in developing countries. From all modern technologies studied, the Internet exhibits the greatest degree of "network exclusion." Raw data courtesy of Mark Crovella, Boston University.

2008 TNT Activities

TNT Research activities in 2008 will primarily focus on three areas:

A workshop on Vulnerability and Opportunities of Methane Hydrates will be convened at IIASA on 13–14 March 2008, co-organized with the Global Carbon Project.

The workshop will review both our current knowledge on the abundance of methane hydrates, their role in past and future climate change and the potential opportunities this vast, exotic resource might ultimately provide for future energy supply. The workshop is a good illustration of TNT's research strategy: assessing technological options that are beyond conventional wisdom with a careful consideration of the potential environmental, economic, and wider systems impacts, should this option become available.

As a contribution to the newly launched Global Energy Assessment (GEA; see also the ENE Progress Report), TNT researchers will coordinate research and assessment work in two main areas: the infrastructural challenges imposed by a rapidly urbanizing world (cities after all are the major hub in the generation and adoption of technological innovations); and the challenges imposed by the multiple demands of sustainable economic, social, and environmental development against a background of declining incentives and resources available to "recharge" the technological innovation chain. A hallmark of both studies will be an attempt to combine macro-level assessments with a detailed "bottom-up" assessment via empirical case studies (analysis of city profiles and of technological innovation case studies) that are anticipated to become a major TNT research output toward 2010.

Finally, the third thrust of TNT research in 2008 will deal with spatial heterogeneity in technology adoption, building on the downscaling work initiated within TNT's contribution to the Greenhouse Gas Initiative (GGI) and ENE (see the ENE Progress Report). The research objective will be to develop methods for mapping the persistent inequitable access to technology services, be it for high quality, clean energy services, or information and communication technologies, that are a prerequisite for crafting strategies and policies for closing the existing energy and digital "divide" (illustrated in *Figure 4* for Internet backbones access points (routers) (i.e., the access ramps of the digital communication highway) across and within nations.

Personnel

Scientific Staff

Nebojsa Nakicenovic (Austria), *Program Leader*
Michinobu Furukawa (Japan)
Arnulf Grübler (Austria)
Tieju Ma (China)
Keywan Riahi (Austria)
Gerald Silverberg (USA)

Postdoctoral Research Scholar

Christopher Doll (United Kingdom)

YSSP

Valentin Nikonov (Russia)
Heekyu Sohn (Korea, Republic of)

Scientific Support

Peter Kolp (Austria)

Administrative Support

Katalin David (Australia)

Energy Program

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Objectives

The central research goal of the Energy Program (ENE) is to provide overarching scientific and strategic analysis to enable a better understanding of the dynamics of future energy transitions, their main driving forces, enabling factors, and consequences for the social, economic, and environmental dimensions of human wellbeing. Decisions made today and in the near future are sowing the seeds that will determine which of the range of alternative energy development paths are followed over the long term, which paths are promoted, and which are hindered. Given the interactions between energy and almost all economic and social activities, it is imperative to better understand the long-term implications of alternative energy policies, related investments, and technological developments now. The activities of the ENE Program in 2007 was geared toward addressing salient challenges confronting the global energy system by pursuing three main areas of research with the objectives to: 1) develop an integrated modeling decision framework with explicit treatment of salient energy-system and policy uncertainties, heterogeneity of agents, and their socioeconomic and behavioral patterns; 2) develop methodologies adapted to bridge alternative time-scales of different energy policies with particular focus on mid-century conditions that would promote the attainability of a wide range of long-term climate goals; 3) facilitate exchange among energy experts and leading businesses, governments, and international organizations, and dissemination of leading-edge technical, policy, and strategic advice, by hosting and coordinating an international Global Energy Assessment (GEA).

Scientific Achievements/Projects in 2007

An important milestone in ENE's research activities in the field of energy modeling in 2007 was the development of a stochastic systems engineering model of the global energy system. The framework builds upon earlier pioneering work at IIASA on stochastic modeling (Gritsevskyi and Nakicenovic, 2000), and is the first model of its type that manages a comprehensive and endogenous representation of salient energy and policy uncertainties within an engineering framework which fully represents the global energy system along all its main energy extraction, conversion, and end-use sectors. The framework is a major step forward in the area of stochastic modeling, as it permits the quantification of risk-hedging strategies that are not only robust vis-à-vis the main expected future trends, but also against the imputed risks of future surprises and uncertainty. The initial scenario analysis in 2007 was geared toward the systematic evaluation of future risks from different types of uncertainties, including fossil fuel and renewable resources, technology costs, energy demand, and the stringency of future greenhouse gas policies. The analysis has helped to identify vital trade-offs and synergies in responding to different types of risks, emphasizing the importance of full cost accounting of all uncertainties jointly for the identification of cost-effective risk-hedging strategies. Another important finding is that already modest insurance premiums of the order of about just one percent of the total energy system costs can significantly reduce the imputed average risk as well as the probability of the occurrence of extreme events. The latter finding is particularly important from the policy perspective, which requires reliable information about the tails of the risk distribution in order that the magnitude of effective hedging investments for reducing the probability of high impact events (*Figure 1*) be better understood. Another important finding for decision makers is that the accounting of future risks has major implications for short- to medium-term decisions. Our analysis shows that risk hedging (compared to the traditional deterministic approaches) translates into higher rates of investments and deployment of advanced technologies, hence leading to the diversification of the technology portfolio as well as emission reductions. It is planned to publish the methodology and results from this initial analysis in the peer-reviewed literature early 2008. In addition, ENE scientists have been invited to give a presentation of the stochastic modeling approach during the forthcoming Uncertainty Workshop of the Stanford University-based Energy Modeling Forum in February 2008.

Important methodological progress in the field of modeling in 2007 also comprises the successful development of a new myopic version of the global MESSAGE model. In contrast to the traditional systems engineering and macroeconomic energy models with perfect foresight, the new myopic model permits

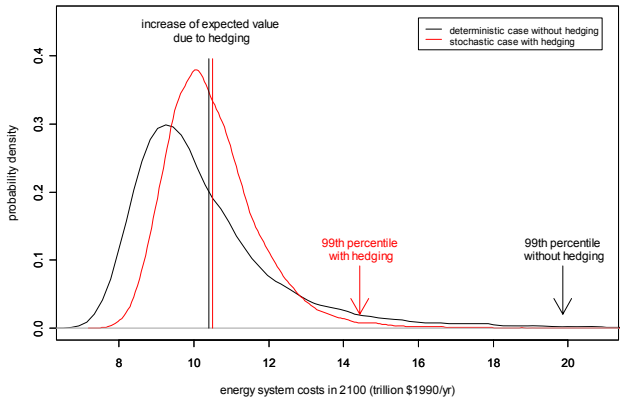

Figure 1. Distribution of energy systems costs without consideration of any uncertainties (deterministic case: black lines) and with additional hedging investments as response to energy-economic and climate policy uncertainties (red lines). The figure illustrates the change of the distribution of future energy systems costs as well as the shift of the expected value (vertical lines). Note the massive reduction of the risk of extreme events (tails of the distribution at the 99th percentile) due to hedging investments of just about one percent above the deterministic case.

analysis of the implications of alternative planning horizons for decision making. The model thus provides a suitable framework for exploring "path-dependency" and "lock-in effects" in the energy system. The framework provides a flexible platform for the explicit assessment of the consequences of short-term decisions for a range of long-term energy objectives. It can thus help to bridge different time-scales, which are an important characteristic of alternative energy objectives (e.g., short-term security of supply concerns versus long-term climate change objectives). The first application of the model focused during 2007 on the exploration of mid-century emission targets and their implication for achieving long-term climate stabilization goals. The assessment is conducted in collaboration with IIASA's Greenhouse Gas Initiative and the Population and Climate Program (PCC) Program. A series of scenario sensitivity analyses for a range of long-term climate stabilization targets were preformed to assess the socioeconomic and technological consequences of "early action" versus "late response." The aim of this research is: 1) to provide a better understanding of the appropriate emission reduction levels and their costs over the medium term; and 2) to identify critical mid-century emissions thresholds, which would prevent the attainability of a wide range of future long-term stabilization targets (*Figure 2*). The scenario results are expected to provide quantitative input into international post-Kyoto negotiations.

A further ENE project, established in 2007, exploring the nexus between energy and climate policies, focuses on the potential environmental co-benefits of greenhouse gas abatement strategies for regional air pollution. Climate policies can provide the necessary impetus for adoption of cleaner fuels and advanced technologies and can thus serve as a vehicle that not only ensures local and regional responses to environmental issues but also lowers the overall costs of emission reductions and ensures long-term benefits. To take advantage of such benefits, it is necessary to develop integrated policy frameworks that fully account for all the potential benefits and costs. A recent collaborative initiative between the ENE Program and the Atmospheric Pollution and Development (APD) Program launched in 2007 looks into these issues more closely and makes an important contribution to bridging the link between short- and long-term policy concerns. The study is comprehensive in nature and covers a range of local pollutants like sulfur dioxide, nitrous oxide, carbon monoxide, carbonaceous aerosols, and volatile organic compounds. In parallel with this research at the global and regional scale, work has started in collaboration with the TNT Program on developing a methodology for spatially explicit pollutant emissions scenarios. This spatial information is needed to position the global Greenhouse Gas Initiative (GGI) scenarios for the planned IPCC Integrated Assessment Activities (see further below). Work completed to date includes a comparison of the GGI scenarios with the EDGAR emission inventory for the base year, as well as the development of separate allocation algorithms for different source categories. First results are expected by February 2008 and the spatially explicit emission scenarios (ß version) should be available by May 2008 for posting on the IIASA Web site.

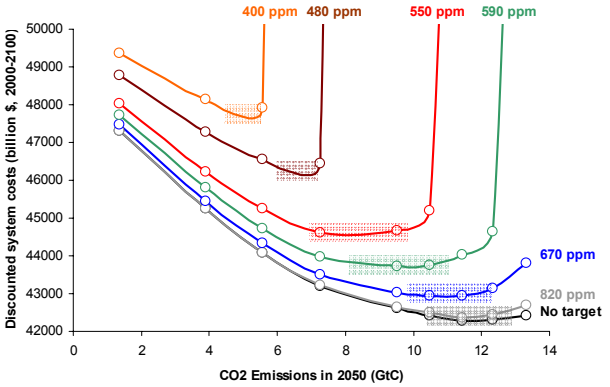

Figure 2. Relationship between long-term costs of stabilization (2000–2100) and short-term targets for emissions by 2050. Horizontal bars denote emissions ranges of CO_2 emissions by 2050 in order to achieve the long-term stabilization targets at least costs. Too stringent or too high interim-targets for emissions bear the risk of increased long-term costs for any of the stabilization targets. Doing too little over the short-term, however, imputes the additional risk that the long-term objective becomes unattainable. For example, emissions targets above about 11 GtC by 2050 exclude the attainability of long-term targets below 550 ppm CO-eq. concentrations.

Besides the aforementioned applied research and major progress on modeling methodologies during 2007, ENE scientists have also continued their active involvement in the Intergovernmental Panel of Climate Change (IPCC). The IPCC decided in early 2006 that it would not be directly involved in the development of new emission scenarios, but rather help in "catalyzing" a process where the scientific community itself would self-organize and coordinate the development of new emission scenarios for the estimation of future climate change and related mitigation, adaptation, impacts, and vulnerability assessments. ENE scientists have, since then, played a central role in the planning and coordination of necessary future activities across the main international climate research communities. A series of workshops were organized in 2007 to identify research needs, discuss the development and design of coordinated community climate change scenarios, and to establish coordinating organizations across the research communities. While the World Climate Research Programme (WCRP) and the International Geosphere–Biosphere Programme (IGBP) are the main coordinating bodies of research activities related to the Earth System and the atmosphere–ocean coupled general circulation model (AOGCM), the Integrated Assessment Modeling (IAM) Community has organized itself through an *IAM Consortium (IAMC)*. The Consortium comprises all main global and regional IAM modeling groups and is co-led by IIASA-ENE, the Stanford-based Energy Modeling Forum (EMF) of the United States, and the National Institute of Environmental Studies (NIES), Japan. After co-organizing the efforts across the scientific communities to establish IAMC, the Energy Program is thus planning to continue to play a critical role in shaping the future research agenda of the IAM work in this area.

Building upon the above-mentioned planning activities, the IAM, Earth system models (ESM), and interannual variability (IAV) research communities met with representatives of the gov-

ernmental and international user communities, including major stakeholders and decision makers at the IPCC Expert Meeting on New Emissions Scenarios in Noordwijkerhout, Netherlands (19–21 September 2007). The meeting established a comprehensive plan for the scenario-related research activities and identified a process that would facilitate efficient interaction among the research communities over the coming years. The summary report of the meeting is under preparation, with two ENE scientists as Lead Authors and one ENE scientist as a Steering Committee member of the responsible IPCC Task Group. The community plan addresses the transfer of information from energy/emissions modeling to climate change modeling groups, and the provision of scenario-based information on climate change and related socioeconomic conditions to groups modeling impacts and response strategies. In particular, the report identifies the small number of four *Representative Concentration Pathways (RCPs)* to serve throughout future research phases as an analytical thread between the integrated assessment, impacts, adaptation, and earth system modeling communities. Because of the comprehensiveness of the IIASA modeling framework and the high quality of the scenarios developed in collaboration with GGI, the ENE-MESSAGE model was selected to provide one of the four RCPs. The RCPs will be used by all major climate models to develop an ensemble of climate projections for both the near term (next few decades) and the long term (next few centuries). The research plan, involving all major research organizations in the climate area, is expected to extend beyond 2010. Results from this integrated research activity is planned to serve as the main quantitative backbone for the IPCC's assessment of mitigation, impacts, and climate change projections for the next (fifth) Assessment Report. This activity is thus a unique opportunity for the ENE Program to play a leading role in the major international climate research initiative of the coming years, and to widely disseminate its scenario work in the policy as well as scientific user communities.

The Global Energy Assessment (GEA) represents a critical complement to and source of value-added for other Energy Programs (ENE) and broader IIASA research activities. By assessing and synthesizing an extensive range of energy research literature, the GEA will identify the state of knowledge and key strategic gaps that need to be addressed to support long-term decision making in energy. The identification of these strategic gaps will assist in guiding the ENE research agenda toward the most critical questions. The GEA will also support energy research more broadly by contributing to a better understanding of the interlinkages across the range of energy-related challenges, namely, development, security, technology investment, and environmental amenity, by identifying areas where the prevalence of competing objectives may necessitate more sophisticated analytical approaches. In addition to supporting research activities directly, the GEA will also provide a forum through which ENE can disseminate policy-relevant research findings and other insights to a receptive and representative audience of key energy stakeholders and decision makers. More broadly, the GEA will facilitate exchange among energy experts and leading businesses, governments, and international organizations, as well as dissemination of leading-edge technical, policy, and strategic advice to redefine the global energy policy agenda.

The GEA was launched in a two-day meeting at IIASA in January 2007 attended by 30 scientists familiar with large assessments and systems analysis. One key outcome of the meeting was the agreement to spend several months consulting with stakeholders regarding what, specifically, they would like to see in the GEA, both in terms of substance and process, such as the nature and timing of written products. One such consultation took place at the 15th Session of the UN Commission on Sustainable Development in May 2007 with the staging of a side- event on the GEA. Based on this and other consultations, the GEA Council Co-Presidents recommended the appointment of 13 additional members to the GEA Council. These appointments were approved by the Director of IIASA, who is an ex officio member of the GEA Council. With this governance structure in place, the GEA Council held its first meeting in July 2007 at IIASA to discuss the financing and substantive orientation of the Assessment and strategies to engage stakeholders. The Council approved the appointments of key officers of the GEA, including the Director and the Executive Committee Co-Chair. With the assent of the Council, the Co-Presidents appointed 11 scientists to the GEA Executive Committee or "ExComm"—the organization charged with conducting the analyses and producing the written products. Immediately following the GEA Council meeting, the ExComm held its first meeting. The Executive Committee discussed the major analytical report that is to be the key output of the GEA, agreeing on the broad outline of a "zero-order draft" that will include the key findings and preliminary conclusions of the Assessment. The ExComm continued the work of developing the zero-order draft throughout 2007, holding monthly teleconferences to coordinate its work. The ExComm is expected to have a zero-order draft by mid-2008 that the GEA officers can share with stakeholders.

In 2007, several organizations provided financial support for the GEA, including the Austrian Development Agency, FORMAS (the Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning), and the UN Foundation. To augment this, the GEA Council Co-Presidents continued fundraising activities in Europe and in North and South America. The GEA officers approached a number of organizations seeking financial support, in addition to those that provided support in 2007, including: the European Commission's Directorate-General for Environment; the World Bank Group's Energy Sector Management Assistance Program (ESMAP); the UN Industrial Development Organization; and Petrobras (Petróleo Brasileiro). At year's end, the United States Congress appropriated US$1,000,000 in the Consolidated Appropriation Act of 2008 "to support the International Institute for Applied Systems Analysis's Global Energy Assessment."

Beyond the research and coordination activities highlighted above, ENE has continued in 2007 a number of strategic collaborations on specific topics. These comprise collaboration with the Tokyo Electric Power Company on distributed hydrogen systems, the Tsinghua University in China on end-use investments, Toyota Inc. on automobile technology strategies for GHG abatement, and the IIASA in-house collaboration with GGI toward further development and testing of an integrated energy-climate model (extension of MESSAGE climate component to aerosols

and long-lived gases). ENE Program members also continued in 2007 to expand their networking activities in the Energy Modeling Forum (EMF) studies. Other networking activities comprised the participation of ENE scientists in a number of international workshops and conferences, among others, on Energy Security at the *Nobel Laureates Symposium*, organized by the Potsdam Institute of Climate Impact Research (8–10 October, Berlin); the *7th Meeting of the Global Forum on Sustainable Energy* (GFSE-7, 1 October, Vienna), and the *IEA World Energy Outlook Meeting on China and India Insights*, organized by the International Energy Agency, Paris, 29 May 2007 (for other presentations of individual ENE Program members see the list below). Networking activities in 2007 were complemented by the organization and coordination of the Methane Hydrates Workshop in collaboration with the Global Carbon Project (GCP), to be held at IIASA in March 2008. Bringing together 25–30 leading experts with different institutional background from various fields (research, exploration companies, stakeholders), the emphasis will be on the review of current knowledge and on major controversies surrounding hydrates both as a potential energy source and as a potential source of catastrophic climate change.

2008 ENE Activities

ENE Research activities in 2008 will primarily focus on three areas:

1) Development and provision of detailed scenario information to the Climate Modeling Community. This activity will be a central part of the IAMC Scenario Consortium activities in 2008 and will facilitate the use of the IIASA A2r scenario as one of the four *Reference Concentration Pathways* (see also above).

- Development of internally consistent land-use and land-cover change maps (at a resolution of 0.5 x 0.5 degrees) in collaboration with the LUC and FOR Programs. This activity will build upon initial land-use maps of the GGI scenarios, and improvements will primarily focus on the classification of land classes, which are most relevant from the climate change perspective (e.g., albido changes due to deforestation)
- Development of downscaling methodologies in collaboration with TNT for spatial emission projections of radiatively active gases (including all aerosol and pollutant emission sources). This information is of particular importance for improved estimates of local climate change. In addition, the results from this exercise are envisioned to provide important inputs to impact and vulnerability assessments including co-benefits of climate mitigation for local air pollution.
- Extension of the A2r scenario to 2300. For this activity a stylized methodology needs to be developed to guide the extrapolation of emissions and concentrations beyond the presently adopted time horizon up to 2100. Climate projections extending beyond 2100 will help to improve our understanding regarding the irreversibility of some key impacts (such as glacier meltdown) over the long term.
- In addition, the ENE modeling team will participate in an attainability analysis exploring extreme low stabilization scenarios. This research, which will be conducted in collaboration with the other main RCP modeling teams (IMAGE team at MNP, Netherlands; MiniCAM at the University of Maryland, USA; and the AIM team at NIES, Japan), will help to identify a robust low stabilization level for the selection of the low-end RCP scenario.

2) Further development of the stochastic modeling framework with focus on the exploration of "path-dependency" of policy decisions and learning under uncertainty.

3) For 2008 the GEA will produce a preliminary draft of its major analytical report. In addition, white papers will be released, each highlighting an issue of interest in the near term to the GEA audience. To draft the report and white papers, analysts will hold working group meetings of their Lead Authors. The Council and Executive Committee will also continue to meet.

Personnel

Scientific Staff

Nebojsa Nakicenovic (Austria), *Program Leader*
Gerald Davis (United Kingdom)
Jose Goldemberg (Brazil)
Ilkka Keppo (Finland)
Volker Krey (Germany)
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Patrick Nussbaumer (Switzerland)
Martin Offutt (USA)
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Keywan Riahi (Austria)
Atsumasa Sakai (Japan)
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Bing Zhu (China)

Postdoctoral Research Scholar

Lars Lundgren (Sweden)

YSSP

Simona Cantono (Italy)
Heekyu Sohn (Korea, Republic of)
Li Yue (China)

Administrative Support

Patricia Wagner (USA)

TNT and ENE Scientific Recognition

Awards

Nobel Peace Price awarded to IPCC. TNT and ENE scientists are IPCC contributors.

Invited Lectures/Presentations

Nebojsa Nakicenovic

- Invited to give a presentation at the Scientific Session "Energy & Climate: Managing Climate Change and the Recommendations of the World Federation of Scientists," Pontifical Academy of Sciences, Vatican, 20 December 2007.
- Invited to a Panel Discussion organized by UC RUSAL International Advisory Group, Vienna, 10 December 2007.
- Invited to give an opening keynote speech on "Technological Development" at CIENS Days 2007, Climate Policy Conference, Oslo, 27–28 November 2007.
- Invited to give a keynote presentation on "How can Global Greenhouse Gas Emissions Peak?" at the International Conference on "What's next? Policy responses to the IPCC Fourth Assessment Report" organized by the European Climate Forum and the German Federal Ministry of Environment, Nature Conservation, and Nuclear Safety, Abgeordneten Haus, Berlin, 22–23 November 2007.
- Invited to give a keynote presentation on "The Changing World: Energy, Climate and Social Futures" at the IIASA 35th Anniversary Conference "The Changing World: Energy, Climate, and Social Futures," Hofburg, Vienna, 13–15 November 2007.
- Invited to give a lecture on "The Global Energy Assessment" at The Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning, Stockholm, 18 October 2007.
- Invited to give a keynote lecture on "The Global Energy Perspectives and the Role of Africa" at the G8-AMCOST Expert Meeting on Science and Technology for Africa's Future, organized by the United Nations University, Berlin, 17–18 October 2007.
- Invited to give a keynote presentation on "The Potential of Energy Efficiency" at the 15th Annual Conference of the European Environment and Sustainable Development Advisory Councils/EEAC, Évora, Portugal, 11–12 October 2007.
- Invited to give a presentation in the panel discussion on Energy Security at the Nobel Laureates Symposium, organized by the Potsdam Institute of Climate Impact Research, at the New Palace Theatre, Potsdam, 8–10 October 2007.
- Invited to participate the workshop entitled "Future Climate Change Research and Observations: GCOS, WCRP, and IGBP Learning from the IPCC Fourth Assessment Report," organized by the World Climate Research Programme, Sydney, Australia, 2–7 October 2007.
- Invited to give a presentation on "The prospects for a carbon-free hydricity age" at the 2nd Austrian Hydrogen Conference organized by Technical University, Graz, 25–26 September 2007.
- Invited to give a presentation on "The cost of mitigation and adaptation options" at the World Bank Executive Directors' Colloquium 2007 entitled "Climate Change: Implications for Developing Countries," Potomac, Maryland, 20–24 September 2007.
- Invited as Member of IPCC Emissions Scenarios Task Force to give a plenary presentation on "Available scenarios and options for new IPCC benchmarks" at the IPCC New Scenarios Expert Meeting on "Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts and Response Strategies" hosted by the Dutch government, Noordwijkerhout, 19–20 September 2007.
- Invited to give a presentation on "Perspective on the long-term stabilization experiments, status of benchmark stabilization concentration scenarios" at the 11th Session of JSC/CLIVAR (Climate Variability and Predictability) World Climate Research Programme Workshop, 2–5 September 2007.
- As Member of IPCC delegation, invited to give a presentation on "Mitigation costs and potentials for stabilizing GHG concentrations" at the IPCC side event on "Economic mitigation and pathways toward stabilization: New findings from the IPCC 4th Assessment Report" on the occasion of the "UNFCCC Vienna 2007: Intersessional Meetings," Austria Center Vienna, 29–31 August 2007.
- Invited to give a presentation on "Energy strategies for mitigating climate change" at the International Symposium on "Global Climate Change—the Need for Action," hosted by the Norwegian Minister of the Environment and sponsored by Kings Bay AS, Ministry of Foreign Affairs, Ministry of Trade and Industry, the Research Council of Norway, 18–26 August 2007.
- Invited to give a seminar on Global Energy Perspectives at the US National Renewable Energy Laboratory, Golden, Colorado, 3 August 2007.
- Invited to give a presentation on "Approaches to Modeling Science and Technology Innovation" at the Improving Integrated Assessment Model Representations of a Science- Driven Energy Future Workshop of the Energy Modeling Forum XIII, Snowmass, 1–2 August 2007.
- Invited to give a presentation on "Potential Roles of the Integrated Assessment Models for New Stabilization Scenarios" at the Climate Change Impacts and Integrated Assessment Workshop of the Energy Modeling Forum XIII, Snowmass, 23–31 July 2007.

- Invited to give a keynote presentation "Pathways to sustainable energy use" at the 866th Wilton Park Conference on "Climate and Energy Security: Towards a Low Carbon Economy," organized in cooperation with the Renewable Energy and Energy Efficiency Partnership (REEEP), Steyning, West Sussex, UK, 22–25 July 2007.
- Eingeladen ein Vortrag über „Die Zukunft der weltweiten Energieversorgung" bei EControl, Journalistenseminar "Energieversorgung 2020" zu halten, Langenlois, Oesterreich, 11–12 July 2007.
- Invited to chair and give an opening keynote at the Global Energy Assessment meeting at the International Institute for Applied Systems Analysis, Laxenburg, Austria, 2–4 July 2007.
- IEA World Energy Outlook 2007 Brainstorming Meeting: China and India Insights, International Energy Agency, Paris, 29 May 2007.
- Invited to give a keynote presentation on "Global Energy Assessment and Climate Change" at New Environmentally Friendly Energy Research Challenges Seminar, Environmental Research Centre (HERC), Helsinki University, Helsinki, Finland, 22–23 May 2007.
- Invited to give a presentation on "Energy strategies for mitigating global climate change" at Climate Change Conference organized on the occasion of 50th Academic Year of MEDEA, ENI Corporate University, Milan, 17–18 May 2007.
- Invited to give a presentation on Global Energy Assessment, at the side event of the 15th Session of the UN Commission on Sustainable Development, United Nations, New York, 7–11 May 2007.
- Invited to give a lecture on "Good policy on clean energy and conservation, and how the Bank can implement and promote it," at the World Bank Executive Directors' Colloquium 2007, World Bank, Washington, 4–5 May 2007.
- Invited to participate as Coordinating Lead Author in the 9th Plenary Session of the Intergovernmental Panel on Climate Change, Working Group III, Royal Princess Hotel, Bangkok, Thailand.
- Invited to participate as Coordinating Lead Author in the CLA Meeting of the Intergovernmental Panel on Climate Change, Working Group III, Royal Princess Hotel, Bangkok, 25–28 April 2007.
- Invited to give a presentation on "Strategies for Energy, Development and Climate Change Mitigation," National Research Foundation, CSIR Convention Center, Pretoria, South Africa, 11–13 April 2007.
- Invited to give a presentation on "The Role of Baselines in Stabilization Scenarios at the Global Environmental Futures: Interrogating the Practice and Politics of Scenarios" Workshop at Brown University's Watson Institute for International Studies, Providence, RI, USA, 21–23 March 2007.
- Invited to give a presentation on "Climate Stabilization Strategies" at the IAM Consortium Meeting, United Nations Foundation, Washington, 19–20 March 2007.
- Invited to give a presentation on "Technologies for Stabilizing Climate Change," at the International Symposium "Toward Stabilization of Global Warming," organized by RITE, METI, and IIASA, Tokyo, 12–14 March 2007.
- Invited to give a presentation on "Global Energy Assessment," at the side event of the Intergovernmental Preparatory Meeting 15th Session of the UN Commission on Sustainable Development, New York, 1– 2 March 2007.

Arnulf Grübler

- Urbanization: What Can the Experience of the Last 1000 Years Tell Us for Modeling the next 100 Years? Global Carbon Project Workshop on Urbanization, Development Pathways, and Carbon Implications, 28 March 2007, Tsukuba, Japan.
- IIASA Integrated Assessment via Downscaling of Population, GDP, and Energy Use, Global Carbon Project Workshop on Urbanization, Development Pathways and Carbon Implications, 29 March 2007, Tsukuba, Japan.
- Bioenergy in Long-Term Development and Climate Stabilization Scenarios, National Institute for Environmental Studies (NIES), 30 March 2007, Tsukuba, Japan.
- Looking into the Future, DANFOSS Innovation Day, 17 April 2007, Schloss Pichlarn, Austria.
- Putting Climate Change in Context, Financial Innovations Lab for Energy Independence, 23 October 2007, Milken Institute, New York.
- Coping with Uncertainty, Global Development: Science and Policies for the Future (IIASA 35th Anniversary Conference), 15 November 2007, Hofburg, Vienna, Austria.
- Technology and Global Change, World Fellows Program, 28 November 2007, Yale University, New Haven, USA.
- Environmental Implications of Technological Transitions, Bloustein School for Planning and Public Policy, 29 November 2007, Rutgers University, New Brunswick, NJ, USA.

Shilpa Rao

- Presentation on Global Energy Investments and Climate Change Mitigation at the Workshop on Finance and Investment Flows to Address Climate Change: The Way Forward, UNFCCC, 31 October 2007, Bonn, Germany

Keywan Riahi

- Presentation on "Energy Perspectives and Climate Change" at the IIASA Days in Korea, Seoul, Korea, 20–21 August, 2007
- Presentation at the IIASA side event at UNFCCC SBSTA on "Long-Term Emissions Scenarios: Implications for Medium-term Decision Making," 14–15 May 2007, Bonn, Germany

- Invited to make a presentation on "Energy Transitions for Developing Countries—A Long-Term Perspective," 7th Meeting of the Global Forum on Sustainable Energy (GFSE-7), Vienna International Centre, Vienna, 21–23 November 2007
- Invited to make a presentation on „Langfristige Emissions-Szenarien, Vermeidungspotentiale und Kosten" at the BASF Symposium zu Klimaprojektionen für das 21. Jahrhundert, Ludwigshafen, 1 October 2007.
- Keynote speech on "Global Challenge of Climate Change" at the Conference on Adaptation of Water Management to the Effects of Climate Change in the Danube River Basin, Austrian Ministry for European and International Affairs, Austria, 3 December 2007, Vienna
- Lecturing as Professor of Energy Systems Analysis at Graz University of Technology, Austria, Summer Semester 2007
- Invited lecture on "Perspectives on the Use of Renewable Energy" for the MSc Program on "Renewable Energy in Central and Eastern Europe" at the University of Technology Vienna, Austria, Summer Semester 2007
- Invited lecture on "Energy Modeling" at the University of Technology Vienna, Energy Economic Group, Austria, Summer Semester 2007

Takahiro Shiga

- Main Organizer of the 2nd Toyota CRDL Workshop on Complex Systems—Interaction and Emergence of Autonomous Agents, 24–26 September 2007, Baden, Austria
- Co-author of poster presentation on "Investigation of Macroscopic Behavior in Traffic Networks," (with Rainer Berkemer, Jens Starke, Atsushi Kawamoto, and Takahiro Shiga) at the European Conference on Complex Systems (ECCS), 1–5 October 2007, Dresden, Germany

Gerald Silverberg

- Using Complexity Theory to Understand the Innovation Process: From Stylized Facts to Stylized Models, Summer school on "The Economics of Innovative Change," 9 August 2007, Jena, Germany.
- Complexity approaches to innovation and product lifecycles, DIME Workshop Conference on "Demand, Product Characteristics and Innovation," 18 October 2007, Jena, Germany.
- Outside the Black Box: The Phenomenological Complexity of the Innovation Process, Biannual conference of the European Association for Evolutionary Political Economy, 2 November 2007, Porto, Portugal.

Hal Turton

- Turton, H., 2007, Global Energy Assessment: Chapter Outline, Presentation at the Launch of the Global Energy Assessment, International Institute for Applied Systems Analysis, Laxenburg, Austria, 30 January.
- Turton, H., 2007, Global Energy Assessment: Structure and outline, Presentation at the Intergovernmental Preparatory Meeting to the 15th Session of the United Nations Commission on Sustainable Development, New York, 2 March.

Editorships

Arnulf Grübler

Journal of Industrial Ecology, Editorial Board member
Technological Forecasting and Social Change, Advisory Board member

Tieju Ma

International Journal of Knowledge and Systems Sciences, Editor

Nebojsa Nakicenovic

Climate Policy, Advisory Board member
International Journal of Energy Sector Management, Editorial Board Member
Technological Forecasting and Social Change, Associate Editor

Keywan Riahi

Energy Economics, Associate Editor

Gerald Silverberg

Cliometrica, Editorial Board member
Journal of Economic Behavior and Organization, Associate Editor
Journal of Evolutionary Economics, Editorial Board member
Structural Change and Economic Dynamics, Associate Editor

Serving on Advisory Boards, Steering Committees

Arnulf Grübler

- Advisory Board Member of the UK Energy Research Center, London, UK

- Advisory Board Member of the BP Imperial College Urban Energy Systems Project, London, UK

Nebojsa Nakicenovic

- Advisory Board Member of Friedrich-Schiedel Foundation on "Energy technology," Vienna, Austria
- Chairman of ENERGEX 2008 Scientific Committee, Vienna, Austria
- Member of ENERGEX 2008 Local Organizing Committee, Vienna, Austria
- Advisory Board Member of OMV Future Energy Fund, Vienna, Austria
- Advisory Group Member of European Environment Agency, 2004–present, Copenhagen, Denmark
- Scientific Steering Committee Member of The Global Carbon Project, 2004– present, CSIRO, Canberra, Australia
- Energy Advisory Group Member of Research Center, Jülich, Germany
- Steering Committee Member of International Programme on the Economics of Atmospheric Stabilization (IPEAS), London, UK
- Member of the United Nations Sigma Xi Scientific Expert Group on Climate Change and Sustainable Development, Triangle Park, NC, USA
- Member of Organizing Committee of International Energy Economics Conferences (IEWT), Vienna University of Technology, Vienna, Austria
- Expert for Energy Economics of WEC Austrian National Committee, Vienna, Austria
- Member of the EC High-Level Expert Group on "Foresighting the New Technology Wave," Brussels, Belgium
- Member of InterAcademy Council (IAC) Study "Transitions to Sustainable Energy," Amsterdam, the Netherlands
- Member of International Council for Science (ICSU) Working Group "Energy and Sustainable Societies," Paris, France
- Steering Group Member of the Study Group on Energy Technologies in the 21st Century, Phase II, World Energy Council (WEC), London, UK
- Member of the Working Group on Coupled Modelling, Joint Scientific Committee for the World Climate Research Programme (JSC/WCRP) and CLIVAR Scientific Steering Group, Geneva, Switzerland
- Member of IPCC WGIII Task Group on New Emission Scenarios, Bilthoven, Netherlands
- Scientific Advisory Board Member of Dubrovnik Conference on "Sustainable Development of Energy, Water and Environment Systems," Zagreb, Croatia

Keywan Riahi

- Steering Committee Member of IPCC Special Report on Renewable Energy, Geneva, Switzerland
- Core Writing Team Member of IPCC AR4 WGI-III Synthesis Report, Geneva, Switzerland

Part IV

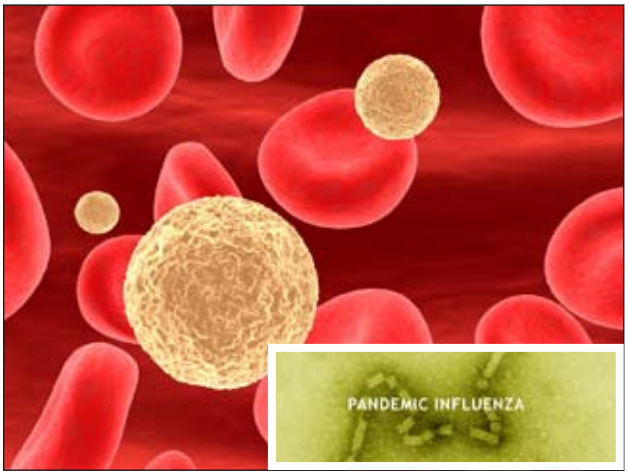
Special Projects

Health and Global Change Project

Landis MacKellar
mckellar@iiasa.ac.at

Objectives

The Health and Global Change (HGC) Project's long-term goal is to contribute to research and deepen international policy dialogue related to health—considered one of the human dimensions of global change. IIASA's Science Advisory Committee counseled that HGC begin by concentrating on economic and social aspects of infectious disease and responses thereto. In its first two-year phase (2005–2007), HGC concentrated on pandemic influenza. HGC is currently disseminating work produced during this period and exploring new aspects of health and global change, notably (in collaboration with the International Science Council or ICSU) urban health.



Influenza and pandemic influenza

Scientific Achievements

Workshops

The joint IIASA–Peking University Institute for Population Research roundtable "Pandemic Influenza in China: Challenges, Responses, Needs" was held at Peking University on 22 October 2007. In attendance were some 15 experts on human and animal health from IIASA, Peking University, the Chinese Centre for Disease Control, the Agriculture Academy, the Ministry of Agriculture, Chinese Centre for Animal Disease Control, and the Natural Science Foundation of China. This national-level workshop was a follow-up to the 4–5 August 2006 international scoping workshop, Policy and Social Science Aspects of Pandemic Influenza, held at IIASA and reported on previously. The Beijing workshop was significant because, exceptionally, national experts from agencies responsible for human and veterinary public health were brought together to discuss policy coordination and research needs.

Peer-Reviewed Scientific Publications (all 2007)

- Landis MacKellar, "Pandemic influenza: a review." Population and Development Review 33(3): 429-51.
- Landis MacKellar (coauthor, with Richard Smith), "Global public goods and the global health agenda: problems, priorities and potential." Globalization and Health 3:9.
- Andrew Noymer, "Contesting the cause and severity of the Black Death: A review essay." Population and Development Review 33(3): 616–627.1

Invited Lectures/Presentations (all 2007)

- Landis MacKellar, "Health and global development: Trends and uncertainties; challenges and responses." Presentation to IIASA Conference "Global Development: Science and Policies for the Future," 14 November.
- Andrew Noymer, "Down under, up over: Comparative trends of infectious disease in Australia and the United States in the twentieth century." Stanford University/Applied Biosystems Symposium ``Demography and Infectious Disease: Integrating Multiple Levels of Biological and Social Organization'', 23 February 2007.
- Andrew Noymer, "Influenza and tuberculosis in 1918: Lessons from an historical plague." Wenner-Gren Foundation Conference ``Plagues: Models and Metaphors in the Human `Struggle' with Disease'', Tucson, 15 September 2007.

Other presentations (not by invitation) were:

- Andrew Noymer, "Tuberculosis in the Union Army during the Civil War." California Center for Population Research, UCLA, 24 January.
- Andrew Noymer, "Mortality selection: The 1918 influenza pandemic's role in the decline of tuberculosis in the US." Department of Mathematical Sciences/Center for Applied Mathematics and Statistics, New Jersey Institute of Technology, 28 March; Institute for Mathematical Behavioral Sciences, UC--Irvine, 26 April.
- Andrew Noymer, "The twentieth century evolution of American mortality." Economic History Seminar, University of Michigan, Ann Arbor, 6 November.

1 PDR review essays, while not formally peer-reviewed, are invited surveys by recognised experts in the field and have been weighted by U.S. faculty committees as equivalent to a peer-reviewed publication.

Editorships/professional service

- Landis MacKellar, Editor in Chief, *Population and Environment* (Springer), 2004–2007; member, International Council for Science (ICSU) Planning Group on Health and Well Being in the Urban Environment.
- Andrew Noymer, board member, Society of Biodemography and Social Biology (SBSB), 2005–2007; editorial board member, *Contemporary Sociology*, 2007–2008.

Policy-advisory work

HGC staff member Clara Cohen, financed by the U.S. National Academy of Sciences African Science Academy Development Initiative (ASADI), mentored science academy counterparts in Nigeria on the design and planning of convening activities in the areas of under-five mortality and health systems, and on the writing, editing, and publication of a peer-reviewed summary of a workshop, Blood Safety in Nigeria. She assisted counterparts in Cameroon with the writing and publication of a peer-reviewed conference report, Prioritizing Food Security Policies for Health and Development in Africa. She provided capacity building and technical assistance to counterpart academies in Senegal, Cameroon, and Nigeria in strategic planning and in the development of draft guidelines for the conduct of consensus-based policy-advisory studies.

During 2007 Landis MacKellar provided an impact analysis of World Bank support for health care finance reform in Bosnia-Herzogovina; served as a USAID-financed advisor on pension reform in Armenia; was team leader of the EC–EuropeAid evaluation of country cooperation strategy with Moldova; and provided an economic analysis of health insfrastructure development in Lesotho to the U.S. Millennium Challenge Corporation.

Personnel

Scientific Staff

Landis MacKellar (USA), *Project Leader*
Clara Cohen (USA)
David Horlacher (USA)
Steven Ney (Germany)
Andrew Noymer (USA)

YSSP

Jufen Liu (China)
Soumya Rangarajan (USA)

Administrative Support

Deirdre Zeller (Ireland)

Integrated Modeling Environment Project

Marek Makowski
marek@iiasa.ac.at

Strategic Goal and Objectives

The Integrated Modeling Environment (IME) Project in its second year achieved further significant progress in meeting its strategic goal *to build capacity to meet IIASA's growing needs for integrated modeling support where commonly known methodology and/or general-purpose modeling tools are inadequate*. The long-term aim is to strengthen IIASA's in-house capabilities and competitive advantage in modeling complex problems.

IME's strategic goal is achievable only because the small in-house team is greatly supported by colleagues from: (1) collaborating IIASA programs, and (2) a network of collaborating research institutes and universities.

The IME strategic goal can be deconstructed into the following objectives:

1. Integrate and extend modeling methods and tools developed to address individual demands into an advanced Web-based modeling environment adapted specifically to the needs of IIASA programs.
2. Develop methods and tools for policy analyses to cope with inherent endogenous uncertainties and risks with potential catastrophic consequences and to properly represent abrupt changes, spatial and temporal distributional heterogeneities, vulnerabilities, and robust solutions.
3. Develop methodology and tools for integrated model analysis aimed at combining the capabilities of different methods (such as various types of simulation, optimization, multicriteria model analysis, sensitivity analysis) with data analysis (including data mining, estimation, and down- and upscaling) technology.

Scientific Achievements in 2007

As IME objectives are mutually dependent, its research cannot really be split in order to associate each research activity with a specific objective. However, the description of the 2007 activities below is organized according to the main contribution to one of the three IME objectives.

Advanced Web-based modeling environment

The Structured Modeling Technology (SMT) prototype developed by IME provides a Web-based modeling environment supporting interdisciplinary teams during whole modeling process (model specification, data processing, generation of model instances, and integrated model analysis). In 2007 we finalized research on two problems that are critically important for reliable modeling of complex problems. IME started to research these in 2006 as a basis for a new implementation of the SMT which will be capable of handling a new generation of IIASA models that are not only growing fast, both in complexity and in size, but also pose new requirements for the modeling process as a whole:

- Analysis of the semantic consistency of complex algebraic expressions. The basis for this is an effective handling of measurement units in which model components (parameters, variables, relations) are represented. The challenge of this research issue is best illustrated by the fact that analysis of the consistency of measurement units is not supported by any of the widely used general purpose modeling systems. IME, in collaboration with Wojtek Michałowski and Vivi Nastase of the University of Ottawa, has developed a methodological framework for this problem.
- An efficient way of handling complex indexing structures needed for compound entities of complex models. The SMT prototype is based on professional database management systems (DBMSs), which provide technical possibilities for efficient handling of huge amounts of data. However, standard ways of using DBMSs are not efficient for handling data structures with a huge number (over 109 of possible combinations of indices values).

IME also researched approaches for Web-based interactive multicriteria analysis of complex (in terms of number of criteria and their value distributions, and the number of alternatives) problems of discrete alternatives aimed at development of an application that meets requirements of analysis of future energy

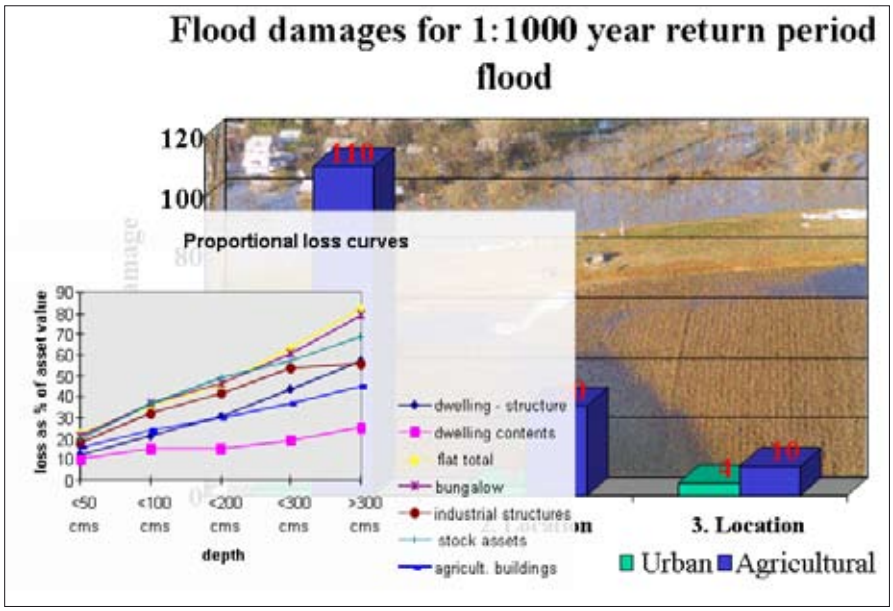


Figure 1. Illustration of spatio-temporal risk profiles applied to the hazardous flood modeling of the Tisza river, Ukraine.

technologies by a large number of stakeholders having diversified backgrounds. This research provides a basis for prototype implementation of the Web-based system to be converted in 2008 into a robust application supporting actual policy analysis within the EU-funded NEEDS project.

Moreover, IME staff researched approaches to the design of Creative Environments (CEs) that support creative processes in research. A prototype CE was developed with the following functions: creative group communication environment (posting papers, debating panels, brainstorming panels, casual knowledge sharing); electronic environment for experiment support; adaptive hermeneutic agents (help in Web search; special search in texts and specialized text mining); planning and road-mapping systems. This research was supported by 21st Centers of Excellence (COE) Program, *Technology Creation Based on Knowledge and Science*, of the Japan Advanced Institute of Science and Technology (JAIST) funded by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT, Japan).

Coping with endogenous uncertainty and risks

Proper integrated modeling and decision analysis of ongoing socioeconomic and environmental global changes raise new fundamental methodological challenges. Therefore IME continues to research the key methodological issues of inherent uncertainties and risks, interdependencies, spatio-temporal (economic, social, environmental, risk exposures, political, etc.) heterogeneities—critical elements of these processes that have to be dealt with effectively in designing robust policy decisions. Methods for decision making under uncertainties and related issues of risk management have been at the center of methodological developments in the last couple of decades. However, these methods mainly consider the case of a relatively simple system under control facing external sources of risk and uncertainty. This, in particular, allows the data and uncertainty analysis to be separated from decision analysis.

The actual challenge of integrated modeling of global change processes is that the uncertainty and risks are often endogenous to the system, generated by inappropriate policies (decisions) and/or its structural interdependencies. The data and uncertainty analysis then has to be linked directly with the scales and main goals of desirable robust decisions. In 2007 IME advanced the development and application of new concepts of robust decisions under inherent uncertainty and risks with potential catastrophic consequences and applied them in cooperation with colleagues of several IIASA Programs (please consult the publication list for published results). Here we summarize the main results:

- Jointly with the Land Use Change (LUC) Program, IME developed the new concept of endogenous spatio-temporal discounting, so-called stopping time discounting, which was further analyzed. Its applicability to catastrophic flood management (data, models, and risk management approach) to the Narew River (Poland) was evaluated. Important connections with the notion of Darwinian fitness were established.
- The integrated modeling approach for robust sustainable agricultural planning under environmental and health risks was investigated and applied in case studies of livestock production expansion in China. The approach is based on specific indicators of risks that identify critical limitations, thresholds, and trends in locations to assist in the planning. It essentially relies on probabilistic downscaling methods, developed jointly with LUC program, that convert available multi-scale data into consistent estimates of required scales.
- On the basis of the last year's special project on integrated hazardous flood modeling in Ukraine financed by the program, Technical Aid to the Commonwealth of Independent States (TACIS), a new concept of polyhedral risk measures was studied and applied to evaluating robust risk management investments. This was done in collaboration with a former participant in the Young Scientists Summer Program (YSSP), and with the LUC Program.
- IME with the Forestry (FOR) and LUC programs studied an integrated modeling framework for assessing the robustness of Kyoto flexible mechanisms (e.g., emission trading). The proposed model incorporates probabilistic risk-based detection techniques with a sequential bilateral emission trading procedure in a fair and mutually beneficial way, allowing the creation of a stable coalition of participants.
- Long-term research with the TNT Program was continued on analysis-robust energy development under increasing returns and inherent uncertainties.
- Motivated by the needs of designing robust global change policies (requiring stable coalition), IME also researched methods for analysis of rather general risk-sharing stable coalitions. The approach analyzed goes beyond the concept of Pareto optimality. Instead of the standard fixed-point arrangements, the approach entirely relies on optimization theory with its powerful computational methods. The same type of simple direct and computationally efficient methods have been analyzed in relation to other financial problems of pricing, portfolio selection, and hedging which are typical of integrated modeling of socioeconomic and environmental processes.

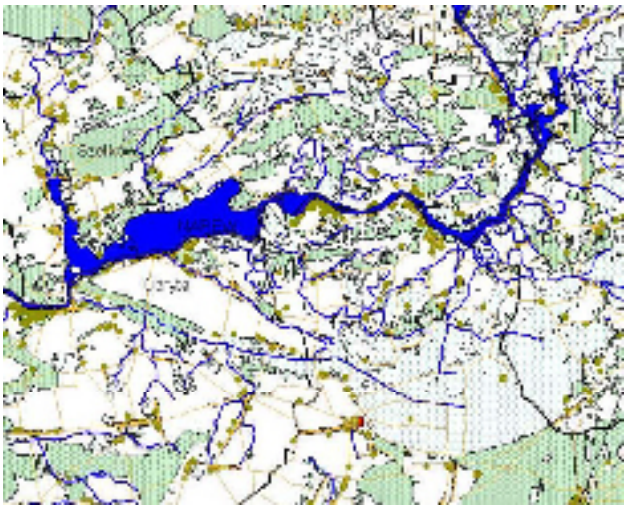


Figure 2. Inundation map on the river Narew. Application of endogenous discounting technique to evaluation of structural flood protection measures on the river Narew, Poland

- As a start-up contribution to the new IIASA cross-program initiative on *Fragility of Critical Infrastructures*, IME studied novel approaches to analysis of the network risks, which are typically interdependent and endogenous. These type of risks are the key issue in defining the robustness of infrastructures (e.g., energy systems, gas, transport, and distribution systems, information, and communication networks).

The study of the network risks is also essential for designing robust catastrophic risk management strategies. Besides involving methodological issues, this activity aims to create an integrated modeling decision support environment that will enable the identification and evaluation of critical bottlenecks inherent in infrastructures seen as specialized networks. In particular, this is conducted based on the example of important problems arising in the process of building the information infrastructure. In particular, it was shown how related network risks can be analyzed by extending the portfolio theory. The Bayesian nets have been used to develop a stochastic, dynamic model of attitude formation and service adoption patterns that depend on the complex interplay of the attitudes of different groups of population and policies which may improve the overall performance of the network.

Integrated model analysis

Building on long-term past research in the Multicriteria Model Analysis (MCMA) field, IME continued in 2007 to lead the activities of multicriteria analysis within the EU FP6 Integrated Project NEEDS. The IME team is collaborating in NEEDS with the Paul Scherrer Institute (Switzerland). In 2007 the research focused on development of new methods for multicriteria analysis of future energy technologies. The analysis of such a problem is characterized by four main challenges:

Multicriteria analysis is carried out for a large set of alternatives, each characterized by a large number of criteria organized in a hierarchical structure.

- The criteria values have multimodal distributions.
- The interactive analysis process will involve many stakeholders (about 1500 will be invited) from four countries with diversified backgrounds and conflicting interests.
- The results of interactive analyses by stakeholders will provide a basis for the second stage analysis aimed at providing policy advice on future energy technologies.

There are no methods that can effectively support analysis of such problems. Therefore, in 2007 IME developed new methods for Web-based interactive multicriteria analysis.

IME has also finalized a prototype version of a decision support system for groundwater management in the Mexico City basin. The main challenges solved while developing this system were:

- Collecting data from different sources in diversified formats.
- Designing a consistent and efficient data structure.
- Implementing the data base in PostgreSQL,
- Development of regional groundwater level dynamics model.

Finally, the research by former YSSP participants was finalized in 2007 in collaboration with IME staff on the following topics:

- New practical method for estimation of input–output tables.
- Search techniques for multi-objective optimization of mixed-variable systems having stochastic responses.
- Qualitative models of climate variations impact on crops yields (in collaboration with the LUC Program).
- Weather indicators and crop yields analysis with wavelets (in collaboration with the LUC Program).

Research by YSSP participants

IME welcomed three YSSP participants in 2007, all of whom achieved very good results:

- Agnieszka Banrowska (from Warsaw University of Technology, Poland) researched the insurance and capital market tools as non-structural elements of flood protection systems. The research is ongoing; its results are being considered

Scientific Recognition

Yuri Ermoliev was invited to give a keynote lecture on *New Methodological Challenges of System Analyses* at a special session of the International Conference on Problems of Decision Making under Uncertainties organized in cooperation with IIASA by a network of leading Ukrainian universities and institutes.

Marek Makowski was invited to give a plenary lecture on *Knowledge Integration and Creation for Solving Complex Problems* at the Eighth International Symposium on Knowledge and Systems Sciences organized by the Japan Advanced Institute of Science and Technology. He was also invited to talk on *Rational Governance of Conflicting Goals, Uncertainties and Risks* at the 2007 IEEE International Conference on Systems, Man, and Cybernetics, and on *Modeling of Large Systems Related to Environmental Problems* at the 21st Conference on Informatics for Environmental Protection.

Janusz Granat and **Marek Makowski** were invited to organize a session on *Multicriteria Optimization and Decision Support* at the 23rd IFIP TC-7 Conference on System Modeling and Optimization.

Hongtao Ren obtained his Ph.D. for the dissertation *Implementing Creative Environments for Scientific Research in a Research Institute* defended at the Japan Advance Institute for Science and Technology.

Jaime Carrera-Hernandez received his Ph.D. for the dissertation on *Spatio-temporal analysis of aquifer recharge and groundwater levels in the Basin of Mexico City* defended at the McGill University, Canada.

for new regulations in Poland and are being applied to the Narew River in Poland.

- Aron Larsson (from Mid Sweden University) developed a framework for evaluating emergency preparedness plan and response strategies. The proposed approach is novel and promising, bridging advanced methods of decision analysis, and of ex ante risk management. The method developed is being tested on the actual emergency preparedness plans from several Scandinavian countries.
- Marcin Salwa (from the National Institute of Telecommunications, Poland) developed a prototype of the database for the Web-based multiuser application supporting multicriteria analysis of discrete alternatives characterized by a large number of criteria with hierarchical structure.

IME follows the proven tradition of keeping in contact with former YSSP participants. It is thus likely that at least some of them will collaborate with IIASA in the future.

Activities for 2008

The following research areas will have priority in 2008:

- The Web-based multicriteria analysis of future energy technologies, and the development of new data analysis methods aiming to find a portfolio of technologies that best correspond to the stakeholder preferences implicitly specified during the multicriteria analysis.
- Further advancement of research on the selected problems of inherent uncertainties and endogenous risks, aimed at designing robust policymaking decisions:
  - endogenous spatio-temporal discounting,
  - assessment of Kyoto Protocol flexible mechanisms,
  - increasing returns, especially in the context of robust energy technology development,
  - downscaling/upscaling and uncertainty.
- New generation of the SMT-based modeling environment tuned to the needs of the collaborating IIASA Programs.

Contingent on additional/external funding/resources also the following topics will be further researched:

- The network risks in the context of robustness of critical infrastructures, for example, energy systems, gas, transport, and distribution systems, information and communication networks (within the forthcoming IIASA inter-program activity on Fragility of Critical Infrastructures).
- The insurance and capital market tools as non-structural elements of a flood protection system, and its application to the Narew River (Poland) case study.
- Pricing of catastrophe bonds and options focused on applications to integrated management of risks related to natural disasters.
- Integrated management of catastrophic flash flood risks.

Personnel

Scientific Staff

Marek Makowski (Poland), *Project Leader*
Jaime Carrera Hernandez (Mexico)
Yuri Ermoliev (Ukraine)
Sjur Flam (Norway)
Alexei Gaivoronski (Norway)
Janusz Granat (Poland)
Hongtao Ren (China)

YSSP

Agnieszka Banrowska (Poland)
Oscar Larsson (Sweden)
Marcin Salwa (Poland)

Administrative Support

Amalia Priyatna (Indonesia)
Deirdre Zeller (Ireland)

Part V

Cross-cutting Activities

Greenhouse Gas Initiative

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Objective

The Greenhouse Gas Initiative's (GGI) overall objective is to advance scientific understanding and inform policy processes related to the challenge of climate change. The Initiative takes as its context the ultimate goal of the UN Framework Convention on Climate Change to stabilize atmospheric concentrations of greenhouse gases in order to avoid dangerous impacts. Principal research activities include: 1) the development of global, long-term, multigas stabilization scenarios; 2) the development of short- to medium-term country-specific case studies and policy options analysis within a global stabilization framework; and 3) the development of a policy assessment tool for analyzing alternative international climate change policy regimes. Through these activities, GGI aims to integrate IIASA's expertise in global and long-term analyses of population, technology, energy systems, and agriculture with more place-specific assessments of land use, forestry, and air pollution, both for industrialized and developing countries.

Scientific Achievements and Policy Impact in 2007

Myopic MESSAGE

To assess the role of mid-century targets as a milestone on the way to achieving long-term mitigation targets, a new prototype MESSAGE model without perfect foresight has been developed as a collaboration between GGI, World Population Program (POP), Energy (ENE), and Transition to New Technologies (TNT). The idea here is to set up a model that first runs only over a limited period into the future, say, until the year 2050. Only when the results until 2050 are known, does the model run over a longer time frame, from 2050 until, say, the year 2100. In contrast with the traditional systems engineering and macroeconomic energy models with perfect foresight, the new myopic model permits the implications of alternative planning horizons for decision making to be analyzed. The new MESSAGE model thus provides a suitable framework for exploring "path-dependency" and "lock-in effects" in the energy system. In particular, the framework will be used for the explicit assessment of the consequences of short-term decisions for achieving long-term objectives. First applications of the model will be geared toward the exploration of interim targets (mid-century) for long-term climate stabilization.

Policy Assessment Framework

The collaboration between Atmospheric Pollution and Economic development (APD) and ENE on the Policy Assessment Framework continued into 2007. A set of global GHG-mitigation scenarios have been used to examine the temporal feedbacks of the climate targets on national short-term energy planning, while different approaches for merging multiple objective values have been tested with a model that lets IIASA's GAINS and MESSAGE models communicate directly with each other (modelers speak of "hard-wiring" the models). The preliminary results indicated that the methodology in principle delivers promising results. However, the model philosophies in MESSAGE and GAINS are so different that a very time-consuming recalibration of the underlying baseline scenarios is necessary for each new baseline scenario. Therefore, in its current form, the tool has only limited value for policy analysis at the national or regional level, based on bottom-up projections by national experts. The key question is thus whether common scenarios for the GAINS and MESSAGE model can be generated in a more efficient way—and how.

SEDIM (Simple Economic Demographic Interaction Model)

In 2007 GGI, in collaboration with the POP program, further developed the SEDIM. To date, a number of national case studies have been used to test the SEDIM methodology. The main objective until the end of 2007 was to calibrate SEDIM for 11 world regions to historic data. In a second step, socioeconomic scenarios for the 21st century will be generated, eventually including projections for energy demand. These projections will be used as input parameters to other models, such as MESSAGE and PET. Most of the data necessary for running the model on 11 regions has been collected and a new specification for interregional capital flows has been programmed. The regions are running correctly on an individual basis now; the next task will be to link them together in an integrated world model.

Endogenous climate and carbon cycle model in MESSAGE:

As part of our collaboration with Bern University the Bern carbon cycle model, including its carbon cycle and temperature feedbacks, have been endogenized in the MESSAGE model. After an overhaul of the methodology, the MESSAGE model now indeed includes the full Bern-CC model. With this it will be possible to directly study the responses of the MESSAGE model to temperature or rate of change constraints. Moreover, the relative importance of short-lived gases can now be consistently assessed.

GGI scenario database

In 2007 GGI also continued to maintain the GGI scenario database established in 2006 and now frequently used by researchers and journalists at institutions around the world. The database contains scenario data that form the basis of the analyses published in the Special Issue of *Technological Forecast and Social Change* in 2006.

Young scientists in GGI

Under the umbrella of the Young Scientists Summer Program (YSSP) various programs have worked with GGI on a number of

interdisciplinary topics: in collaboration with the TNT and ENE programs a group of four YSSP students explored the option value of individual mitigation technologies in the context of the GGI stabilization scenarios. The analysis aims to estimate the relative value of the contribution of principal demand and supply-side measures for achieving stabilization of GHG concentrations. The idea here is to compare the results for two alternative scenario results, with and without the option to use a given technology. The analysis has helped understand investment priorities to be better understood across a wide range of mitigation options.

In another collaboration involving GGI, Population and Climate Change (PCC), and Risk and Vulnerability (RAV) within the YSSP, the relative merits of mitigation and adaptation were explored with a DICE model which was modified to also include adaptation options. A number of insights were gained for further developing the methodology.

GGI also collaborated with Forestry (FOR) and a YSSP student on a project in which optimal control methodologies were applied to analyze the consistency between long-term "aspirational" mitigation targets on the one hand, such as a 2-degree target for the year 2100, as proposed by the European Union, and short-term policies aiming at an emission reduction by a certain percentage relative to 1990 in the year 2020 or 2030 on the other. This work introduces the concept of a "controllability domain" (the set of climate targets for the year 2030 that are consistent with an aspirational target in 2100) and combines it with the concept of attainability domains used in earlier work. The analysis was carried out again using a simplified version of the DICE model. The analysis has revealed how certain long-term targets become very costly in conjunction or inconsistent with short-term targets and that there are quite clearly defined threshold values that mark the boundary between attainable and unattainable targets. In contrast to the detailed bottom-up

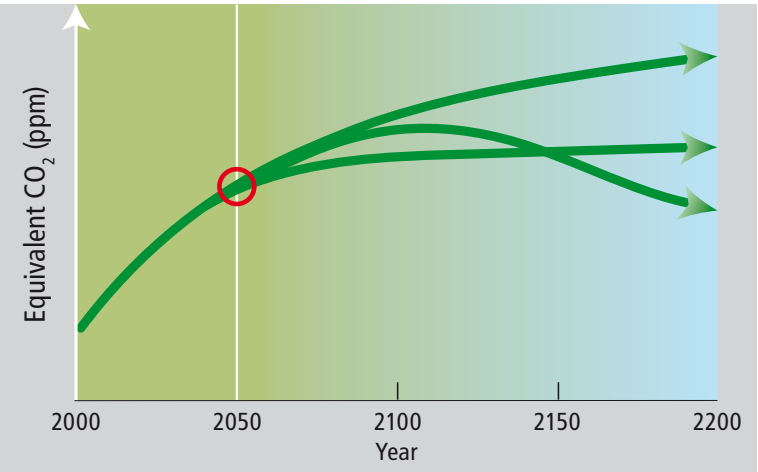

Figure 1. Mid-century concentration targets keep long-term options open.

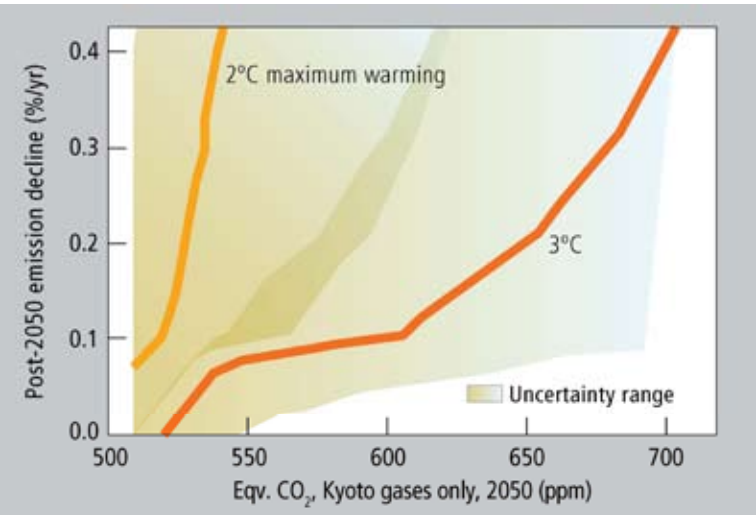

Figure 2. Annual reductions in emissions needed to reach a given long-term stabilization target (2 or 3 degrees), as a function of a mid-century concentration target reached in 2050.

MESSAGE model, with which an analysis of this type had been carried out earlier, the setup with DICE allowed large numbers of scenarios to be generated and the solution space to be systematically analyzed.

Competition over land

In 2007 GGI fostered initial discussions between the Land Use Change (LUC) and the FOR programs on competition over land for different production uses, such as for food, bio-fuels, timber, and carbon credits. The two programs use different methodologies, and synergies from a cooperative research effort are to be expected. The dialog on competition over land will thus continue in 2008.

Skunk projects

GGI has continued to encourage and to fund a number of small-scale methodological and exploratory projects or skunk projects. The following projects have been completed in 2007 or are still ongoing at the end of 2007:

- Dimitri Rokityanskiy of FOR initiated a study on optimal control of greenhouse gas emissions in the context of abrupt climate change. The starting point of the analysis is the fact that there may be thresholds in the climate system, beyond which the climate system changes no longer gradually, but rather abruptly. So far science is very uncertain about whether or not such thresholds exist, where they lie, and in what way the climate may change at these thresholds. Moreover, the economic impact of abrupt climate change is uncertain. The aim of the analysis was to understand better how its potential existence, and also the uncertainty in time and magnitude, may influence mitigation decisions today. An important aspect in this work was to also include the possibility of more than one threshold.
- For a related question Elena Rovenskaya of Dynamic Systems (DYN) developed a different methodology. She used a newly developed simplified stochastic DICE-type model to study the implications of uncertain climate thresholds.

Finally, researchers from the RAV program in collaboration with GGI started a case study for Bangladesh to assess current and future impacts of climate-related extreme events. The main question the study aims to answer is: what the relative importance of climate change versus social/economic drivers, such as increasing population and vulnerability, in current and future disaster losses? This project will be finalized in the first quarter of 2008.

Further activities

GGI continued to play an active role in bringing together scientists from different programs within the Institute. In 2007 GGI organized 21 seminars and established new links in research agendas.

Staff

In 2007 GGI hired Geza Toth as a part-time program assistant to support the GGI leadership in administrative matters. As of September 2007, GGI is hosting Christopher Doll, one of IIASA's postdocs, who specifically collaborates with the TNT program on downscaling of socio-economic datasets.

Gregg Marland, a senior scientist from the Oak Ridge National Laboratory in the USA joined GGI in the summer of 2007 for twelve months. Gregg strengthens the collaboration between programs, and, being a prolific writer, increases the visibility of GGI in the scientific community and press. In 2007 a collaboration with the FOR program has already resulted in an article in *Science*.

Brian O'Neill, one of the three GGI co-leaders, left IIASA at the end of 2007 and consequently resigned from his post. Michael Obersteiner and Keywan Riahi resigned from their positions as scientific coordinators. Fabian Wagner, the third scientific coordinator, remains in office on an interim basis.

Personnel

Initiative Co-Leaders
Markus Amann (Austria)
Nebojsa Nakicenovic (Austria)
Brian O'Neill (USA)

Scientific Coordinators
Michael Obersteiner (Austria)
Keywan Riahi (Austria)
Fabian Wagner (Germany)

Scientific Staff
Karl Franklin (Sweden)
Arnulf Grübler (Austria)
Jan Johansson (Sweden)
Qiang Liu (China)
Gregg Marland (USA)
Peter Rafaj (Slovakia)
Shilpa Rao-Skirbekk (India)
Dmitry Rokityanskiy (Russia)
Elena Rovenskaya (Russia)
Warren Sanderson (USA)
Alexey Smirnov (Russia)
Erich Striessnig (Austria)
Manfred Strubegger (Austria)
Hal Turton (Australia)

Postdoctoral Research Scholars
Christopher Doll (United Kingdom)
Katsumasa Tanaka (Japan)

YSSP
Cheol Hung Cho (Korea, Republic of)
Tyler Felgenhauer (USA)
Miyuki Nagashima (Japan)
Denis Pivovarchuk (Russia)

Scientific Support
Peter Kolp (Austria)

Program Assistant
Geza Toth (Hungary)

Scientific Recognition (awards, selected invited lectures, and editorships)

Scientific networking

In 2007 GGI researchers continued to actively participate in various high-level international workshops and conferences to disseminate the results of the GGI scenarios to research and policy communities.

- Participation at IPCC events (working groups II and III, Intergovernmental panel on Climate Change (IPCC) Expert Meeting on New Emissions Scenarios in Noordwijkerhout, Netherlands (19–21 September 2007))
- Participation at EMF events
- 23 July–5 August, Energy Modeling Forum (EMF) Workshop: Climate change impacts and integrated assessment, Snowmass, Nebojsa Nakicenovic, Keywan Riahi, Brian O'Neill
- Scenario Consortium activities:
  19–22 March, Consortium on New Emission Scenarios Meeting, Washington, DC, USA, Nebojsa Nakicenovic

Bern

The collaboration with the University of Bern on the endogenous climate model in MESSAGE continued. Moreover, a project on future sink capacities and their representation in the LPJ model resulted in a publication in *Tellus B*.

Policy briefing/interactions

In May 2007 GGI organized a side event at the session of the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC in Bonn. Four presentations by GGI scientists under the heading "Keeping options open through mid-century targets" were met with keen interest. A summary can be found in the Earth Negotiation Bulletin on the Web[1]. The presentations focused in particular on the short-to medium-term requirements for stabilizing GHG concentrations, emphasizing in particular the policy implications of the GGI scenario analysis.

Early in 2007 GGI responded positively to an initial request by the World Conservation Union (IUCN) to cooperate on a series of scenario workshops for high-level policymakers. However, as time went by, IUCN changed their concept and the collaboration did not materialize.

1 http://www.iisd.ca/climate/sb26/enbots/14may2007.html

Part VI

Programs for Young Scientists

Young Scientists Summer Program

Tanja Huber, Coordinator
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Fifty-one young scientists from 18 countries took part in IIASA's Young Scientists Summer Program (YSSP) in 2007.

The Program, established in 1977, lasts from June through August and provides gifted young researchers with an opportunity to research and produce a paper, for possible publication, on a theme related to IIASA's ongoing research on issues of global environmental, economic, and social change. Each young scientist joins an IIASA Program and experiences at first hand the atmosphere of interdisciplinary cooperation in an international setting that typifies IIASA's work.

YSSP 2007 also challenged participants to experience science and science-related issues in an international multidisciplinary setting beyond their own research through lectures, seminars, and discussion groups. The first seminar in a series of many provided an opportunity for YSSP participants to listen to and interact with Simon Levin, the IIASA Council Chair. The overall theme of most lectures was on IIASA science and policy guidance research. Eminent speakers, Professor Norman Meyers, Professor Machiko Nissanke, Professor Norman Neurieter, and Mr. David Kinley, addressed global challenges of the environment, poverty and globalization, and the science–policy divide and knowledge communication—all in the context of moving from agenda to action. Most of the lectures, which received very encouraging feedback, were recorded and are available at "IIASA Podcasts" on the IIASA Web site. A full program of sporting and leisure activities was extended to the young scientists during their stay.

The substantive efforts of the summer were varied and of high quality. Among many others, Vithal Karoshi of India (FOR) assessed forest plantations for climate change mitigation. Maiko Sakamoto of Japan (PIN) worked on coalition and information relationships among the littoral countries of the Caspian Sea. Marta Vicarelli of Italy (RAV) won the Peccei scholarship with her study on integrating climate forecasts into climate-indexed insurance schemes in Africa. Andries Richter from the Netherlands (EEP) won the Mikhalevich Scholarship for his research on the evolution of social norms for renewable resource harvesting. An honorable mention went to Aron Larsson of Sweden (IME) for his research on evaluating emergency preparedness plans and response strategies

This was the first year as YSSP Dean for Mahendra Shah (LUC) who took over the responsibilities for this successful IIASA program from Joanne Linnerooth-Bayer, who was Dean for 15 years.

As a 2007 participant summed up his experience: "I believe the YSSP to be an excellent program that finds the right balance between social, networking, academic, and professional activities."

It is, in fact, a measure of the success of the network effect of YSSP that a second Young Scientists Winter Symposium was held in February 2008 at which 16 YSSP 2007 participants (together with invited speakers) presented their most recent research since summer 2007 under the title "Adaptation, diversity, and sustainablity in a vulnerable world" to IIASA staff.

More information: www.iiasa.ac.at/Admin/YSP/

Postdoctoral Program

Barbara Hauser, Coordinator
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IIASA's postdoctoral program again offered in 2007 the opportunity for young researchers who have just received their doctorates to conduct their own research within one of IIASA's research programs or special projects on topics closely related to IIASA's agenda.

Christopher Doll, **Tapas Mishra**, **Katsu Tanaka** and **Edmar Teixeira** took up in 2007 the post-doctoral positions funded by IIASA.

Dr. Doll joined the crosscutting Greenhouse Gas Initiative Project where he is investigating alternative characterizations of urban areas with a view to improving downscaling methods of socioeconomic parameters.

Dr. Mishra is studying within the World Population Program the consequences of stochastic demographic systems on economic growth and development by exploiting their non-stationary temporal and spatial features.

Dr. Tanaka,of the Population and Climate Change Program is investigating how the prediction of future climate can be improved by analyzing the uncertainty in the carbon cycle, atmospheric chemistry, and climate system based on an inverse estimation approach.

Dr. Teixeira is working with the Land Use Change and Agriculture Program modeling the impact of surface ozone, heat stress, and pests on agricultural production by incorporating the response of crops to these climate change related factors in the FAO/IIASA Global Agro-Ecological Zones (GAEZ) model.

In addition to the above-mentioned fellowships, IIASA's National Member Organizations in Finland and the Netherlands, as well as the Kempe Foundation in Sweden and some projects funded by the European Commission, also provide the possibility for postdoctoral fellows to work at IIASA. The following fellows worked at IIASA during 2007:

Dr. Åke Brännström (EEP) is working as part of the European Research Training Network on Fisheries-induced Adaptive Changes in Exploited Stocks (FishACE).

Dr. Fredrik Dahl (FOR) is researching how large-scale habitat changes and climate change affect the fauna in the boreal forest.

Dr. Maria Hörnell Willebrand (FOR) focuses on wildlife GIS applications and habitat relationships of forest wildlife and harvest management.

Dr. Adam Kun (EEP), a Lise Meitner Fellow is studying problems relating to the evolution of cooperation.

Dr. Joakim Lundgren (ENE) researched the future energy situation of the county of Norrbotten in the northern part of Sweden.

Dr. Shuichi Matsumura (EEP) is working on spatial modeling of interactions between anglers and fish populations.

Dr. Rupert Mazzucco (EEP) is working on computational models of non-allopatric speciation.

Dr. Emma Terämä (POP) is developing multi-state population projections of the future of religions worldwide.

Dr. Rebecca Whitlock (EEP) is working on an EU FishACE project to apply ecogenetic modeling approaches that account for fisheries-induced adaptive changes to sturgeon stocks in the Caspian Sea.

Part VII

Appendices

Communications

Iain Stewart
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IIASA's communication activity disseminates information about IIASA to the public, scientific community, and national and international institutions. It achieves this by organizing events, producing publications, generating media coverage and hosting the IIASA Society for former IIASA staff.

Events

In 2007 over 1,500 participants attended 58 IIASA conferences and scientific meetings, and some 300 scientific collaborators were welcomed as visitors. The most notable event was IIASA's anniversary conference on global development (see box).

In turn, IIASA scientists were invited to, or took part in, numerous external conferences and symposia, including, for example, the UN Climate Change Conference in Bali in December 2007. Florian Kraxner, Petr Havlik, and Michael Obersteiner from IIASA's Forestry Program spoke about the political economy of avoided deforestation. And Reinhard Mechler and Pablo Suarez of IIASA's Risk and Vulnerability Program argued in favor of innovative donor-supported options for sharing extreme-event risks for developing countries.

IIASA also attracted 21 distinguished speakers to give guest lectures at IIASA (see also section on Guest Lectures), including on 14 May, Dr. Rajgapala Chidambaram, Chairman of TIFAC and Principal Scientific Advisor to the Government of India, Scientific Advisory Committee to the Cabinet, on "India's Technology Needs and Science Policy."

More information: www.iiasa.ac.at/Admin/OSR/

Publications

In 2007 IIASA's scientists published over 300 books and reports, some in prestigious journals such as *Nature* and *Science* (see section on publications). IIASA also published a range of materials for a wider audience and increased their readership. For example, the circulation of IIASA's magazine *Options* increased by 50 percent to 6,000. The redesigned *PINPoints* magazine featuring IIASA's research on negotiations has also attracted 30 percent more readers.

Using new technology to disseminate IIASA's work has also reaped benefits. Over 3000 IIASA publications are now freely available on the Web site. And podcasts of lectures at IIASA attract over 3000 subscribers a month.

More information: www.iiasa.ac.at/Publications

In the News

In 2007 IIASA was mentioned in the media 176 times.

The IIASA Society

The IIASA Society continued to expand in 2007 and to help facilitate communication between colleagues working at the Institute during the 35 years since its founding.

The focus of activity in 2007 was participation in IIASA's Conference, "Global Development: Science and Policies for the Future" held in Vienna in November. Members of the Board of the Society served at an information table throughout the Conference, offering membership to alumni and information about the history of IIASA and the Society, as well as helping Conference participants to locate each other.

A season's greetings card was mailed to all members, and our follow-up work after the Conference has concentrated on updating the Society's e-mail list, which is available online.

At Board meetings in 2007 plans were made for an online questionnaire, so that the Society can offer members activities they want and need, as well as an alumni day in the near future.

More information: www.iiasa.ac.at/IIASA_Society/

GLOBAL DEVELOPMENT: SCIENCE AND POLICIES FOR THE FUTURE

In November 2007, IIASA brought together a star-studded cast of scientists, policymakers and thinkers to discuss global development. Over 650 experts attended the event in Vienna and viewers in 22 countries watched the live Webcast. Speakers ranged from Jeffrey Sachs, Director of the Earth Institute at Columbia University, to Manfred A Max-Neef, an alternative Nobel Prize winner.

The conference delivered a wide-ranging discussion on what a sustainable and equitable future might look like, and how to get there. All agreed that the world faces two fundamental challenges in the twenty-first century. One is to root out the persistent and entrenched poverty of the "bottom billion" of humanity. The other is to prevent economic growth from overwhelming the global commons—the atmosphere, oceans, water cycle, and biodiversity.

But there was disagreement about whether these goals can best be secured through better management of the existing political and economic systems, or whether more fundamental changes were needed. Put simply, can continued economic growth be made sustainable or not?

Agendas for improving human and social capital and for maintaining natural capital were laid out. But there was a lack of integration between the two – suggesting an important focus for future systems research. Likewise the competing threats of over-consumption and over-population were often discussed rhetorically rather than analytically. Competing demands for land and water resources threaten future supplies of the "3Fs": food, fiber, and fuel. The boom in biofuels amplified the risks.

More positively, there was discussion of potential no-regrets solutions that addressed both social and environmental problems. Finding alternatives to burning fossil fuels, for instance, addressed human health problems from smog and climate change. And the benefits of good governance in solving problems were illustrated.

The conference also celebrated the thirty-fifth anniversary of IIASA.

More information: www.iiasa.ac.at/iiasa35

Contracts, Grants, and Donations

- Austrian Development Agency, Vienna, Austria
- Austrian Exchange Service, Vienna, Austria
- Austrian Research Promotion Agency, Vienna, Austria
- Austrian Science Fund, Vienna, Austria
- Federal Chancellery, Vienna, Austria
- Federal Ministry for Agriculture and Forestry, the Environment and Water Management, Vienna, Austria
- Federal Ministry for Education, Science and Culture, Vienna, Austria
- Federal Ministry for Science and Research, Vienna, Austria
- MERIT Consulting and Brokerage, Vienna, Austria
- City of Vienna, Cultural Department, Science and Research Promotion, Vienna, Austria
- Vienna Science and Technology Fund, Vienna, Austria
- Carl von Ossietzky University, Oldenburg, Germany
- Forschungsverbund Berlin e.V., Berlin, Germany
- Friedrich Schiller University Jena, Jena, Germany
- Dipartimento di Economia e Sistemi Arborei, Sassari, Italy
- Acid Deposition and Oxidant Research Center, Niigata, Japan
- Kyoto University, Kyoto, Japan
- The Japan Foundation, Tokyo, Japan
- Tokyo Electric Power Company, Tokyo, Japan
- Tokyo Gas Co. Ltd., Tokyo, Japan
- Toyota Central Research & Development Laboratories, Inc., Aichi, Japan
- Energy Research Centre of the Netherlands, Amsterdam, Netherlands
- Netherlands Environmental Assessment Agency, Bilthoven, Netherlands
- Norwegian Meteorological Institute, Oslo, Norway
- ENIPPF Ltd., Moscow, Russia
- Russian Academy of Sciences, Moscow, Russia
- Swedish Environmental Protection Agency, Stockholm, Sweden
- Swedish Meteorological and Hydrological Institute, Norrkoeping, Sweden
- The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, Stockholm, Sweden
- National Academy of Sciences, Washington, DC, USA
- National Aeronautics and Space Administration, Washington, DC, USA
- United States Institute of Peace, Washington, DC, USA
- Department for Environment, Food and Rural Affairs, London, United Kingdom
- Department for International Development, London, United Kingdom
- Unilever UK Central Resources Limited, London, United Kingdom
- University of Bristol, Bristol, United Kingdom
- European Commission, DG Agriculture & Rural Development, Brussels, Belgium
- European Commission, DG Environment, Brussels, Belgium
- European Commission, DG Environment, LIFE, Brussels, Belgium
- European Commission, DG Fisheries and Maritime Affairs, Brussels, Belgium
- European Commission, DG Research, Brussels, Belgium
- Food and Agriculture Organization of the United Nations, Rome, Italy
- United Nations Economic Commission for Europe, Geneva, Switzerland
- WWF International, Gland, Switzerland
- The World Bank, Washington, DC, USA
- United Nations Foundation, Washington, DC, USA

2007 Scientific Meetings, Sponsored or Co-Sponsored by IIASA

ADAM P3B Workshop
January 22–23
Risk and Vulnerability

Evaluation Committee Meeting on Population and Society
January 29–31
Council and External Relations

GAINS Review Meeting
January 31
Atmospheric Pollution and Economic Development

Pakistan Roadshow PIN
February 11-13 (held in Lahore, Pakistan)
Processes of International Negotiation

First Meeting of the ICES Study Group on Fisheries-Induced Adaptive Change (SGFIAC)
February 26–March 02 (held in Lisbon, Portugal)
Evolution and Ecology

9th Workshop on the Transport of Air Pollutants in Asia–Model Intercomparison Study (MICS-Asia)
February 27–28
Atmospheric Pollution and Economic Development

YSSP 2006 Reunion & SOSWOP
March 01
Young Scientists Summer Program

Global Energy Assessment (GEA) Side Event at the UN Commission on Sustainable Development during the Intergovernmental Preparatory Meeting,
March 02 (held in New York, NY, USA)
Global Energy Assessment

LIFE III–EC4MACS Kick-off Meeting
March 06–07
Atmospheric Pollution and Economic Development

Climate Change and Dharma Restoration (an ADAM Project Workshop
March 21–24 (held in Kathmandu, Nepal)
Risk and Vulnerability

Global Environmental Futures: Interrogating the Practice and Politics of Scenarios
March 23–24 (held in Providence, USA)
Population and Climate Change

CAVES Meeting
March 27–30
Risk and Vulnerability

Urbanization, development pathways and carbon implications
March 28–30 (held in Tsukuba, Japan)
Transitions to New Technologies

NEC-PI Meeting
March 29–30 (held in Vienna, Austria)
Atmospheric Pollution and Economic Development

IIASA Days in South Africa
April 10–15 (held in Pretoria, South Africa)
Directorate

Economic, Societal and Environmental Benefits provided by the Indian Forests
April 25–27 (held in New Delhi, India)
Council and External Relations

CaspiLog II (Caspian Dialog)
May 07–09 (held in Baku, Azerbaijan)
Processes of International Negotiation

Vienna Environment on Human Security (VEHS) Side Event at CSD-15: "Energy Security through Lived Interdependence Contributions from the Vienna Environment on Human Security"; IIASA Presentation on Energy Security & Food Security
May 07 (held in New York, NY, USA)
General Research

Global Energy Assessment (GEA) Side Event at the 15th Session of the UN Commission on Sustainable Development (CSD-15)
May 07 (held in New York, NY, USA)
Global Energy Assessment

Global Energy Assessment Executive Committee Meeting
May 07–09 (held in New York, NY, USA)
Global Energy Assessment

PDMU 2007–Problems of Decision Making Under Uncertainties
May 21–25 (held in Kiev, Ukraine)
Integrated Modeling Environment

GEO-BENE Progress Meeting
June 04–06
Forestry

BIOS Workshop
June 07
Forestry

Council Committee Meetings
June 11
Council and External Relations

Water Science Day
June 11
Directorate

Council Meeting
June 12
Council and External Relations

Workshop: Negotiating with Terrorists II
June 27
Processes of International Negotiation

ASCS 2007
June 28 -29
Integrated Modeling Environment

PIN Steering Committee Meeting
June 28-29
Processes of International Negotiation

SAGE Handbook on Conflict Resolution Workshop
June 30–July 02
Processes of International Negotiation

GEA Council Meeting
July 02
Global Energy Assessment

GEA Executive Committee
July 03–04
Global Energy Assessment

Director Search Committee Meeting and Candidate Interviews
July 09 -13
Council and External Relations

PLUREL Module 1 meeting
July 17-18 (held in Vienna, Austria)
World Population

Adaptive Speciation Theory Meets Population Genetics–Mini-symposium held at The Joint Annual Meetings of the Society for Mathematical Biology and the Japanese Society for Mathematical Biology (SMB/JSMB 2007)
August 03 (held in San Jose, CA, USA)
Evolution and Ecology

IIASA Days in South Korea
August 20–21(held in Seoul, Republic of Korea)
Directorate

CSM'2007–The 21st Workshop on Complex Systems Modeling
August 27–29
Integrated Modeling Environment

IIASA-Tokyotech Workshop on Hybrid Management of Technology in the 21st Century
September 08–09
General Research

MicMac Meeting on Assumptions on Future Mortality and Morbidity Trends in Europe
September 10–11
World Population

Seventh IIASA-DPRI Forum on Integrated Disaster Risk Management
September 16–21 (held in Lake Maggiore, Italy)
Risk and Vulnerability

Preparatory meeting for ICR (Insurance Instruments for Adaptation to Climate Extremes) Workshop and to host the Fall MCII Strategic Meeting
September 23
Risk and Vulnerability

Insurance Instruments for Adaptation to Climate Extremes
September 24–25
Risk and Vulnerability

2nd International Workshop on Uncertainty in Greenhouse Gas Inventories
September 27–28
Forestry

Size-structured Population Models
October 17 -19 (held in Umeå, Sweden)
Evolution and Ecology

TF HTAP Emissions Inventory and Future Projections Workshop
October 18–20 (held in Beijing, China)
Atmospheric Pollution and Economic Development

Pandemic Influenza in China: Challenges, Responses, Needs Roundtable Workshop
October 18–23 (held in Beijing, China)
Health and Global Change

PIN Roadshow
October 27–28 (held in Nanjing, China)
Processes of International Negotiation

IIASA Water Dialogue Meeting
October 29–30 (held in Vienna, Austria)
Council and External Relations

PIN Steering Committee Meeting
October 29–31 (held in Nanjing, China)
Processes of International Negotiation

Council Committee Meetings
November 12
Council and External Relations

Council Meeting
November 12 -13
Council and External Relations

PIN Steering Committee Meeting
November 14–17 (held in Paris, France)
Processes of International Negotiation

IIASA Conference '07 "Global Development: Science and Policies for the Future"
November 14 -15
General Research

IIASA Post Conference Meeting Events
November 16
Directorate

Science Advisory Committee Meeting (SAC)
November 16
Council and External Relations

1st GEO-BENE Annual Meeting
November 19–20
Forestry

Task Force on Integrated Assessment Modelling and COST 729 Action–Workshop on Integrated Assessment Modelling of Nitrogen
November 28–30
Atmospheric Pollution and Economic Development

ACCENT Workshop on Remote Sensing and Inventories of Anthropogenic Emissions: The best of two worlds
December 04–05
Atmospheric Pollution and Economic Development

IFIP/IIASA/GAMM Workshop on Coping with Uncertainty (CwU) Robust Decisions
December 10–12
Integrated Modeling Environment

2007 IIASA Guest Lectures

19-DEC-07, **Prof. Boris Peltsverger**, Dean, School of Computer and Information Sciences Georgia Southwestern State University, "Role of Monitoring and Prediction in Protection of Criticial Infrastructures"

19-NOV-07, **Dr. Allen Solomon**, National Program Leader, US Forest Service, "US Forest Service Research in Global Change: Current Activities and Future Directions"

06-NOV-07, **Mr. Giang Thanh Long**, Research Fellow, National Graduate Institute for Policy Studies (GRIPS), "Aging, Poverty, and the Role of Social Pension in Vietnam"

16-OCT-07, **Dr. Myriam Dunn** and **Dr. Victor Mauer**, ETH - Swiss Federal Institute of Technology, Center for Security Studies, "The Origin and Evolution of Critical Infrastructure Protection as a National Security Issue"

20-SEP-07, **Prof. Daniel Dolk**, Naval Postgraduate School (IS/Dk) GSOIS/Information Sciences, "Aspects of Next Generation Modeling (The fourth talk in the Foundations of Modeling seminar series)"

17-SEP-07, **Mr. Evan D. G. Fraser**, Lecturer/Assistant Professor, Sustainability Research Institute (University of LEEDS), "Using past climate variability to understand how food systems are resilient to future climate change (Evan Fraser to present)"

27-JUL-07, **Dr. Nico Bauer**, Potsdam Institute for Climate Impact Research (PIK), "The Theoretical Relationship between Bottom-Up and Top-Down Models"

09-JUL-07, **Prof. Hans-Peter Nachtnebel**, University of Natural Resources and Applied Life Sciences, "Assessment of Climate Change Impacts Considering Different Scales"

15-JUN-07, **Dr. Jeff Broadbent**, Dept. of Sociology, University of Minnesota, "Comparing social capital networks in labor policy formation in Germany, the US and Japan"

14-JUN-07, **Dr. Jeff Broadbent**, Dept. of Sociology, University of Minnesota, "The issue of climate change and policy networks"

13-JUN-07, **Prof. Victor Kremenyuk**, Russian Academy of Sciences, PIN SC member, "Human Security and International Negotiations"

21-MAY-07, **Mr. Weine Genfors**, Head Business Unit Plantations, StoraEnso Forest Central Europe GmbH, "StoraEnso going south--why, where and consequences for the European Operations"

14-MAY-07, **Dr. Rajgapala Chidambaram**, Chairman of TIFAC and Principal Scientific Advisor to Govt. of India, Scientific Advisory Committee to the Cabinet, "India's Technology Needs and Science Policy"

30-APR-07, **Mr. Walter Short**, Principal Researcher, National Renewable Energy Laboratory, "NREL's WinDS and SEDS Energy Models"

18-APR-07, **Prof. Ramaswamy Iyer**, Honorary Research Professor, Centre for Policy Research (CPR), "Water policy and science"

05-MAR-07, **Dr. Lindsey Rustad**, Forest Ecologist, USDA Forest Service, "A Multi-faceted Approach to Understanding the Effects of Global Change on Terrestrial Ecosystems - A View from Northeastern North America"

31-JAN-07, **Dr. Richard Dawson**, Core Researcher, School of Civil Engineering and Geosciences, "Simulation and Scenario Analysis to Support Strategic Flood Risk Analysis in the UK"

15-JAN-07, **Dr. Stacy vanDeveer**, Associate Professor, UNH Media Relations, "Knowledge for Policy: Assessment Lessons and Scenario Questions"

15-JAN-07, **Dr. Simone Pulver**, Assistant Professor, Watson Institute, Brown University, "Knowledge for Policy: Assessment Lessons and Scenario Questions"

09-JAN-07, **Dr. Volker Krey**, Research Centre Juelich, Systems Analysis & Techn. Evaluation, "Stochastic Energy Prices in an Energy Systems Model"

2007 IIASA Publications, by Research Program

Atmospheric Pollution and Economic Development (APD)

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Wagner F, Hoeglund Isaksson L, Cofala J & Amann M (2007). Sweden in 2020: Emissions of CO_2 and Air Pollutants for Different CO_2 Reduction Targets. Final Report submitted to the Swedish Environmental Protection Agency, Stockholm, Sweden.

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2007 Personnel Resources per IIASA Program

Program*	Total Person Months of Effort**
Atmospheric Pollution & Economic Development	152.8
Evolution and Ecology	123.5
Forestry	214.3
Land Use Change and Agriculture	114.6
Processes of International Negotiation Network	3.0
Population and Climate Change	44.5
Risk and Vulnerability	105.4
World Population	86.9
Dynamic Systems	62.7
Environmentally Compatible Energy Strategies	0.0
Energy	80.0
Transitions to New Technologies	36.2
Health and Global Change	17.7
Integrated Modeling Environment	38.3
Greenhouse Gas Initiative	115.8
General Research	29.3
Institute Scholars	16.8
Grand Total	**1,241.8**

*This list follows the same order as programs appear in the Progress Report.
**Scientific personnel only, not administrative/support staff.