IIASA PROGRESS REPORT

Progress Report
to IIASA's National Member Organizations
and Governing Council on IIASA's Research
and Other Activities in 2011

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Contents

Introduction

As outlined in last year's Progress Report, formal implementation of the IIASA Strategic Plan 2011–2020, "Research for a Changing World," began on 1 January 2011. Now, well over a year later, we are in a position not only to look back at the progress made in this inaugural year but also to assess any modifications and calibrations needed to keep IIASA's ambitious research on track and bring it to fruition.

Having completed four months as IIASA's Director as this report starts to take shape, I would like to thank my predecessor, Detlof von Winterfeldt, for the contribution he made to the work on the Strategic Plan and to his drive to begin implementing what is undoubtedly a complex program of work for a challenging few years ahead.

The transformations taking place across the world was one of the reasons why IIASA structured its research to address the global problem areas of Energy and Climate Change, Food and Water, and Poverty and Equity. The three main drivers of transformations and their interactions—people, technologies, and economic growth—are also integrated into our research, and overarching the whole is the requirement that our research be "applied," in other words, policy-relevant.

I am confident that our collective research vision for this coming five years, namely, to work toward resolving some of the world's most intractable problems, is a sound one and that we do indeed have the structure, the skills, and the tools at IIASA to make it happen.

Research Approach

IIASA has the key advantage of an in-house Advanced Systems Analysis Program (ASA). Many research organizations today successfully analyze systems, but IIASA also has the capacity to construct new research tools as the necessity arises or to integrate existing tools to reach freshly defined objectives. Modified or new tools can prize valuable information from "old" data, or even fill data gaps, as the World Population Program (POP) has already demonstrated with its sophisticated multi-state population projections. When used in the context of integrated, interdisciplinary systems analysis, they can also be used to examine the often "hazy" areas where disciplines or initiatives intersect and overlap, yielding fresh insights that can spur research to a higher level.

One of the most remarkable insights gained through the use of advanced systems analysis at IIASA has been the discovery of the co-benefits of tackling related research problems simultaneously, which the Mitigation of Air Pollution and Greenhouse Gases Program (MAG) has pioneered with its GAINS model. The holistic approach is being used by other programs at IIASA to widen and deepen their understanding of what the data are telling us.

Along with technical expertise, IIASA is also demonstrating how human communication can help address development challenges. The Risk, Policy and Vulnerability Program (RPV) has been working with stakeholders to understand the human concerns behind development problems and to formulate policy advice based on these, for example, how best to communicate the benefits of insurance to farmers in the developing world. In 2011 methodologies field-tested among communities in France, Hungary, and Italy have provided the foundations for extending this approach to nations in the developing world: India, Bangladesh, Uganda, and Bolivia.

Major Scientific Collaborations, 2011

Throughout this Report, references will be found to members of IIASA's enormous network of scientific collaborators, ranging from states through research bodies to individual scientists and even members of the public.

National Member Organizations

The year 2011 marked the start of the membership of IIASA of the Center for Strategic Studies and Management in Science, Technology and Innovation (CGEE) of Brazil and the Academy of Sciences Malaysia, bringing the number of IIASA's national member organizations (NMOs) to 18. In welcoming them, I would like to acknowledge the contribution of all our NMOs for their funding and research initiatives which allow IIASA to conduct the impartial research for which it is renowned.

The Global Energy Assessment

Over five years in the making and bringing together hundreds of the world's leading experts across the entire gamut of energy issues, the Global Energy Assessment (GEA) was initiated by IIASA and its partner organizations; it is hosted at IIASA, and it contains important contributions from our scientists, especially those in the Energy (ENE) and the Transitions to New Technologies (TNT) programs. In 2011 the GEA was readied for publication by Cambridge University Press and it will be launched at Rio+20 in 2012.

The GEA addresses all the major contemporary energy challenges in an integrated and comprehensive fashion. The scope of the research and information it contains, plus the fact that it has been structured to reflect the requirements of policymakers and energy stakeholders, will make it a major work of reference for these communities in their efforts toward sustainable development.

The work carried out by IIASA for the GEA has been rewarding in terms of generating "spin-offs" for in-house research and informing other work, for instance, research for the upcoming Fifth Assessment Report of the IPCC.

The IPCC/UNFCCC Process

One of the main activities of the Intergovernmental Panel on Climate Change (IPCC) is to publish special reports on topics relevant to the implementation of the United Nations Framework Convention on Climate Change (UNFCCC)—the IPCC/UNFCCC

Process. Since the start of the Process over 20 years ago, IIASA scientists have made noteworthy contributions to its scientific underpinnings, including much of the foundation work on scenario development.

When the IPCC handed over responsibility to the scientific community for the next generation of scenarios for the Fifth Assessment Report (AR5), due for publication in 2014, IIASA co-founded the Integrated Assessment Modeling Consortium (IAMC) to coordinate the work involved. To expedite the modeling process for AR5, IAMC stipulated a new set of greenhouse gas concentration trajectories to replace the traditional scenarios. The Representative Concentration Pathways (RCPs) are based on range of radiative forcing values in the year 2100 (2.6, 4.5, 6.0, and 8.5 W/m^2, respectively). RCP 8.5 has been developed by Keywan Riahi and his team in the IIASA Energy Program using the MESSAGE model. RCP8.5 has been further developed through 2011.

The IAMC promotes, facilitates and helps to coordinate interactions between IAMC members and members of other scientific research communities studying climate change such as the Climate Modeling (CM), the Impact, Adaptation, and Vulnerability (IAV), and the technology and engineering communities. As with previous assessment reports, intensive consultations with other experts in the research community ahead of writing for the AR5 and its summary for policymakers have been an integral part of IIASA scientists' work in 2011.

IIASA also contributed to numerous reports and assessments leading up to the 17th Conference of Parties (COP17) to the UNFCCC held in Durban in December 2011, as part of the IPCC work. Among the most relevant publications were:

- "The Integrated Assessment of Black Carbon and Tropospheric Ozone," an integrated assessment by UNEP and the WMO, was based on mitigation measures identified using the IIASA GAINS model. Using the GAINS model and other tools, it outlines 16 measures that could reduce global warming, avoid millions of premature deaths, and reduce global crop yield losses by tackling black carbon, methane, and ground-level ozone.
- The Summary for Policymakers of an IPCC Special Report "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)" was coauthored by IIASA's Reinhard Mechler. The report assesses changes in climate extremes, exposure and vulnerability, and provides input to decisions on early warning, land use, infrastructure planning, public health, and insurance. Other IIASA contributors to the Report include Joanne Bayer and Stefan Hochrainer.
- IIASA's Volker Krey, Keywan Riahi, Yu Nagai, and several GEA Lead Authors are among contributors to the IPCC Special Report on Renewable Energy, the Summary of which was approved by governments at the 11th session of IPCC Working Group III, 5-8 May. The Report outlines the potential role of renewable energy in mitigating climate change and will inform the IPCC AR5.
- IIASA and the German Advisory Council on Global Change (WBGU) hosted a side event at COP17 at which IIASA's Nebojsa Nakicenovic and Michael Obersteiner outlined integrated energy and land use policy and management options to "achieve a global transformation towards a climate-friendly, sustainable future." Nakicenovic also contributed to "World in Transition. A Social Contract for Sustainability."
- The Geo-Wiki project of Ecosystems Services and Management (ESM) is proving to be a major scientific collaboration in the social networking sense, bringing together a global network of volunteers who wish to help improve the quality of global land cover maps. Volunteers are asked to review hotspot maps of global land cover disagreement and determine, based on what they actually see in Google Earth and their local knowledge, if the land cover maps are correct or incorrect. Their input is recorded in a database, along with uploaded photos, to be used in the future for the creation of a new and improved global land cover map. The concept was extended in 2010 to human impacts, biomass, regional, and urban information validation.
- IIASA researchers contributed to the International Energy Agency's World Energy Outlook 2011 with an assessment of global emissions of major air pollutants under three different scenarios. IIASA's report, based on the GAINS model, projects emissions to 2035 for 25 regions and demonstrates the synergies between climate change and air pollution control policies.

As noted, in 2011 GAINS was used to conduct a comprehensive global assessment of short-lived climate forcers, like black carbon, tropospheric ozone, and methane, having been extended by MAG for this purpose. The emphasis on short-lived climate forcers in the IPCC-related literature in 2011 is an interesting one. As air pollution reduction is measurable and visible in the short term and reduces GHGs in the long term, the concept of air pollution reduction is expected to find resonance among decision makers. The new emphasis could be particularly significant for future climate change policies, given the international community's difficulties in agreeing a successor to the greenhouse-gas-centric Kyoto Protocol.

Worldwide Fund for Nature

IIASA research using ESM's GLOBIOM model underpinned the 2011 "Living Forests Report" of the Worldwide Fund for Nature. The report is based on a new global analysis indicating that more than 230 million ha of forest will disappear by 2050 if no action is taken. The report proposes a goal of zero net deforestation and forest degradation by 2020 as a global benchmark to avoid dangerous climate change and curb biodiversity loss.

Max Planck Institute/PwC

RPV's Anthony Patt and Johan Lilliestam co-authored the report "Moving towards 100% renewable electricity in Europe and North Africa." The study, in conjunction with the Max Planck Institute and PwC, assesses whether political and policy developments over the last year support a transformation of the energy system. Positive trends are seen in renewables capacity, market integration and political commitment to renewable electricity.

The Wittgenstein Centre for Demography and Global Human Capital

Another major collaborative venture was launched early in 2011, with the establishment by POP, the Austrian Academy of Sciences, and the Vienna University of Economics and Business of the Wittgenstein Centre for Demography and Global Human Capital.

The new Centre has been funded in part through ERC Grants and the Wittgenstein 2010 Award to Professor Wolfgang Lutz. It aims to be a leader in the demographic analyses of human capital formation and its impact on society, the economy, and the environment. Amid concerns about the capacity of the planet to support more people, the Wittgenstein Centre in 2011 issued "The Laxenburg Declaration," arguing that the number of people in the world is less important for sustainability than their age, education, health status, and location.

Partners on the Road to Rio

Major preparations have been carried out for the Rio+20 Conference on Sustainable Development, now only 62 days away as I write this Introduction. The major topics of debate at Rio are closely interwoven with the themes of our research plan, and as mentioned above the Global Energy Assessment will be a major platform for IIASA at Rio.

Specifically, the Energy Program (ENE) and the UN Department of Economic and Social Affairs hosted an Expert Group Meeting on Sustainable Development Scenarios for the 21st century where participants from many of the world's leading scenario development teams explored areas such as climate, water, land use, the MDGs, and energy, with the objective of defining a scenario framework to support RIO+ 20 objectives.

Nebojsa Nakicenovic has been appointed to the Technical Group of the UN Secretary-General's (SG) High-level Group on Sustainable Energy for All. The Group will develop a Global Strategy for launch by the SG at the RIO+20 Summit. The Nakicenovic appointment is part of an ongoing and burgeoning relationship with many United Nations agencies to which IIASA can contribute advanced scientific skills.

Diplomatic Contacts

IIASA maintains close contact with the diplomatic representative of the countries of National Member Organizations.

Other diplomatic contacts in 2011 included the visit of the Deputy Prime Minister, H.E. Prof. Dr. Nguyen Thien Nhan, of the Socialist Republic of Vietnam to IIASA as part of an official visit to Austria that focused on science and technology. The delegation, which also included Vietnam's Minister of Science and Technology and senior officials from Government and academia, were briefed on IIASA's strategic plan and current research.

Nebojsa Nakicenovic joined the Austrian Federal Ministry for Science and Research Delegation to Buenos Aires (24-26 May). The Delegation was hosted by the Argentinean Ministry of Science, Technology and Productive Innovation as part of a joint strategy to increase research cooperation between these countries. Nakicenovic provided briefings on energy perspectives and on IIASA.

Publications

In 2011 IIASA had its most successful year to date in terms of scientific publishing. The Institute's researchers published 158 journal articles (143 in 2010) recognized by the independent database of peer-reviewed literature, SCOPUS. Citations of IIASA articles have also continued to increase significantly reaching 5151 in 2011 up from 4068 in 2010.

The highlights, which follow, provide an insight into the diversity of the research being conducted at IIASA:

- *Nature* published the findings of a study by IIASA's Wilfried Winiwarter and Zbigniew Klimont on the impacts of nitrogen, which is essential for food production, but is contributing to climate change and biodiversity loss, costing the EU between €70-€320 billion annually in pollution terms.
- A special issue of *Energy Economics*, "The economics of technologies to combat global warming," was edited by IIASA Deputy Director and energy economist Nebojsa Nakicenovic and Yale University's William Nordhaus. The papers included point to the need to "develop and deploy alternatives to existing technologies on a very large scale."
- *Science* published a new study by IIASA's Ecosystems Services and Management scientists and an international team of researchers, based in part on IIASA boreal forests research, which found that forests absorb about 2.4 billion tons of atmospheric carbon annually, removing about one-third of fossil fuel emissions.
- *Science* published a study by IIASA's Wolfgang Lutz and Samir K.C. showing that projections of future population trends that do not explicitly include education in their analysis may be flawed.
- A special issue of *Current Opinion in Environmental Sustainability* was edited by IIASA's Shonali Pachauri. It explored many aspects of energy including: the scale of the energy access challenge, gender dimensions, and financing options to ensure the sustainability of energy access efforts. A special issue of *Energy Policy* on Clean Cooking Fuels and Technologies in Developing Countries was co-edited by IIASA's Shonali Pachauri.
- A special issue of *Climatic Change*, co-edited by IIASA's Keywan Riahi, gave a detailed overview of the "Representative Concentration Pathways" which will be used in the forthcoming AR5 of the IPCC.
- The *Proceedings of the National Academy of Sciences* published details of a new study by IIASA's Vegard Skirbekk which found that as memory recall is better in countries with higher education and health standards, those countries most burdened by aging may be those where cognitive levels among seniors is poor, not simply those who are chronologically older.

Outreach and Training

Young Scientists Summer Program

IIASA's annual Young Scientists Summer Program offered research opportunities to 55 young scientists from 27 countries whose interests corresponded with IIASA's research programs.

From June through August accepted participants worked under the guidance of IIASA scientific staff.

The YSSP is open to post-graduate research students from IIASA's National Member Organization countries. In 2011 for the first time, IIASA's fundraising efforts through the Annual Fund were able to sponsor three students who would not normally be eligible for a place on the YSSP program.

The young scientists enliven the atmosphere at IIASA each summer with their enthusiasm and new ideas, with the combined youth and experience contributing new ideas and angles to the research mix in general.

Postdoctoral Program

The number of postdoctoral fellowships offered at IIASA will depend on research needs and funding. IIASA offers one to two year postdoctoral scholarships to bridge the gap between the academic and work environments. After a competitive selection process, Narasimha Rao from the United States and Christina Kaiser from Austria were awarded IIASA's 2011 Post Doc Scholarships, which will allow them to conduct research relevant to IIASA's research agenda. Rao will work with IIASA's Energy Program, and Kaiser will do research with the Evolution and Ecology Program.

Workshops

Workshops are an important element of outreach and training by IIASA. The following are highlights from 2011.

A workshop to integrate current theories of biodiversity and speciation was held in Keszthely, Hungary, co-organized by IIASA's Evolution and Ecology Program as part of the European Networking Programme on Frontiers of Speciation Research, the Niche Theory and Speciation Workshop. It featured contributions by 45 researchers from Europe and the USA.

An international workshop was co-organized by IIASA at Tsinghua University, Beijing, in collaboration with Toyota, Tsinghua University (China) and TERI (India). The workshop demonstrated a model which uses data derived from IIASA GAINS to analyze and predict tropospheric ozone concentrations across South and East Asia.

A workshop, organized by the Russian Academy of Sciences and the National Academy of Sciences of Ukraine, used systems analysis to explore the future co-development of the Russian and Ukrainian socio-economic systems. IIASA's Arkady Kryazhimsky and Anatoly Shvidenko presented how IIASA's new research agenda can contribute to such development at the event.

In conclusion, I would like to point the reader to the ensuing pages which provide an overview and highlights of the programmatic work at IIASA in 2011.

I would finally thank all those at IIASA, including Council members, senior management, and staff who have made my first months here so enjoyable. I look forward to working with you all in the coming years in this challenging and invigorating environment.

Professor Dr. Pavel Kabat
Director/CEO
May 2012

Research Areas

IIASA Research Areas: 2011

Background

The IIASA Progress Report is published each year to advise stakeholders on the progress of work conducted by scientists in pursuance of the Institute's ten-year Strategic Plan (2011–2020) and associated Research Plan (2011-2015).

The Strategic Plan was drawn up after 18 months of intensive analysis on the part of the IIASA Directorate, Council, and senior scientists to assess how challenges confronting the human and natural world are likely to unfold over the decade ahead. It identifies three overall global problem areas for IIASA to focus its research expertise:

1. Energy and Climate Change;
2. Food and Water; and
3. Poverty and Equity.

The following research area pages outline how work from IIASA programs feed into all three of the global problem areas. The Energy Program and the Mitigation of Air Pollution and Greenhouse Gases Program have a primary focus on the interactions between energy production, greenhouse gas emissions and climate change, but their research also addresses energy access of the poor and the impacts of energy policies such as biofuels and hydroelectric development on food and water. The Ecosystems Services and Management Program, the Evolution and Ecology Program and the nascent Water Program are studying the systems that are relevant to ensuring food and water security as well as examining the impacts of climate change on the ecosystem and on food and water supplies, particularly in developing countries. The Risk, Policy and Vulnerability Program and the World Population Program conduct research related to poverty and equity, but both cut across the problem areas with interests in vulnerability to disasters and climate change and issues of population growth, education and migration in the world's most vulnerable regions. The Transition to New Technologies Program is closely aligned to the energy and climate change area, but the program scope will expand to include technologies for improving water and food security.

In addition, underpinning the research of the three global problem areas are IIASA's key strengths in:

1. Analyzing the most important drivers of global transformations including population growth and migration; technological change; and economic development;

2. Advanced systems analysis; and

3. Applying the research to policy (see Policy Impact section in each Research Program report).

Energy and Climate Change

Spurred by the start of IIASA's new strategic plan on 1 January 2011, a new generation of integrated energy decision-making tools based on the MESSAGE model came on stream. Developed in collaboration between the Energy (ENE) and Advanced Systems Analysis (ASA) programs, the new tools have contributed to a large ensemble of scenarios and methodologies used for ENE research in 2011.

In the Mitigation of Air Pollution and Greenhouse Gases (MAG) Program, research using the GAINS model in 2011 focused on reducing short-term climate forcers such as black carbon (soot), ammonia, and tropospheric ozone. Reduction of these pollutants, which are shorter-lived in the atmosphere than greenhouse gases, represents an attractive, tangible policy option for short-run climate change mitigation.

One of the most remarkable insights gained through the use of advanced systems analysis at IIASA has been the discovery of the co-benefits of tackling related research problems simultaneously, pioneered by the MAG Program using GAINS. The new ENE tools also represent a shift toward a more holistic approach. ASA in collaboration with ENE developed a Web-enabled interactive multiple-criteria analysis tool for simultaneous exploration of relations between the three main energy sustainability objectives—energy security, climate change mitigation, and the reduction of air pollution and its human health impact.

Studies by ENE, MAG, TNT, and ASA provided critical input to two sets of scenarios for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) and to international research efforts like the Global Energy Assessment (GEA).

Studies also reflect and contribute to many international policy initiatives. Three important "components" of ENE research—ensuring universal access to clean modern energy services, doubling the rate of improvement in energy efficiency, and doubling the share of renewable energy in the global energy mix—were brought to the table in the United Nations Secretary-General's "Sustainable Energy for All" Initiative (SE4ALL) by IIASA Deputy Director and ENE/TNT staff member Nebojsa Nakicenovic. Nakicenovic made major contributions to the work of numerous other international policy bodies in 2011.

Throughout 2011 Markus Amann and his team used the GAINS model to inform renegotiation of the 1999 Gothenburg Protocol to the UN Convention on Long-Range Transboundary Air Pollution. GAINS calculations were also used as input to other studies spearheaded by the international community.

Such high-level participation in international initiatives has a two-fold effect. It helps to showcase IIASA findings in top-level policy arenas and it also ensures that the research pathways undertaken at the Institute remain relevant to the most salient policy challenges of our time.

Following are four representative stories covering the work of the Energy and Climate Change Global Problem Area in 2011. Please refer also the Section on Poverty and Equity in this Annual Report for "Energy Poverty and Energy Access, and Wellbeing in Developing Regions," which highlights research by ENE scientists.

Pollution

GAINS research is effectively reframing the international climate debate, demonstrating that air pollution is no longer just an ancillary benefit of reducing greenhouse gas (GHG) emissions, but a key means of reducing GHGs in the shorter term.

In 2011 research conducted by IIASA's Mitigation of Air Pollution and Greenhouse Gases Program (MAG) using the GAINS model demonstrated a compelling way of promoting climate change mitigation in the shorter term through reduction of short-lived air pollutants.

In some countries, climate change mitigation ranks low on the policy agenda. Thus, implementing long-term measures against carbon dioxide and other greenhouse gases (GHGs) that remain in the atmosphere for decades can seem irrelevant, despite the powerful arguments in favor of "intergenerational" responsibility.

In common with GHGs, most air pollutants act as climate forcers, although on a shorter time scale (carbon dioxide, c. 100 years; methane, 12 years; soot, a few weeks). Mitigating air pollution thus not only reduces temperature increase in the near term but also has short-term tangible benefits that are highly relevant for local policy agendas: better human health and well-being, improved local environment, better food and energy security, and lower water demand.

Of the 2,000 options available in GAINS for improving air quality, MAG researchers identified 16 that, together, could reduce the global warming potential of short-lived air pollutants by up to 60 percent. These range from extended recovery of coal mine gas to mandatory installation of particle filters on diesel engines. The IIASA findings were the focus of a joint United Nations Environment Program–World Meteorological Organization research project "Integrated Assessment of Black Carbon and Tropospheric Ozone," published in February 2011.

NASA's Goddard Institute for Space Studies then modeled the 16 GAINS measures to identify those with the greatest climate benefits—14 in total. The results were widely reported, including in the 13 January 2012 edition of Science. Moreover, a new global climate initiative based on the 14 GAINS measures has just been announced by U.S. Secretary of State, Hillary Rodham Clinton.

Assessments

IIASA's participation in large integrated assessments has always had numerous beneficial "spin-off" effects, not only enlarging the body of data and knowledge available to scientists generally but opening up new research pathways for the Institute itself. International collaborations also foster working relationships

between IIASA and other research organizations and create the potential for future partnerships.

Three international-scale projects in the energy and climate change area continued or were consolidated in 2001:

- The Mitigation of Air Pollution and Greenhouse Gases Program (MAG) in 2011 continued to develop a new series of emission control scenarios, using the GAINS model, to inform negotiations to revise the 1999 Gothenburg Protocol to the Convention on Long-range Transboundary Air Pollution, which set 2010 emission ceilings for sulfur dioxide, nitrogen oxides, volatile organic compounds, and ammonia. MAG was appointed as Centre for Integrated Assessment Modelling (CIAM) for the negotiations in 2007 and will make presentations to negotiators in 2012. The new Protocol will be the first international agreement to address reduction of short-lived climate forcers, like black carbon.
- The IIASA Energy Program (ENE) continued to play a leading role in 2011 in developing a new international policy framework for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5), which will update knowledge on the scientific, technical, and socioeconomic aspects of climate change for the scientific community and for policymakers. In 2011 the Representative Concentration Pathways (RCPs) were finalized and ENE began work with the World Population Program (POP) and Ecosystems Services and Management Program (ESM) on one of the Socioeconomic Pathways underpinning AR5.
- The Global Energy Assessment (GEA) was finalized for publication by Cambridge University Press in 2011 for launch at Rio+20. The GEA, which comprises 24 peer-reviewed chapters and took five years to complete, aims to transform the global energy debate. It urges radically improved energy efficiency, a major shift to sustainable energy sources, an end to the energy poverty of 3 billion people in developing countries, and promotion of new technologies and investment to support the transition from fossil fuels to renewables by 2050.

Technology

A major research theme of the Global Energy Assessment (GEA) is the promotion of innovative energy technologies and investment to support the transition toward improved efficiency of energy use and from fossil fuels to renewable energy sources by 2050.

The research for GEA Chapter 24 on Policies for Energy Technology Innovation Systems (ETIS) was coordinated by Arnulf Grubler of IIASA's Transitions to New Technologies (TNT) Program and included a team of 20 authors, many IIASA alumni or former participants in IIASA's Young Scientists Summer Program. Alongside a comprehensive literature review, the chapter also reports on new research performed by the writing team including the new conceptual systemic innovation model ETIS, 20 detailed case studies of technology policy successes and failures, and the first-ever comprehensive quantification of worldwide investments in energy technology innovation over all technology life cycle stages, across the full spectrum of energy supply and energy end-use technologies, and by both public and private sectors. A commercial book on the case studies is being prepared for Cambridge University Press, and summary papers have been accepted for publication in the high-level journals Nature Climate Change and Annual Review of Environment and Resources.

The research confirms that for technological innovation to fully support the transition to sustainable energy use, two predominant policy changes are needed. First, there must be an appropriate incentive environment for innovation adoption and phase-out of outdated technology vintages to complement traditional public sector R&D policies. Second, the critical importance of energy end-use technologies must be much better reflected in R&D budgets and market deployment incentives. The assessment also identifies the need for improved international coordination in technology research, given that the emerging economies are now outstripping traditional OECD countries in terms of energy technology R&D and investments.

The Chapter introduces the new concept of technological "granularity," emphasizing the importance of multiple, "small" (locally adapted), diverse solutions to problems even at the global scale, rather than single, large-scale, planetary solutions like geo-engineering or single-design nuclear fusion reactors. "Granular" technologies reduce the innovation and financial risks per project and allow significantly more experimentation and learning to take place compared to traditional, capital-intensive energy innovation projects.

New scenarios

As part of its research for the upcoming Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5), which is aimed at curbing climate change and its impacts, the Energy Program (ENE) in 2011 finalized work on the four Representative Concentration Pathways (RCPs), the results of which were published in a Special Issue of Climate Change, co-edited by ENE's Keywan Riahi. Riahi's MESSAGE modeling team developed the RCP 8.5 scenario of relatively high greenhouse gas emissions for the new RCP ensemble.

ENE also started work in 2011 on quantifying one of the five new Shared Socioeconomic Pathways (SSPs) which will be used with the RCPs to analyze feedbacks between climate change and socioeconomic factors, like world population growth, economic development, and technological progress. In the process, related issues like environmental status, effectiveness of national institutional efforts against climate change, and progress in poverty alleviation will come under the microscope.

To develop the new SSPs, ENE spearheaded a cross-program collaboration with IIASA's World Population (POP) and Ecosystem Services Management (ESM) programs. Integrated SSP scenarios were developed covering energy, land-use, and the social dimension of future transformations. ENE is also supporting the overall process by hosting the SSP database, which will become the major dissemination tool for SSP data.

The new two-pronged RCP/SSP framework is devised to reflect policymakers' shift in focus away from new climate change policies and toward comparison of the costs and benefits of different types of climate policy. The RCPs facilitate the work of

the climate modeling community (CM), while the SSPs will serve the integrated assessment modeling community (IAM) and the vulnerability, impacts, and adaptation (VIA) community. The overarching aim is to integrate, in a consistent and timely manner, the work of these three communities, whose research corresponds to the three main working groups of the IPCC.

Strengthening cooperation between these groups, and most importantly, facilitating and expediting the development of more consistent and comparable research within and across them, will take climate research through to AR5 and beyond.

Food and Water

The amount of land on Earth is finite. The demands we place on it are not.

By 2050 an extra three billion people will need sustenance from ever-dwindling land and water resources. While advanced technologies and agricultural intensification have successfully kept up with rapidly growing global food demand, this has occurred at the expense of massive land conversion and environmental deterioration. These changes mainly affect forest ecosystems, which provide more than three-quarters of the population's accessible freshwater. Competing demand for land in the form of increasing urbanization and the growing interest in biofuels for "green energy" are adding to these problems.

The Ecosystems Services and Management Program (ESM) is working with policymakers to facilitate development of sound land management, including the production of "green food." However, no aspect of land and water management stands alone. Interventions in one area can provoke multiple effects in others: some beneficial, some not. A radically improved understanding of the interconnecting and competing uses of land, water resources, and ecosystem services is needed to inform decision makers and stakeholders. To this end, more and highly detailed information is required about the current state of ecosystems and how they will change in the future as a result of human and natural interventions—deforestation, other changes in land use, more extreme climate patterns, and extreme events like wildfires.

In 2011 ESM continued to develop new methodological backgrounds and to make further improvements to the ESM Integrated Modeling Cluster. Efforts to collect new data and to verify existing data were also intensified. A new livestock module was added to the land-use model, GLOBIOM. A stochastic version of GLOBIOM was developed, with findings showing the adverse effects that introducing fixed biofuel targets would have on commodity price volatility. The BEWHERE model, which optimizes the size, location, and technology of bioenergy production plants, was upgraded and developed for more specific use.

Notably, the Advanced Systems Analysis Program (ASA) worked with ESM and the Evolution and Ecology Program (EEP) on adaptive forestry modeling, developing eco-evolutionary principles and mathematics for better predictions and optimal management.

With respect to data, ESM is developing Earth Observation Tools as a repository of the newest verified information on the extent, condition, vitality, and dynamics of ecosystems and related landscapes. It is also using innovative methods of data collection and verification drawing on social networking and crowd-sourcing tools like Geo-Wiki.

A new version of the Global Agro-Ecological Zones methodology was released, incorporating two important new global data sets on actual and potential crop yields, adding a new dimension to the array of agriculture and food-related models at IIASA.

EEP research on the evolutionary implications of fishing attracted great interest in 2011, resulting in invitations to senior scientists to expand its research results to broader groups of fisheries scientists, managers, and policymakers through international forums, workshops, and publications.

Forests and Land Use

An international analysis of deforestation by the World Wide Fund for Nature (WWF) indicates that over 230 million ha of forest will disappear by 2050 if no corrective action is taken. Research for the Report, "Forests for a Living Planet," was based on IIASA's G4M and GLOBIOM models developed by IIASA's Ecosystems Services and Management Program (ESM), both of which are part of the extensive suite of IIASA models and tools maintained by ESM.

The chapters are part of an ambitious WWF initiative to mark the 2011 International Year of Forests aiming for zero net forest loss deforestation and forest degradation (ZNDD) by 2020. They are being released on to the WWF Web site at regular intervals to maximize impact. Currently, three are available: the Introduction; Forests and Energy; and Forests and Climate, all of which are based on IIASA modeling.

ESM's modeling for the Report allows various global land-use scenarios to be explored. It calculates the effect on forests of forces such as population growth and consumer demand, and describes possible consequences for key areas such as food production, climate change, biodiversity, commodity prices, and economic development. The Living Forests Model features a reference Do Nothing Scenario and shows how this would change if measures were introduced to curb deforestation and forest degradation.

All data in the IIASA models are spatially explicit, with each data point anchored to a point of reference on a 1-50 km grid of the Earth's surface, and data derived from a number of different, frequently updated sources.

The Living Forests Model finds that achieving ZNDD is both possible and urgent, but a number of tough trade-offs will be required to make it happen. As well as the "big questions" such as maintaining biodiversity, safeguarding livelihoods, and mitigating global warming, individual choices on diet and lifestyle will also need to be questioned.

Yield gaps

In 2011 IIASA and FAO generated data sets using the newly released Agro-Ecological Zones (AEZ) methodology for use in global, regional, and national assessments of agricultural resources and potentials. GAEZ v3.0 provides a major update of data and extension of the methodology used in the 2000 and 2002 GAEZ releases. It incorporates two important new global data sets: actual yield and production; and the gaps between actual and potential yield and production.

The new data sets were made available from specially designated GAEZ Data Portals, accessible on the IIASA and FAO Web sites. These contain a wealth of spatial and tabular data covering five thematic areas: land resources, agro-climatic resources, agricultural suitability, yields, and yield gaps. The formal launch was at FAO in Rome in May 2012.

The Global AEZ system assists rational land-use planning on the basis of an inventory of land resources and an evaluation of the biophysical limitations and production potentials of land.

Being geo-referenced, GAEZ allows a user to identify agricultural zones across the globe that share similar ecological conditions and are producing the same crops using the same kinds of production system, but which do not have the same production levels. This means the reasons underlying lower production—inadequate or inappropriate agricultural practices, policies, institutions, support services and access to markets—can be pinpointed and dealt with. The potential exists to expand food production efficiently while limiting impacts on other ecosystem values.

In particular, given the scarcity of suitable resources in some regions, future demand and expected negative impacts of climate change, GAEZ would allow users to evaluate options for more widespread adoption of sustainable land and water management practices in agricultural systems at risk

The importance of GAEZ is reflected in a technology transfer agreement signed by FAO and IIASA, under which IIASA staff will hold workshops of the GAEZ v3.0 modeling framework and related databases at site at FAO HQ to facilitate application of the GAEZ modeling framework/software in FAO's project work and studies.

Fishing

Providing fishery managers with tools to evaluate the impacts of fisheries-induced evolution in their standard assessment practices has been a focus of the Evolution and Ecology Program (EEP) in 2011.

For several years, EEP scientists have highlighted that the pace of Darwinian evolution was being accelerated in oceans and lakes through large-scale fishing operations by commercial vessels and private anglers. Convincing fishery managers that fish are responding to fishing by evolving rapidly over decades, rather than slowly across the centuries, has been facilitated through EEP's steadfast contacts with the International Council for the Exploration of the Sea (ICES), the world's oldest intergovernmental organization concerned with marine and fisheries science.

In the context of an international ICES expert group, EEP scholars have been developing a practical framework for managers to conduct evolutionary impact assessments (EvoIAs) for the fish populations they oversee. The EvoIA framework represents the first effort to apply a structured approach to assessing the evolutionary consequences of fishing: it is based on four modules that enable managers to assess whether observed changes in fish populations are due to environmental change or are heritable, to study the consequences such changes have for stock dynamics, to account for their socioeconomic implications, and to optimize strategies for managing fish stocks accordingly.

The removal of larger, older fish from fish populations through large-scale fishing is shifting the evolutionary balance toward earlier reproduction. In the Northeast Arctic cod, for example, this has reduced the number of eggs a female produces in her first reproductive season by half over the last 75 years. The genetic changes induced by fishing are thus altering the potential "catch" for many years to come. This is especially worrisome since evolutionary decline is relatively fast, but recovery from it is much slower.

Many stakeholders benefit from sustainable fisheries through the provision of food, employment, revenue, and recreational services, including individual anglers, commercial fishing enterprises, coastal communities, consumers, tourists, and conservation groups. Coupling biological models of fish stocks with corresponding socioeconomic models, EEP's research helps to describe quantitatively what these different stakeholders derive from a fish stock, or will lose through its depletion, thus aiding decision makers with the challenge of reconciling interests among all stakeholder groups.

Putting land use right on the map

Many factors, like growing population, deforestation, changing diets, and urbanization, are putting unprecedented pressure on land resources, particularly land for agricultural production. Estimates regarding the extent of cropland areas range between 1.22 and 1.71 billion hectares—a wide margin of uncertainty. Achieving food security will depend on establishing the facts "on the ground," to optimize future land use planning.

The Ecosystem Services and Management Program (ESM) in 2011 continued its initiative to collect and improve data on land use. A 2011 ESM study on uncertainty in global land cover maps, published in Environmental Research Letters, was downloaded more than 500 times, putting it in the top 3 percent of downloads from the IIASA Web site.

ESM is leading the drive among research and national mapmaking communities to share data and products to cover medium-term needs until new and improved remote-sensing products start coming on stream in a few years' time. In 2011 five existing data sets for Africa—GLC-2000, MODIS Land Cover, GlobCover, MODIS Crop Likelihood and AfriCover—were combined by ESM and partners into a "synergy map" at 1 km resolution, where every pixel was compared or ranked to assess the likelihood or probability that it is cropland. The resulting cropland map has a proven accuracy of 83 percent, higher than the accuracy the single individual maps, but still leaving a 17 percent gap that ESM are attempting to narrow by involving the global scientific and lay community in data gathering and verification of land cover through the Geo-Wiki social networking tool, hosted at IIASA.

Volunteers review hotspot maps of global land cover disagreement and determine, based on what they see in Google Earth and local knowledge, if the land cover maps are correct or incorrect. Inputs are recorded in a database, and any photos are uploaded, so that a new and improved global land cover map can be created in future.

In 2011 ESM were appointed to lead the GEO sub-task on agricultural mapping which will lead to the next-generation global hybrid cropland map.

Poverty and Equity

The historical paradigm of economic growth as the dominant catalyst for development no longer bears close scrutiny. Poverty and equity are not just related to economics, but to low education level, poor health, degraded environment, and lack of access to resources like energy and water. Poverty and equity are therefore deeply cross-cutting topics, pervading every aspect of IIASA's research, from the theoretical to the practical.

A 2011 statement on sustainable development, issued by the new Wittgenstein Institute for Demography and Global Human Capital, founded by World Population Program (POP) Leader Wolfgang Lutz, called for the international community to place human beings at the center of sustainable development in accordance with the 1990 Rio Declaration. Education, particularly of women, as a means to improve human capital and wellbeing, is one of the main themes of population research at IIASA.

Wellbeing flows partly from improved employment opportunities, especially in developing countries. The Risk, Policy and Vulnerability Program (RPV) in 2011 researched potentials to deploy large-scale renewable energy capacities in North African countries and to assess the influence of technology transfer on socioeconomic development and jobs in the region. North Africa has one of the highest unemployment rates among young people and women in the world, and 42 percent of all employed earn less than US$2 a day.

The pioneering work RPV in the field of risk pooling and the use of insurance to offset the vulnerability of the poor has deepened understanding about the human and economic costs of disasters and the physical and social patterns that cause them. Joanne Bayer and Reinhard Mechler made a significant contribution to the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) of the Intergovernmental Panel on Climate Change (IPCC), with Mechler authoring the "Summary for Policymakers," published in 2011.

The Evolution and Ecology Program (EEP) used game theory in 2011 to look at the equitable governance of common goods, such as forests, fisheries, and the atmosphere. Research Karl Sigmund found that regulations to prevent the abuse of resources can emerge bottom-up, through agreements among stakeholders, or be imposed top-down, through the involvement of governing agencies. The challenge of "mechanism design" is to find ways in which the successful features of those approaches are best combined. Stakeholder consultations continue to be an important part of IIASA's research.

Underpinning work in the area of Poverty and Equity, the Advanced Systems Analysis Program (ASA) developed with RPV and EEP, respectively, new methodology for recognizing the precursors of extreme events and assessing the vulnerability of highly populated ecosystems to the degradation of one critical species.

Education benefits

Formal education has a positive influence on people's capacity to cope with and adapt to adverse climatic conditions, according to research conducted by the World Population Program (POP) in 2011. POP researchers are recommending that access to formal education be urgently promoted in areas where risk from climate change is greatest, especially as the benefits of education take a number of years to materialize.

POP uses its own "multi-state" approach to projections of fertility, mortality, and migration, with parameters including not only age and sex but also education attainment level. As level of education affects health, economic growth, and democracy, such projections provide a much more comprehensive picture of the when, how, and where of human well-being worldwide. They make policymakers aware of the double benefit of improving education levels in terms of increased economic prosperity and greater human well-being. Indeed, a study by IIASA's Wolfgang Lutz and Samir K.C. published in 2011 in Science shows that projections of future population trends that do not explicitly include education in their analysis may be flawed.

POP research in 2011 also showed the particular benefits of educating women. More educated women typically want fewer children and are better able to overcome obstacles to family planning. Universal secondary female education, POP research suggests, could lower population growth and ultimately break the vicious circle of poverty and is the best way of supporting efforts toward sustainable development.

In the final analysis, however, universal access to education is the key. A 2011 study of Pakistan showed that rapid population growth, a lack of education for males and females, and poor opportunities for young people in general are putting the country at increasing risk of political violence. On a positive note, Pakistan's increasingly favorable age structure means that, from 2025, it will have a large young labor force. If well educated, this labor force could be a major asset in terms of driving forward economic development.

Energy access

In 2011 Energy Program (ENE) scientists deepened their understanding of the causes of energy poverty. A new Web-based interactive energy access policy analysis tool (ENACT) was developed to help policymakers assess future policy choices and their effectiveness in achieving universal modern energy access goals by 2030. ENACT users can visualize the costs and benefits of specific policy choices and better understand their likely impacts on the development of future demand for and access to residential energy.

In Africa and two Asian regions alone, ENE researchers found that the total population dependent on biomass such as

dried dung, wood, and charcoal for cooking will rise from 2.2 billion in 2005 to 2.3 billion by 2030 unless there is improved accessibility to clean cooking fuel, for instance clean-burning liquefied petroleum gas (LPG). Implications of improved access to clean cooking fuels for wellbeing, in particular human health, and for greenhouse gas emissions were also assessed. Analysis of the future of electrification in developing countries, also indicate that over 800 million rural inhabitants of South Asia and sub-Saharan Africa are likely to remain unelectrified by 2030 without new targets.

Two journal special issues published in 2011, co-edited by ENE researcher Shonali Pachauri, explored numerous related themes. Papers in Current Opinion in Environmental Sustainability (COSUST) on "energy security and energy access— interconnected global challenges," looked at the scale of the energy access challenge, its gender dimensions, the challenges of rural electrification, and the financing required to ensure sustainable energy access. Papers in Energy Policy on "household cooking fuels and technologies in developing countries," focused on the use of clean cooking fuels and stove adoption in developing economies.

In 2011 two Young Scientists Summer Program (YSSP) participants worked on developing and refining the MESSAGE-Access model. A wider range of technical options for decentralized electricity supply for expanding access to electricity in South Asia were incorporated into the model. Regional coverage was also expanded, enabling policy scenarios for improved modern cooking fuels and stove access in China to be explored. Both YSSP projects culminated in papers that have been submitted for publication to international scientific journals.

Green jobs

IIASA's Risk, Policy and Vulnerability Program (RPV) in 2011 analyzed two initiatives to deploy large-scale solar and wind capacities in the North Africa countries from a technology transfer perspective: the public Mediterranean Solar Plan, which foresees deployment of 20 GW of renewable energies capacities, and the private Desertec Industrial Initiative, those long-term goal is to satisfy 15% of the Europe´s electricity demand by 2050. The research drew a distinction between vertical transfer—in which intellectual property and manufacturing capacity remains in industrialized countries—and horizontal transfer, in which manufacturing and development skills shift to the developing countries.

The process of transferring renewable energy technologies (RET) from industrialized to developing countries is essential for global reduction of greenhouse gas emissions and for much-needed job creation. North Africa has one of the lowest new job creation ratios in the world: unemployment actually increased after the Arab spring which, combined with increasing food prices, is contributing to poverty in the region.

The RPV research adapted a model of the U.S. National Renewable Energy Laboratory (NREL) according to the costs parameters and conditions in the North African region, such as construction and equipment costs as well as financing patters and wages. RPV found that deployment of renewable energies could begin to boost North African economies under horizontal technology transfer necessary to generate 700 TWh/y of electricity. If 40 percent of component manufacturing were local, then total, direct and indirect, job-years would be 430,000 and the induced employment will generate over 2 million job-years; if 100 percent local manufacturing, then 6 million job-years in induced employment would result. Over 20 years, this would lead to annual employment of between 100,000 and 300,000 people, while under vertical technology transfer, fewer than 100,000 job-years would be created. As a case study of Morocco by RPV suggests, if any country were to gain a disproportionate share of new investment, job creation would be substantial—enough to push the country towards the more service-oriented economy typical of industrialized countries.

Poverty traps

To escape poverty traps induced by natural disasters, low-income households need assistance from public and private partnerships informed by risk analysis and based on local needs. The Risk, Policy and Vulnerability Program (RPV) in 2011 analyzed the effects of systemic risk on the incomes and livelihoods of low-income households, including farmers, focusing on South Asia, one of the world's most disaster-prone regions.

A central question is how extreme events can trap people in poverty. The research focuses on assessing the type and scale of such poverty traps and identifying mechanisms to help overcome them. Of particular concern are the livelihoods of small farmers, for whom natural disasters are the primary sources of risk. Although many conceptual studies of poverty traps have been done, very few empirical and quantitative insights exist, and assessments have generally been based on deterministic analysis.

IIASA researchers Stefan Hochrainer and Reinhard Mechler, with regional collaborators, surveyed about 320 households in Uttar Pradesh, one of India's largest and poorest states, and facing a multiple climate hazards. Of the households surveyed, 53 percent lived below the poverty line defined by the Indian government, while 69 percent had a least one outstanding loan, and a quarter had no savings. During the 1998 Uttar Pradesh flood, losses affecting all income groups were 43 percent of total annual household income, but the very poor experienced losses of more than 70 percent.

With 73 percent of people reporting that their household income was insufficient for coping, researchers realized that much more comprehensive adaptation packages, combining risk reduction, risk financing and risk communication, were needed. To this end, recent model analysis by IIASA on coping with drought in Uttar Pradesh suggests that the greatest local and societal benefits are achieved through integrating micro-insurance with physical adaptation measures. People cope with drought more effectively if they are capacitated to irrigate fields to reduce the risks from commonly occurring, less-serious droughts and if subsidized micro-insurance is purchased to cover losses from rare but catastrophic droughts. The research shows, importantly, that farmers are in dire need of donor support for adaptation tailored to their specific needs and circumstances.

Research Programs

Advanced Systems Analysis

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Research Objectives

At the core of IIASA's research is advanced systems analysis, which uses mathematical models and analytical techniques to investigate complex systems with a focus on an integrated, interdisciplinary approach. The Institute has long been involved in developing new, more sophisticated methodologies for systems analysis so that better solutions to global problems can be found. The ASA Program aims to advance this type of research. ASA's overall objective is to achieve a cutting edge in systems analysis and to provide a substantial basis for tying together systems methods and applied research on global change. ASA's core themes include *Assessment of Dynamical Systems*; *Systemic Risks and Robust Solutions*; and *Integrated Modeling and Decision Support*. The ASA Program supports development of IIASA's Advanced Systems Analysis Forum.

Alignment with the Strategic Plan

Development of core methods and novel systems-analytic techniques will contribute to the area of Advanced Systems Analysis. Development of cross-cutting activities on economic growth will contribute to the area of Driving Forces of Global Transformation. Research on model integration, systemic risk in ecological networks, and food security will contribute to the area of Food and Water. Research on attainability of low-carbon economies and energy management will contribute to the area of Energy and Climate Change. Data harmonization methods and Web-based interactive tools will support research in the areas of Food and Water, and Energy and Climate Change.

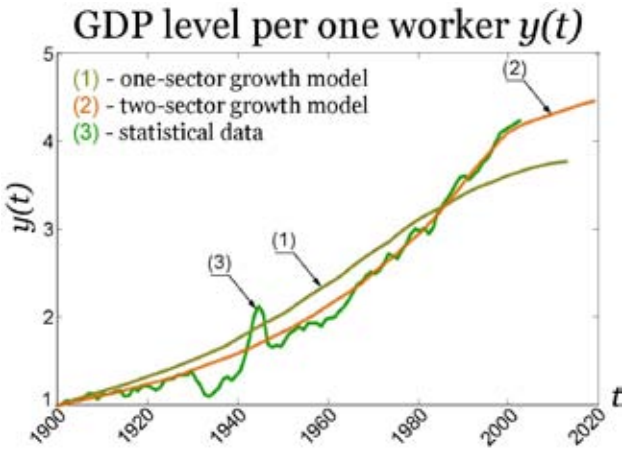

Figure 1. The US's optimal GDP-per-worker trajectories simulated using one- and two-sector economic growth models (in relative unites – ratios to the level of 1900).

Scientific Achievements in 2011

Assessment of Dynamical Systems

Global Economic Growth and Optimization

Infinite-horizon Optimal Control and Economic Growth Theory. In recent years, IIASA has developed a basic theory of infinite-horizon optimal control providing a set of tools for rigorous analysis of long-term macro-economic growth. In 2011 ASA researchers extended the theory to new classes of optimal economic growth problems. The theory was used to solve the problem of optimal management of a two-sector economy in anticipation of a random switch in the economy's structure.

Dynamic Optimization of Investment in Capital and Labor. ASA researchers carried out numerical analyses of one- and two-sector optimal growth models calibrated for several European countries, Japan, and the USA. *Figure 1* shows the optimal GDP-per-worker trajectories for the USA, simulated using the one- and two-sector models. The two-sector model exhibits a better fit with the data, although the qualitative behaviors are similar. Research was carried out in collaboration with the World Population Program (POP).

Length and Breadth of Optimal Innovation. The structure of economic innovations was explored. The expected duration of imitation of innovations was treated as an innovation length, and the profit share due to the imitation as an innovation breadth. A theoretic analysis showed that externality in production relative to R&D has a positive impact on innovation length and a negative impact on innovation breadth.

Global Optimization. A new successive optimization method for finding global solutions in a class of non-convex optimal control problems was proposed.

Management of Heterogeneous Dynamical Systems

Adaptive Forest Modeling. Eco-evolutionary Principles and Mathematics for Better Predictions and Optimal Management. Research focused on analysis of optimal long-term policy in forest management. The global stability of the steady state of the underlying model was stated. A stationary size-structured forest growth model incorporating a perfect plasticity phenomenon was designed and analyzed. Long-term economic benefit and ecological damage criteria were introduced; and a multi-criteria optimal forest management policy was characterized. Research was carried out jointly with ESM and EEP with support from the Greenhouse Gas Initiative (GGI).

Optimal Cycles in Crop Rotation and Carbon Stock Dynamics in southern Finland under Climate Change Scenarios. Options in adaptation to climate change at a farm level were explored using a long-term farmland management model. The study was supported by the Finnish Academy.

Systemic Risks and Robust Solutions

Drivers of Extreme Events

Recognition of Precursors of Extreme Events. A method for recognizing early warning signals in a time series preceding a collapse observed in the past is proposed. The method was applied to financial data series. The danger and safety signals were recognized using a time series preceding the "Dot Com" financial crisis of 2000-2001. The random signal generation model was identified based on a long data series of 1954-2000 and then used to assess, retrospectively, the probability of a financial crisis occurring in October 2008 . Starting from October 2007, the model showed a steady growth in that probability.

Systemic Risk and Network Dynamics. Research focused on assessment of expanding collapse in dynamical networks. Numerical experiments showed that highly populated ecosystems are likely to be vulnerable to the degradation of one critical species, whereas the system's connectivity may smooth out the vulnerability effect. *Figure 2* shows the result of collapse analysis of an ecosystem network. Research was carried out jointly with EEP.

Risk Management IME

Methods for Systemic Risk Management. New methods for comparative analysis of game-theoretic and decision-theoretic approaches in systemic risk management were proposed, and robust stochastic models for supporting policymaking in the areas of food, water, and energy security were constructed.

Energy Efficiency and Risk Management in Public Buildings. Within the framework of the EU-funded EnRiMa project, a requirement analysis for supporting decisions on robust energy-efficient and cost-effective energy use in public buildings was developed; a corresponding dynamic stochastic optimization strategic planning model was elaborated; and a Web-enabled decision support system engine supporting data warehousing for the whole corresponding modeling process was designed. Research was carried out in collaboration with ESM.

Integrated Modeling and Decision Support

Model Integration

Conditional Model Integration Analysis. Research focused on integration of random variables acting as models for a certain quantity estimated using different observation instruments. A conditional (Bayesian) random variable integrating the original models was defined. Analysis of the integrated random variable in simple cases reveals a threshold separating mutually compatible and mutually incompatible models. Conditional integration analysis was tested with stochastic models for net production of forests; the models turned out to be structurally compatible and the integrated model less uncertain than each one individually.

Integrated Modeling IME+BRIAN

Carbon Emission Trading under Uncertainties. In collaboration with the ESM and MAG programs, a multi-agent stochas-

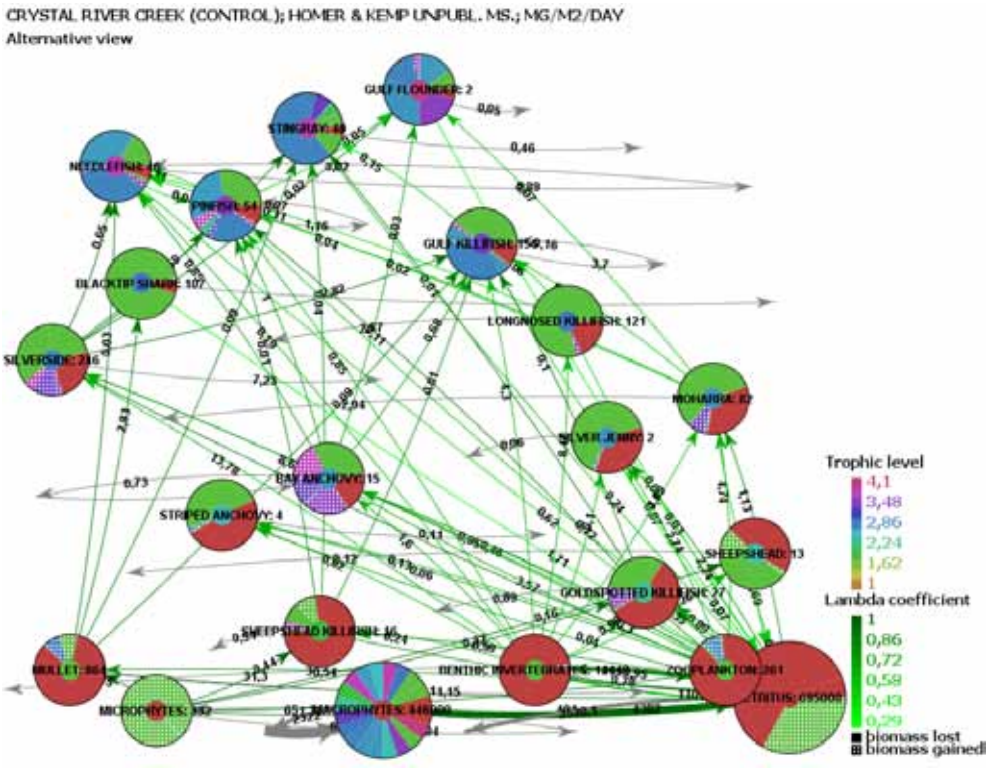

Figure 2. An example of the matrix of losses for an ecosystem network. The sizes of the circles represent the sizes of the biomass stocks of the network's species. The green arrows show the energy flows between the species. The background colors of the circles symbolize the species' trophic levels according to the scale given on the right. The sectors in each circle show the normalized relative losses of the corresponding species from collapse of the other species.

tic emission reduction model was developed. The model was used to find robust solutions by redistributing emission permits through trading under asymmetric information. A Web-enabled application supporting interactive analysis of these solutions was developed.

Multiple-Criteria Analysis for Energy Objectives. A Web-enabled interactive multiple-criteria analysis tool for simultaneous exploration of relations between three key energy sustainability objectives—energy security, climate change mitigation, and the reduction of air pollution and its human health impact, was developed. Research was carried out in collaboration with ENE.

Analysis of Discrete Choice Problems. A new method and a corresponding Web-enabled application were developed for analysis of discrete choice problems whose attributes are characterized by distributions of opinions rather than by crisp values. Research was carried out in collaboration with the Japan Advanced Institute of Science and Technology.

Network Analysis. Network methodologies were used to study urban metabolism for four cities in China. In this work, the urban energy transfers and transformations were modeled using a trophic structure paradigm showing that most cities have an inverted pyramid (unsupportable energy producers). An investigation into the ecological relations of the energy sectors showed they are not mutualistic systems, as is typically the case with ecosystems. Network analysis was applied to develop new ecological risk indicators. In a study on system resilience Holling's adaptive cycle was applied to ecosystem services and ecological orientors.

Advanced Systems Analysis Forum

Dream Valley. In this exploratory project, a goal is to develop a cross-disciplinary modeling and assessment framework for simulation of complex dynamical systems and testing methods for forecasting their future behaviors. In 2011 the pilot version of an agent-based Dream Valley model describing the dynamics of a regional socioeconomic-environmental system was constructed. The model simulates the states of the individuals who inhabit a certain geographic area and work at a factory located there. A factory produces goods, sells them on market, pays taxes to the government, and invests part of its income in capital accumulation. The production process pollutes the environment, which in turn harms people's health. The government uses the tax to support public health.

Policy Impact in 2011

(including lists of policy briefings given [written or at meetings], membership of policy-relevant committees)

Yuri Ermoliev: Participation in long-term activities aimed at supporting policymaking under uncertainties in Ukraine, organized by the Ukrainian Committee for Systems Analysis providing expertise for the design of governmental and regional programs in Ukraine.

Yuri Ermoliev, **Marek Makowski**, **Hongtao Ren**: (i) Input to the summary report on sustainability assessment of advanced electricity supply options, prepared as policy advice for the EU as the main outcome of the EU-funded project NEEDS; (ii) Web-based site for wide public participation in evaluation of future European energy technologies.

Brian Fath: (i) Baltimore County Commission on Environmental Quality (CEQ). 2005–present, Chair 2010–present; (ii) Co-author of a report dealing with Alternatives to Plastic Bag use. In response to an earlier report on Overuse of Salt for Road Clearing, the County Government has formed a task force looking in to a pilot project to reduce salt application (http://www.baltimorecountymd.gov/Agencies/ceq/currentprojects.html).

Arkady Kryazhimskiy: (i) Talk on perspectives for an IIASA-based project on socioeconomic development of Russia and Ukraine. Round Table "Socioeconomic Co-evolution of Russia and Ukraine: A Systems-Analytic Perspective", organized by the Russian and Ukrainian NMOs, with participation of representatives of the governments of Russia and Ukraine, Kiev, 14-15 April, 2012 (http://iasa.kpi.ua/pr/coev/); (ii) Invited expert's comments to the results of a strategic reflective game "Russia in World Projects". Seminar on Modeling and Co-development in a Multi-polar World, Analytic Center for the Government of the Russian Federation, Moscow, 19 May, 2011 (http://www.cea.gov.ru/includes/periodics/seminars/2011/0519/00007002/detail.shtml); (iii) Invited talk "Demand for Science: a Key Factor of Modernization." Round Table on Contribution of Russian-speaking Communities in Modernization of Russia, organized by the German Coordination Committee of Russian-Speaking Citizens under support of the Ministry of Foreign Affairs of the Russian Federation, Berlin, 25 November, 2011 (http://www.russkoepole.com/index.php?option=com_content&view=article&id=599%3Astol-berlin-25-11-11&catid=1%3Alatest-news&Itemid=18&lang=ru).

Elena Rovenskaya: Talk on Open Innovations; participation in expert sessions. International Youth Innovations and Technology Forum Seliger – 2011, Seliger, Russia, 5 - 8 July 2011 (http://www.interseliger.com/).

Activities for 2012

In 2012 ASA's activities will include development of *core methods* of systems analysis, *exploration* of novel systems-analytic techniques, and *applications* of systems analysis. In the area of core methods a focus will be on methods for assessment and control of long-term dynamics; global optimization; game-theoretic methods; multi-criteria analysis; dynamic recursive downscaling methods; and robust solutions methods. In the exploration area, ASA will concentrate on development of model integration techniques, and the ASA-Forum-based Dream Valley project that will combine agent-based modeling and forecasting tools with elements of artificial intelligence. In the area of applications, ASA will develop cross-cutting research activities on economic growth, including regional case studies (China; Russia and Ukraine, and, probably, India); carry out research on attainability of low-carbon economies (in collaboration with MAG), assessment of systemic risk, including applications to ecological networks (in collaboration with EEP and RAV), identify precursors of extreme events (in collaboration with EEP), forest management (in collaboration with ESM), energy management (in

collaboration with ENE), and food security (in collaboration with ESM); develop data harmonization methods (in collaboration with ESM) and Web-based interactive tools for multi-criteria analysis (in collaboration with MAG and ESM).

Personnel Resources

Scientific Staff

Arkady Kryazhimskiy (Russia), Program Leader
Elena Rovenskaya (Russia), Deputy Program Leader (42% p-t)
Sergey Aseev (Russia) (25% p-t)
Alexey Davydov (Russia) (8% p-t)
Brian Fath (USA) (29% p-t)
Hongli Ju (China)*
Masakazu Katsumoto (Japan) (10% p-t)*
Andrey Krasovskiy (Russia) (70% p-t)
Marek Makowski (Poland)
Tapio Palokangas (Finland)
Yulia Pavlova (Russia)*
Irina Petrenko (Russia)
Hongtao Ren (China)
Tatyana Shutkina (Russia)
Gerald Silverberg (USA) (20% p-t)*
Alexander Tarasyev (Russia) (17% p-t)
Stefan Thurner (Austria) (20% p-t)
Chihiro Watanabe (Japan) (10% p-t)*
Yurii Yermoliev (Ukraine)

YSSP

Jing Dai (China)
Matthew Lampert (USA)
Huayi Lin (China)
Alena Puchkova (Russia)
Weronika Radziszewska (Poland)
Shahriar Rahman Bangladesh
Tatyana Shutkina (Russia)
Rafal Ulanczyk (Poland)
Mar'yana Vakolyuk (Ukraine)

Administrative Support

Angela Dowds (United Kingdom)
Suchitra Subramanian (India)

p-t = part time; *Guest Research Scholar

Publications [1]

Journal Articles

*Aseev SM, Besov KO, Palokangas T & Ollus S-E (2011). Optimal growth in a two-sector economy facing an expected random shock. *Proceedings of the Institute of Mathematics and Mechanics, Ural Branch of Russian Academy of Sciences*, 17(2):271-299.

*Burkhard B, Fath BD & Mueller F (2011). Adapting the adaptive cycle: Hypotheses on the development of ecosystem properties and services. *Ecological Modelling*, 222(16):2878-2890 (24 August 2011) (Published online 9 June 2011).

*Carpio OV & Fath BD (2011). Assessing the environmental impacts of urban growth using land use/land cover, water quality and health indicators: A case study of Arequipa, Peru. *American Journal of Environmental Sciences*, 7(2):90-101 (26 May 2011).

*Chen S, Fath BD & Chen B (2011). Information-based Network Environ Analysis: A system perspective for ecological risk assessment. *Ecological Indicators*, 11(6):1664-1672 (November 2011) (Published online 13 May 2011).

*Chen S, Fath BD, Chen B & Su M (2011). Evaluation of the changed properties of aquatic animals after dam construction using ecological network analysis. *Procedia Environmental Sciences*, 5:114-119.

*Cutlip L & Fath BD (2011). Relationship between carbon emissions and economic development: case study of six countries. *Environment, Development and Sustainability*, Article in press(Published online 5 October 2011).

*Davydov AA & Platov AS (2011). Optimization of stationary solution of a model of size-structured population exploitation. *Mathematical Sciences*, 176(6):860-869 (August 2011).

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Book Chapters

*Ermolieva T, Ermoliev Y, Fischer G, Jonas M, Makowski M & Wagner F (2011). Carbon emission trading and carbon taxes under uncertainties. In: White T, Jonas M, Nahorski Z & Nilsson S (eds), *Greenhouse Gas Inventories: Dealing With Uncertainty*. Springer-Verlag, Dordrecht, Netherlands. [ESM, MAG]

Books

*Joergensen SE & Fath BD (eds) (2011). *Fundamentals of Ecological Modelling: Applications in Environmental Management and Research*. Elsevier, Amsterdam, Netherlands (28 February 2011).

Other Publications

IIASA (2011). New methods for managing water resources. *Options* (IIASA, Laxenburg, Austria), Summer 2011.

Kryazhimskiy A (2011). Early warning signals and binary classifications of historical paths (Lecture notes). Advanced School on Understanding and Prediction of Earthquakes and Other Extreme Events, 26 September - 8 October 2011, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy (4 October 2011).

Kryazhimskiy AV & Tarasyev AM (2011). Integrated socio-economic modeling for analysis of countries' sustainable development (Abstract). In: *Book of Abstracts*, ERA.Net RUS Brokerage Event, 28 February - 1 March 2011, Ekaterinburg, Russia.

Palokangas T (2011). International biodiversity management with technical change. Discussion Paper No. 330. HECER - Helsinki Center of Economic Research, University of Helsinki, Finland (May 2011).

Silverberg G (2011). Complexity and Co-evolution: Continuity and Change in Socio-economic Systems (Review of the book by Elizabeth Garnsey and James McGlade. Edward Elgar, Cheltenham: 2006). *Economica*, 78(309):188-190 (January 2011) (Published online 14 December 2010).

Conference Proceedings

Tarasyev AM & Usova A (2011). An iterative direct-backward procedure for construction of optimal trajectories in control problems with infinite horizon. In: *Proceedings, 18th IFAC World Congress*. 28 August - 2 September 2011, Milan, Italy.

Tarasyev AM & Usova A (2011). The value function as a solution of Hamiltonian systems in linear optimal control problems with infinite horizon. In: *Proceedings, 18th IFAC World Congress*. 28 August - 2 September 2011, Milan, Italy.

Interim Reports

Amjad M, Fath BD & Rovenskaya E (2011). Ecological Network Model and Analysis for Rawal Lake, Pakistan. IIASA Interim Report IR-11-023.

Nikonov OI, Krivorotov VV & Kalina AV (2011). Methodological Approach to the Study of Sustainable and Safe Social and Economic Development of the Territories. IIASA Interim Report IR-11-006.

Scientific Recognition

Sergey Aseev

Invited lectures

- Application of Pontryagin's maximum principle in growth theory. International Scientific School "Economic Growth: Mathematical Dimensions - 2011", Lomonosov Moscow State University, 29 January – 6 February, 2011, Moscow, Russia
- The Pontryagin maximum principle for overtaking optimal controls (co-authored with V.M. Veliov). Tikhonov Memorial Conference, Lomonosov Moscow State University, 14 June, 2011, Moscow, Russia;
- An optimal endogenous growth model with exhaustible resources (co-authored with K.O. Besov and S. Kaniovski). Petrovskii Memorial Conference "Differential Equations and Related Topics", Lomonosov Moscow State University, 29 May – 4 June, A two-sector optimal economic growth model with a random price jump (co-authored with K.O. Besov, T. Palokangas, and S.-E. Ollus). International Congress ISAAC 2011, Peoples Friendship University, 22-27 August, 2011, Moscow, Russia.

Editorship and membership

- Deputy Editor, Proceedings of Steklov Mathematical Institute; (ii) Member, Technical Committee 2.4, Optimal Control, International Federation for Automatic Control (IFAC).

Alexey Davydov

Invited lectures

- Singularity theory in control and optimization problems. Minicourse, 2 lectures. Russian School on Contemporary Problems of Mathematics, Institute of Mathematics and Mechanics UrB RAS, 30 January – 6 February, 2011, Ekaterinburg, Russia;
- Implicit differential equations. Minicourse, 2 lectures. Banach Center Conferences, Workshop on Singularities in Geometry and Applications, 15 – 21 May 2011, Warsaw, Poland; (iii) Optimization of steady state of forest management model. The Sixth International Conference on Differential and Functional Differential Equations, 14 – 21 August, 2011, Moscow, Russia.

Editorships and membership

- Member, Editorial Board, Journal of Dynamical and Control Systems;
- Member, Editorial Board, Izvestiya: Mathematics;
- Co-chair, Organizing Committee, Vice-chair, Program Committee, International Conference on Mathematical Control Theory and Mechanics, Suzdal, 1 – 5 July 2011.

Yuri Ermoliev

Invited lectures

- Data requirements for integrated modeling of food, water and energy security ; On country-wide food security modeling. Institute of Remote Sensing, National Academy of Sciences of Ukraine, 22-23 August 2011;
- Systemic Risks and Security Management. 25 August 2011, Kiev, Ukraine.

Award

- Medal for Outstanding Achievements in Science Capacity Building, awarded by the National Academy of Sciences, Ukraine.

Brian Fath

Invited lectures

- How ecological modelling contributes to global change science. Keynote presentation. International Society of Ecological Modelling Conference, 20 September 2011, Beijing, China;
- Ecosystem resilience and the adaptive cycle. 2nd Viennese Talks on Resilience Research & Networks: New perspectives on growth, development and innovation, 26-27 May 2011, Vienna, Austria;
- Sustainable Development, ecosystems, and resilience. Resilience and adaptation to Climate Change Workshop, 21–22 February 2011, Vienna, Austria.

Award

- Regents Award for Outstanding Scholarship, University System of Maryland, 2011.

Editorships, memberships

- Editor in Chief, Ecological Modelling;
- Invited to the Editorial Board of Ecological Complexity;
- Invited to the Editorial Boards of Ecological Informatics; (iv) President, North American Chapter of International Society for Ecological Modelling.

Arkady Kryazhimskiy

Invited lectures

- Early warning signals and binary classifications of historical paths; Optimal development and seeds of change in economic trends; Recovery times as indicators of stability loss. Advanced School on Understanding and Prediction of Earthquakes and other Extreme Events in Complex Systems. The Abdus Salam International Center for Theoretical Physics, 4 October 2011, Trieste, Italy.

Editorships, memberships

- Member, Editorial Board, Journal of Computational Mathematics and Mathematical Physics;
- Member, Editorial Board, Mathematical Game Theory and Its Applications;
- Acting Member, Russian Academy of Sciences;
- Scientific Supervisor, International School "Economic Growth: Mathematical Dimensions - 2011", Moscow, 31 January – 6 February, 2011;
- Member, Organizing Committee, XVI Annual Conference on Dynamics, Economic Growth, and International Trade (DEGIT), 8 – 9 September, 2011.

Marek Makowski

Invited lectures

- Model-based decision support. International Intensive School on Mathematical Decision Analysis, Japan Advanced Institute of Science and Technology, 7-11 March, 2011, Ishikawa, Japan;
- Multiple-criteria analysis of discrete analysis: methodology and tutorial to web-based implementation. Department of Intelligence and Informatics, Konan University, 14 March, 2011, Kobe, Japan;
- Multiple-criteria analysis of conflicting attainable goals. Symiosis Workshop at the 21st Century Center of Excellence, Kyoto University, 18 March, 2011, Kyoto, Japan.

Tapio Palokangas

Invited lecture

- Integration, labor market regulation, lobbying, and technological change. IFAC World Congress, 29 August – 2 September, 2011, Milan, Italy.

Memberships

- Member, Technical Committee 2.4, Optimal Control, International Federation for Automatic Control (IFAC);
- Research Fellow, IZA;
- Member, Academic Council, International Society on Dynamics, Economic Growth and International Trade (DEGIT);
- Member, Organizing Committee, XVI Annual Conference on Dynamics, Economic Growth, and International Trade (DEGIT), 8 – 9 September, 2011;
- Member, Organizing Committee, Symposium on Green Growth and Sustainable Development, 9-10 December 2011.

Hongtao Ren

Invited lecture

- Multiple-criteria analysis of discrete alternatives: methodology and web-based implementation. School of Business of East China University of Science and Technology, 28 April, 2011, Shanghai, China.

Elena Rovenskaya

Award

- Annual Award for Talented Young Scientists and Teachers, Lomonosov Moscow State University, 2011.

Membership

- Organizing Committee, International School "Economic Growth: Mathematical Dimensions - 2011", Moscow, 31 January – 6 February, 2011.

Gerald Silverberg

Invited lecture

- "If you can't be with the theory you love, love the theory you're with", Some reflections on Robert C. Allen's "The Industrial Revolution in Global Perspective". Plenary session talk, DIME Final Conference, 7 April 2011Maastricht, The Netherlands.

Editorial article

- Op-ed article in New York Times Global Edition "One way to save the Euro", 18 January, 2011.

Alexander Tarasyev

Invited lecture

- Dynamic optimization techniques for analyzing proportions and trends of economic growth: optimal investments in capital and labor effiency. XVI Annual Conference on Dynamics, Economic Growth, and International Trade (DEGIT), 8 – 9 September, 2011, St-Petersburg, Russia.

Editorships, memberships

- Associated Editor, 18th IFAC World Congress, Milan, 29 August – 2 September, 2011;
- Chair, Technical Committee Optimal Control (TC 2.4) of the International Federation of Automatic Control (IFAC);
- Member, Organizing Committee, Symposium on Green Growth and Sustainable Development, 9 - 10 December 2011.

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"EnRiMa Energy Efficiency and Risk Management in Public Buildings"	European Commission, DG Information Society and Media	01.10.2010	31.04.2014	291,305.00	96,036.00
Guest research assistants from Russia: Irina Petrenko and Tatyana Shutkina from Vladimir State University (Russia President Grant)	The Ministry of Education and Science of the Russian Federation	15.02.2011	31.05.2011	18,122.00	18,122.00

Ecosystems Services and Management

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Anatoly Shvidenko, Acting Program Leader (January to June 2011)

Florian Kraxner, Acting Deputy Program Leader (January to June 2011)

Objectives

The well-being of human populations depends on the vitality of the planet's diverse ecosystems, whether forests, wetlands, grasslands, agricultural land, or densely populated urban/industrial areas. Natural ecosystems provide habitats for more than half of the world's known plant and animal species; and more than three-quarters of the population's accessible freshwater comes from forested catchments.

Advanced technologies and the intensification of agriculture have successfully kept up with rapidly growing global food demand, though at the expense of massive land conversion and environmental deterioration, mostly affecting forest ecosystems. Sound land management strategies are needed that support further expansion of food production while improving agricultural lands, preserving water resources and quality, and protecting the large variety of natural ecosystems.

Land use and human appropriation of ecosystem services for food production regularly compete with other uses. Ignoring such tradeoffs can lead to unsustainable exploitation, environmental degradation, and avoidable long-term societal costs. Transition to sustainable land use and ecosystem management, however, faces substantial challenges. To facilitate this process, improved understanding and management of competing uses of land, water resources, and ecosystem services are required. This includes the responsible expansion of food and bio-energy production, sustaining regulating natural ecosystem functions and biodiversity, protecting and preserving global gene pools, and enhancing terrestrial carbon pools, while also accounting for diverse impacts of climate change.

ESM provides integrated impact assessment of ecosystem management options for policy processes following a science-based approach. ESM research combines spatially detailed modeling of land use options and ecosystem services in diverse social and environmental conditions and accounts for physical and financial flows across multiple scales. To this end, much more information about the current state of ecosystems is needed. ESM is developing Earth Observation Tools as a repository of the newest verified information on the extent, condition, vitality, and dynamics of ecosystems and related landscapes.

The ESM program is charting possible pathways to the future by linking ecosystems, policy and governance, and Earth Observation, while building on active collaboration with many institutions worldwide.

Alignment with IIASA's Strategic Plan

ESM dedicates a large part of its work to the multitude of research topics under IIASA's Food & Water (F&W) area, inter alia, to food security and the sustainable management of scarce resources including water and land, while concentrating on the wider sector of agriculture and its commodities, as well as on forest ecosystems.

ESM addresses the major problems subsumed under F&W within an integrated global modeling approach. These include biophysical tools (e.g., G4M, EPIC, and GAEZ) and economic tools (e.g., GLOBIOM) which are interlinked, and research bridges the key disciplines such as agriculture, forestry, land use, environmental economics, climate change, and natural resources management..

Policy impact assessments form the basis for innovative adaptation and mitigation strategies as part of the insight we offer to our international partners. The latest integrated cross-sectoral research developments reach out to other IIASA problem areas, programs, and tools such as RAINS/GAINS and MESSAGE from MAG and ENE, respectively. Furthermore, ESM's globally consistent national assessments and scenario analyses support decision making at the regional scale and also under uncertainty (downscaling methodology development together with ASA), while approaches like robust decision making and trade-off analyses are complementary tools for economic assessments of management schemes.

ESM maintains and further extends its scientific collaborators network which also forms the basis for enriching and validating its large databases that are so crucial to carrying out global analyses in the research fields mentioned. Both IIASA and its NMO country research organizations are benefiting from innovative ESM developments in the area of Earth Observation, such as GEO-WIKI.ORG, which has become an essential tool in improving the accuracy of ESM results that directly support relevant regional and global policy processes.

Scientific Achievements in 2011

A critical mass of intellectual capacity and available resources is a prerequisite for conducting effective cutting-edge research. Under the new IIASA Research Plan, ESM has worked on about 50 small- and large-scale projects financed by different international and national agencies. Many of ESM's scientific achievements in 2011 were reported in peer-reviewed editions, including high-level international journals including *Science*, *Nature*, *PNAS*, and *Global Change Biology*. As well as solving specific scientific problems, ESM paid special attention to the development of methodological backgrounds for integrated modeling, and continued to make further improvements to the ESM Integrated Modeling Cluster such as:

- **Disaggregation of Europe in the global land use model GLOBIOM**: Over the last year GLOBIOM has undergone several changes and improvements both to its structure and data sets. A major task was the improved representation of the European Union in the model. As a first step to achieving this goal the former 5 coarse regions for Europe in GLOBIOM were disaggregated into the EU member states. In total the European version of GLOBIOM (EUBIOM) now consists of 23 regions outside Europe plus the 27 member states, resulting in a total of 50 world regions. Besides the disaggregation of the model structure and related input data, additional data sets were implemented to improve representation of, for instance, high-nature-value farmland areas for Europe and the National Renewable Energy Action Plans (NREAPs). Recent updates of the PRIMES model on bioenergy demand were also included in the last scenario runs.
- **Harmonization of GLOBIOM and CAPRI Baselines**: As CAPRI and GLOBIOM differ substantially in terms of input data, processing paths, price and demand projections, general modeling concept, etc., a harmonization of the two models has been started. A first comparison was conducted, in which crop areas, supply and total demand quantities, and livestock supply and demand quantities were compared and harmonized at the European level.
- In the course of 2011, **ESM's global biophysical models, namely, EPIC (Agriculture) and G4M (Forestry) underwent further improvements** with respect to methodological development, as well as structural adaptations and data-processing techniques. In the forestry model the developers concentrated on the inclusion of growth estimation based on temperature, precipitation, soil, and CO2, which will allow harvesting amounts to be estimated with higher accuracy and to be more spatially explicit, indicating areas suitable for afforestation. In the EPIC environment, ESM researchers prepared the model for parallel runs in ESM's computer cluster environment to substantially speed up processing time. To improve the model linkage between EPIC and ESM's economic model GLOBIOM, the EPIC code was optimized with respect to direct output to the GAMS format

1) Ecosystems Functioning including Greenhouse Gas Cycling and Climate Change

- The EU Project **ClimateCost**, concentrating on the assessment of damage from climate change to ecosystems in Europe, finished successfully. To assess the impacts of climate change on forestry, the linked ESM models G4M and GLOBIOM were used. The project consortium's central model LPJmL was coupled with G4M through the linking of NPP and disturbance parameters. A major result was to show that, to 2040, accumulated carbon in forests is substantially higher for certain scenarios if strong CO2 fertilization effects are assumed.
- ESM continued to modify and improve systems and methodology as well as the modeling framework of the **Terrestrial Ecosystems Verified Full Greenhouse Gas Account** (FGGA) with special emphasis on carbon cycling. The general methodology is designed to allow a reliable assessment of result uncertainties from FGGA to be carried out. This effort is represented by a systems integration of major approaches to carbon cycling. Among other things, a modeling system for assessing heterotrophic respiration of ecosystems was developed in 2011. The methodology was applied to assess the FGGA of Russia as (1) experimental control of Level 4 Products of the Japanese satellite GOSAT (carried out in a joint project with the Global Environment Fund, Japan) and (2) for assessment of carbon cycling of ecosystems of Russia within the Global Carbon Project (GCP). The results were published in *Science* with a detailed background report in the Russian Forest Sector Outlook Study, 2011-2030, as well as Geosciences.
- ESM researchers carried out a study on **Uncertainty in an Emissions Constrained World**. Research focused on uncertainty in reconciling short-term commitments to reduce greenhouse gas (GHG) emissions and to meet long-term temperature targets. A holistic emissions-temperature-uncertainty framework allows any country to understand its national and near-term mitigation and adaptation efforts in a globally consistent and long-term emissions-temperature context.
- ESM became a partner in a new EU-funded project, **GEO-CARBON**, which aims to design a coordinated Global Carbon Observation and Analysis System, addressing the climate targets of the Group on Earth Observations (GEO) in efforts to build a Global Earth Observation System of Systems (GEOSS) for carbon. IIASA co-leads a component/work package on the economic assessment of the value of an enhanced Global Carbon Observing System.
- ESM also became a partner in the EC FP7 project **IMPACT2C** in which IIASA will mainly concentrate on impacts and adaptation in forestry and agriculture, but also on risk and vulnerability (together with IIASA's RPV program.)
- Together with its partner the Chinese Academy of Sciences Institute of Geographic Sciences and Natural Resources Research (CAS-IGSNRR), ESM is working on a Joint National Natural Science Foundation of China (NSFC)-IIASA project entitled **Decision Support System for Integrated Management of Terrestrial Carbon Sink in China**. This project is the latest in a series of studies with other Asian and non-Asian NMO countries to develop globally consistent national/regional case studies and models in order to analyze the Carbon and other GHG cycles. The series started with C flow assessments in Russia and continued with Japan, China, and India. These activities with NMO countries are fully coordinated with the IIASA/ESM research strategy and are based on a broadly synergetic approach. For the Chinese project, a symposium titled **Co-benefits of Forest Management Strategies in Mitigation and Adaptation to Climate Change – Europe, China, Global** was organized at the I**nternational Conference on Response of Forests and Adaptation Management to Climate Change**, held on 8–10 August 2011 in Yichun, Heilongjiang, China, and a project/ESM-sponsored YSSPer

(Lei Zhou) from CAS has been contributing to the project (results to be published in 2012).
- **A theory of adaptive microbial growth and nutrient cycling** was published by ESM scientists and provides the core for a new type of soil carbon and nutrient cycling models.
- ESM experts also developed and published an **improved radiation interception model for forest canopies**, which will be used in a novel forest ecosystem model under development in collaboration with IIASA's EEP and ASA
- Among other contributions to the ESM publication record in the field of agriculture, was a scientific article published in Climatic Change on the **impacts of extreme weather on wheat and maize production in France** evaluated by regional EPIC crop model simulations, remotely sensed soil moisture, and reported data.

2) Economics of Ecosystems and Land Use Change including Food Security and Water

- ESM's GLOBIOM modeling group joined the **AgMIP project**, an interdisciplinary initiative aiming at comparing and improving climate, crop and agro-economic models to refine analysis of climate change on food security in the future (www.agmip.org)
- Ongoing projects in the field of ecosystems economics include **PASHMINA**, an EU FP7 project dealing with paradigm shift modeling and innovative approaches within which ESM models are being further developed.
- In a collaboration project with Norway, **PURELEC**, the main research question is whether real option models can explain how investors in small hydropower and wind farm projects respond to climate policy uncertainty, and thus guide authorities in designing better policies.
- In the bridging context between land use change, economics and Earth observation, ESM and partners successfully applied for the FP7 project **ISAC**. This new project will explore improvements of current agricultural services based on availability of better spatial and temporal resolution in satellite images. IIASA is taking the lead in the core information service on agricultural change. Based on Epic and GLOBIOM runs, land use change and the impact of climate change on main agricultural crops for Belgium, Spain, and Ethiopia are being assessed. An Internet platform isac.geo-wiki.org has been set up to visualize results and to collect feedback from stakeholders of the project.
- ESM partnered in an FP7 project called **Global-IQ** with a number of economic research institutes across Europe to assess the impacts of global change and the costing of adaptation to these changes; as well as **LIMITS** with its focus on the preparation of a model linkage between MESSAGE-(ENE) and GLOBIOM (ESM).
- Within the **EC FP7 Project LC-Impact**, a methodology to analyze the impacts of agriculture on ecosystems services within a Life Cycle Impact Assessment framework is being developed by ESM researchers. Preliminary findings were presented at the 2011 SETAC (Society of Environmental Toxicology and Chemistry) conference in Milan, Italy.
- Key findings of ongoing projects in agricultural economics were presented, for example, in a paper entitled **Farming system modeling for agri-environmental policy design: The case of a spatially non-aggregated allocation of conservation measures**. The paper addresses the issue of designing policies for habitat conservation on agricultural land.
- Further results were presented in **Implications of alternative metrics for global mitigation costs and greenhouse gas emissions from agriculture**. Using the land-use model GLOBIOM, this paper shows that alternative metrics could have more significant effects on food production in different world regions, and that those effects are highly dependent on regional characteristics of future land-use change to meet growing food demand.
- In a publication entitled **Production system-based global livestock sector modeling: Good news for the future**, ESM agricultural economists investigated whether productivity gains which, in the past decades have enabled the crop sector to satisfy increased demand under decreasing real prices and with little additional land, can also be expected in the livestock sector in the future. Results show that if the composition of the production system is allowed to freely adapt to economic and resource constraints, the increases in per hectare productivity will allow 2030 demand for ruminant products to be satisfied with less land than in 2000, and that the livestock product prices will remain stable.
- ESM researchers investigated the **Impacts of population growth, economic development, and technical change on global food production and consumption**. Over the next decades humans will demand more food from fewer land and water resources. This study quantifies the food production impacts of four alternative development scenarios from the Millennium Ecosystem Assessment and the Special Report on Emission Scenarios. Simulations showed that per capita food levels increase in all development scenarios examined with minor impacts on food prices. Global agricultural land increases by up to 14% between 2010 and 2030. Deforestation restrictions strongly impact the price of land and water resources but have few consequences for the global level of food production and food prices. While projected income changes have the highest partial impact on per capita food consumption levels, population growth leads to the highest increase in total food production. The impact of technical change is amplified or mitigated by adaptations of land management intensities.
- **Food Security and biofuels**: The first version of the stochastic version of GLOBIOM was developed in 2010 and used for investigation of, for example, trade as an adaptation channel (see previous progress report). ESM used the extended model in 2011 to look at further tradeoffs, by including biofuel mandates and concerns about food security into the analysis. The key observations from the analysis are that prioritizing food security by requiring the safety-first constraint to hold in all yield scenarios will increase the sensitivity of food prices and, even more so, of food price volatility, to the imposition of bio-energy mandates. Furthermore,

the higher the target is, the effect increases. However, if bio-energy mandates are flexible and only required to hold on average, food price volatility can be kept constant, even if the food security constraint is strict. These effects were also published in **Agricultural Price Volatility under Climate Change: The Impact of Multiple Objectives on Commodity Prices**. The analysis was carried out using the stochastic version of ESM's GLOBIOM model (www.globiom.org); the results showed that adding another inelastic demand for agricultural commodities in the form of fixed biofuel targets to what is already a highly inelastic food demand, further exacerbates commodity price volatility. On the other hand, our scenarios show that defining a biofuel target over several years, instead of on an annual basis, could considerably decrease the volatility. Pluri-annual biofuel targets hence act as reverse storage.

- One important issue to be considered in the area of food security research concerns the environmental implications. **Ensuring food security requires several million hectares of additional land, which is mainly sourced from forests and other agricultural land**. The introduction of bio-energy mandates adds to the sum of deforested area. Making bio-energy mandates flexible, so that they would only need to apply on average and not in every scenario, would considerably dampen the effect on deforestation.
- In the course of preparing a joint NSF China-IIASA project on **Grey water footprint and water scarcity assessment**, a YSSP student from Beijing Forestry University (Chuanfu Zang) was hosted at ESM. With his supervisors he developed the **First comprehensive green and blue water assessment of the Heihe river basin**, the second largest inland river basin in Northwest China.
- Another study was carried out on **Spatial and temporal patterns of both blue and green water flows** jointly with Beijing Forestry University. In this study, a Soil and Water Assessment Tool (SWAT) was used to assess the Heihe River basin. The results of both studies are helpful for formulating reasonable water policies to improve water resources management in the arid and semi-arid inland river basins of China. The results are undergoing a peer-reviewed publishing process in *Hydrology and Earth System Sciences*, the Interactive Open Access Journal of the European Geosciences Union.
- Another important aspect of land use modeling is **Assessing land use-related GHG emissions and mitigation options with a special focus on forests (LULUCF)**. ESM is active in this area at the European as well as at global level, and results are also extremely policy-relevant with respect to individual national climate negotiations (e.g., UNFCCC etc.).
- At the **European LULUCF scale**, ESM concluded work for the EC "DG CLIMA" on an analysis of the potential for and costs of LULUCF use by EU member states. The study estimated potential CO2 emission reductions in the LULUCF (land-use, land use change, and forestry) sector for individual EU member states and the associated costs for the time horizon up to 2020 and 2030, using ESM's integrated modeling cluster with G4M and GLOBIOM. The results serve as an important basis for decision making in the Commission on the issue of LULUCF, and the results were also part of the COP17 decision on LULUCF in Durban in December 2011 (see section "Policy Impact in 2011"). In a second contract, these scenarios were prolonged to the year 2050. The report is available online. At the **global LULUCF level**, ESM supported the UK Department for Energy and Climate Change (DECC) and the Danish Energy Agency (DEA) by providing global data sets of forestry baseline emissions projections and associated Marginal Abatement Cost Curves (MACCs). The global models G4M and GLOBIOM were applied to project emissions from afforestation, deforestation, and management of existing forests for individual countries, based on economic, social, and policy drivers. Several sensitivity runs were carried out to better understand the drivers of deforestation and afforestation.

3) Global Earth Observations (GEO)

- **ESM's Earth Observation flagship tool**, www.Geo-Wiki.org (*Figure 1*), continued to undergo new and exciting changes and improvements, with an ever-increasing list of registered volunteers. New branches such as agriculture, biomass, urban, human impact, coffee, NPP, and competition were begun, as interest spread in applying the general Geo-Wiki concept to other environmental problems. Efforts are under way to revamp the entire back-end of the Geo-Wiki, with planned completion in 2012. This will increase security, maintenance, and ease of use, and allow non-programmers to modify the tool for their own needs. In 2011 the tool developers at ESM registered 343 new users living in 54 different countries (with 636 users registered in total from 64 countries). 58,935 validations were recorded in 2011.
- ESM started **Landspotting**, an Austrian Science Fund project aiming at collecting land cover validation points via gaming, social networks, and competitions, with the final goal being to create a hybrid land cover product. In the first competition more than 550,000 validation points were collected (*Figure 2*). This information, combined with existing

Figure 1. Screenshot of global forest and cropland disagreement on Geo-Wiki.

land cover data sets, will be used to produce the first global land cover crowd-sourced data set, to be completed in 2012.

- As part of the Landspotting project, a **prototype of Geo-wiki mobile**, a mobile phone application to collect land-cover information on the ground using pictures has been developed; the mobile phone application is available for Android and Windows, is already downloadable from the "market place" and will become available for iPhone in 2012. Pictures with orientation and GPS coordinates are recorded. The application enables the collection of vast amounts of geo-referenced land cover calibration and validation data.
- The EU regional project **BalkanGEONet** was started with ESM as a consortium member. This project is designed to strengthen existing Earth Observation research participation among the Balkan countries and encourage those countries not yet involved to join the GEO initiative.
- Another new EU Project, **EGIDA**, is a technical project to create a standard methodology to support GEOSS, the Global Earth Observations System of Systems, through development of evaluation processes, assessment indexes, and databases.
- ESM is also lead partner in a bridging project between Earth Observation and Energy. In the EU Project **EnerGEO**, which is also a cross-program activity between ESM, MAG, and ENE, one aspect of IIASA's work is related to biomass for bioenergy for which the Biomass Geo-Wiki has been created. During 2011 the EnerGEO model cluster was also aligned, all data flows were implemented and documented, and the IIASA models GAINS (MAG) and MESSAGE (ENE) are awaiting scenarios from other energy models to prepare final outputs in 2012.
- ESM also applied successfully, with Austrian research partners, for Austrian funding (FFG) for two more project in the domain of Earth Observation - **FarmSupport** and **GEOSAF**. The FarmSupport projects aims to demonstrate the potential of a new soil moisture detection product (from the ASCAT sensor) that will become available for Africa and to use this for validation of EPIC. A secondary aim is to provide weather forecast data to farmers in Africa via mobile phones and collect information from them such as yields, inputs, etc., to further validate EPIC. The start date is March 2012. GEOSAF aims to provide early warning indicators and crop forecasts to organizations involved in food security. As part of this, validation of seasonal weather forecasts over Eastern Africa, assimilation of ASCAT soil moisture data, and rainfall predictions from satellite data will be undertaken. Start date is May 2012.
- ESM also contributed to the success of a **COST proposal entitled Mapping and the citizen sensor**. This COST action is unique in the sense that it will: (i) bring together diverse communities to establish the status of VGI (volunteered geographic information) for mapping, (ii) define good practices in VGI collection and (iii) engage citizens intimately in science by involving amateurs in scientific activity.
- In 2011 ESM used data and insights from past projects (i.e., GEOBENE) or publishing inter alia **The value of rapid damage assessment for efficient earthquake response** and presenting the **Methodology for quantitative assessment of the potential value of information"** in *Safety Science*. **Adaptation capacity of a landslide early warning system to climate change: numerical modeling for the Combeima region in Colombia** was also published, stemming from the same EC Project that was finished in 2009.
- Together with Gamma Inc. and Friedrich-Schiller University in Jena, ESM developed a **new technology of assessing above ground live biomass** (growing stock volume) in boreal forest using hyper-temporal ENVISAT ASAR ScanSAR images of radar backscattered intensity. The research shows a large potential for practical application of the methodology in forest science and forest management. The results have been published in several papers in Remote Sensing of Environment. Further improvements to the methodology

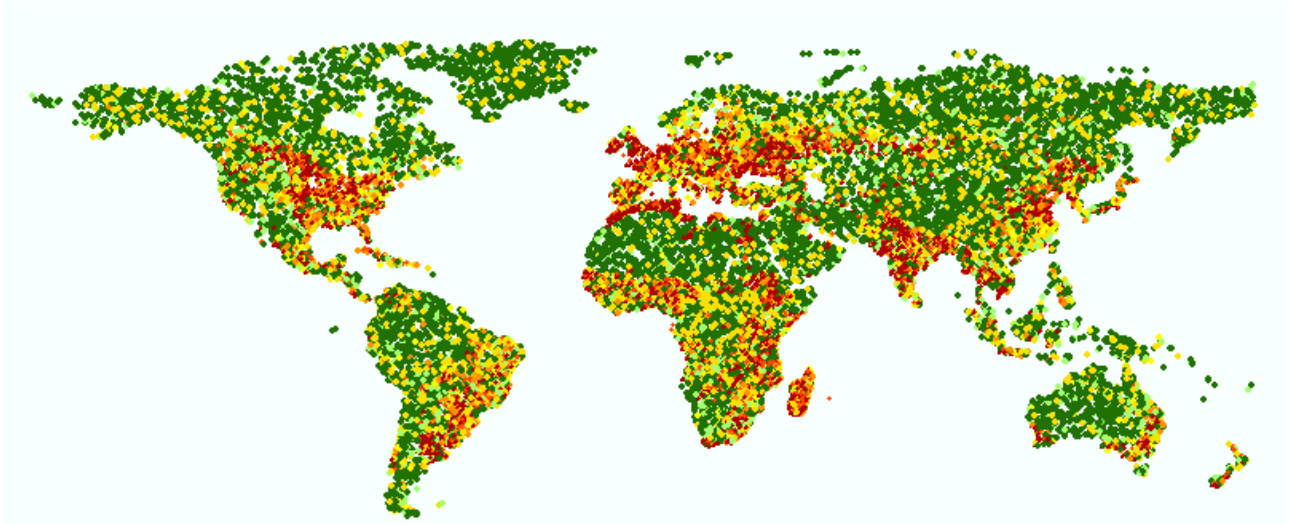

Figure 2. Map of validation points collected via the Geo-Wiki human impact competition, showing the degree of human impact (red, high human impact, yellow, medium human impact, and green, little or no human impact).

are elaborated within the project **ZAPAS** – part of the EU-Russia Space Dialog.

- For sub-Saharan Africa, ESM developed an **improved cropland map by combining five existing cropland data sets from sub-Saharan Africa**. ESM researchers created a new map with a higher accuracy than existing maps, which should reduce uncertainty and improve predictions in land use, vegetation, climate change, and Earth systems modeling. The research was published in *Geophysical Research Letters*.
- A new study by ESM scientists on **uncertainty in global land cover maps** was published in Environmental Research Letters. The article highlights discrepancies in cropland and forest classifications between the global land cover data sets (*Figure 3*): IIASA researchers warn that the spatial disagreements are very high and could impact the outcomes of assessment or modeling exercises. **This publication was downloaded more than 500 times which is in the top 3 percent of downloads from the IIASA Web site**.

4) Bio-technologies and (Bio-) Energy

- In 2011 ESM was also significantly involved in the **global debate on relevance and impact of current biofuel policies**. GLOBIOM was used to assess the land use impact of US biofuels policies in collaboration with a team from Duke University, to be published in 2012 as a Nicholas Institute Report: **The Net Global Effects of Alternative U.S. Biofuel Mandates Fossil Fuel Displacement, Indirect Land Use Change, and the Role of Agricultural Productivity Growth.**
- The EC-funded research project **Biomass Futures** was successfully completed with major ESM involvement. The project aimed to identify the role of biomass in achieving the EU Climate Change & Renewables policy targets by looking at demand and supply dynamics from the perspective of stakeholders. The aim of the ESM-led WP3 was to provide a comprehensive strategic analysis of biomass supply options and their availability in response to different demands in a 2010–2030 timeframe. ESM applied GLOBIOM to quantify impacts of EU bioenergy demand, especially impacts on global trade and land use, by running several scenarios. Results indicate that the European biofuel mandates have some adverse effects on global land use. These land use effects cannot be mitigated simply by applying sustainability criteria to biofuel production and imports, as leakage to other sectors and regions occurs. However, when globally effective land use policies, for example, those targeting emissions from deforestation and biodiversity loss in general are successful, no indirect effects of increased bioenergy use on biodiversity and GHG emissions occur.
- In the framework of the EU FP7 project **PROSUITE** ESM scientists concentrated on life cycle analysis (LCA) with environmental and economic assessment of new technologies. The BEWHERE model has undergone developments to accommodate and optimize bio-refineries; economic real options analysis has been included to prepare the information for a Norwegian model on the impact of uncertainty technology diffusion (nano-fibers, CCS, bio-refineries, cell phones).
- The **Austrian SEBA project** was successfully finalized. ESM experts examined the production of biofuels in Austria under different policy scenarios and competition from existing woody-biomass-based industries applying the BeWhere model. Results indicated that second-generation biofuel can produce up to 4% of the transport fuel consumption at the 2010 fossil fuel price and that setting a carbon tax is the most effective policy for decreasing emissions as well as significantly substituting for fossil fuel.

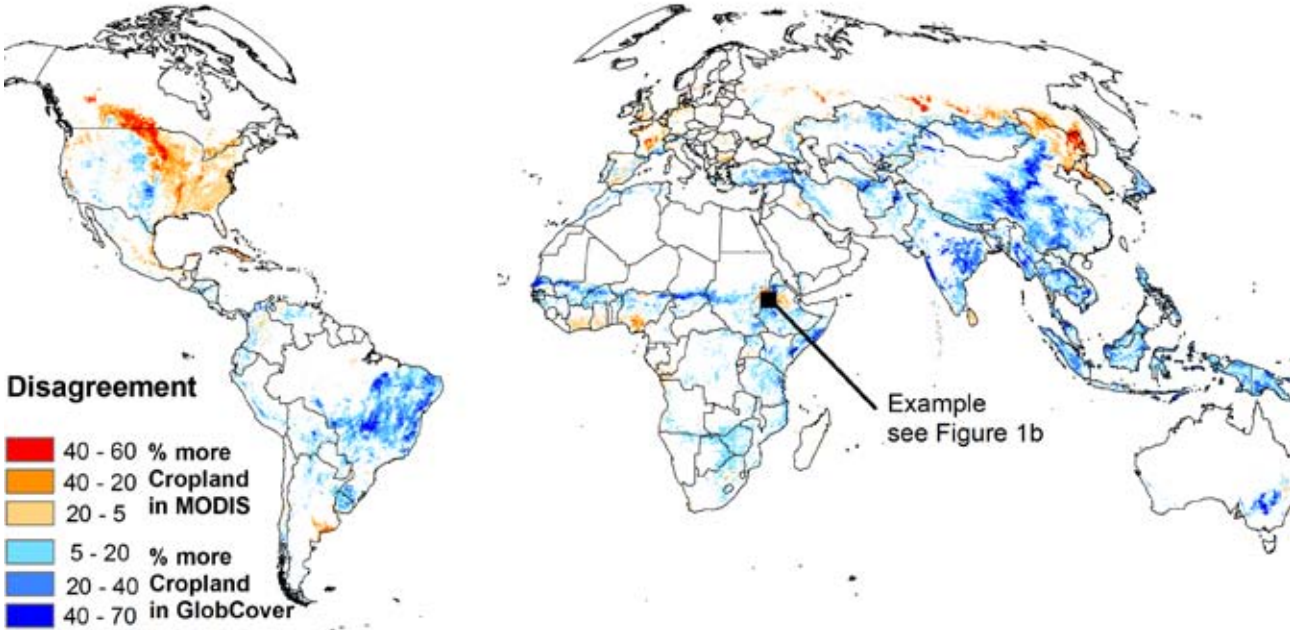

Figure 3. Global disagreement between MODIS v.5 and GlobCover 2005 in the cropland domain.

- The **biomass plant optimization model BeWhere** was upgraded to include a more complete set of feedstock (forest and crop residuals, wood waste, algae, etc.) as well as technologies (biofuel, CHP) at the European level. Second generation biofuel potential has been studied for Europe based on forest residues and wood waste, where 3% of the transport fuel consumption can be reached if the right policy is applied. Trades of different commodities are now permitted between the regions, and Scandinavia and Eastern Europe both appear to be major sources of raw material, as well as potential producers of biofuel for Europe. The computation time of the model has been further considerably improved through major changes in programming.
- An ESM YSSPer has helped study the production of biodiesel from algae, where sea water and CO2 emitted from electrical industries were used as feedstock for the production of algae. A comparison of three regions with different irradiation conditions and access to CO2 was carried out by applying the BeWhere model. First results are expected in 2012.
- ESM started a collaboration with the International Energy Agency (IEA) on the topic of bioenergy combined with carbon capture and storage (CCS) (BECCS) as a source of negative emissions (carbon-neutrally accounted bio-energy minus capture). **A First Joint IEA-IIASA BECCS Experts Workshop** with strong involvement from Sweden, Indonesia, China, and Brazil was held in November at IIASA with a planned follow-up workshop in 2012, hosted by Indonesia. The outcome of the first workshop will be published as an IEA Report in 2012.
- Further work on **BECCS has been carried out, applying the ESM models G4M and BeWhere to South Korea and Japan**. The studies were presented at two international conferences and at a BECCS side event at COP 17 in Durban.
- **Negative emission strategies** were investigated by a group of ESM scientists and published in Climatic Change. Results indicate that while near-term abatement is not sensitive to the availability of R&D policies, the anticipated availability of negative emission strategies can reduce the near-term abatement optimally undertaken to meet the 2°C temperature rise limit. Further, planning to deploy negative emission technologies shifts optimal R&D funding from "carbon-free" technologies into "emission intensity" technologies. Making negative emission strategies available enables an 80% reduction in the cost of keeping year 2100 CO2 concentrations near their current level. However, negative emission strategies are less important if the possibility of tipping points rules out using late-century net negative emissions to temporarily overshoot the CO2 constraint earlier in the century.
- **A first bioenergy study** focusing on CHP plant optimization in **Western Russia** was carried out by applying ESM's G4M and BeWhere models. The results were presented at the International Boreal Forest Conference in Krasnoyarsk.
- **Other renewables such as wind and water were studied by ESM researchers and published in two article**s. Optimal public incentives for companies to invest in renewable technologies were investigated. The studies account for both the specific uncertainty due to the characteristics of renewables and market effects of (competitors') investment decisions: while renewables-based technologies such as wind and solar energy, for example, suffer from uncertain loads depending on environmental conditions. In addition, electricity prices will respond to changes in electricity capacity in the market, which is often neglected in standard electricity sector investment models. ESM experts also analyzed public policies to promote the use of hydropower for the storage of water for release at peak prices, which can be treated as a premium (partially) offsetting higher upfront investment costs.
- A scientific **article on a quantitative review of the effects of biochar application to soils** on crop productivity using meta-analysis was published in *Agriculture, Ecosystems and Environment*.
- ESM participated in various **conferences on the topic of bioenergy and bio-based materials related to the green economy and sustainable development**, for example, Developing Bio-based Economy – Contributions and Needs of the Danube Region, a workshop at the Austrian Permanent Delegation in Brussels; or the World Renewable Energy Congress in Linkoeping, Sweden as well as in the International Conference for Applied Energy in Italy.
- A series of policy-relevant modeling workshops in the area of biofuels modeling was attended by ESM researchers who presented papers or posters: Roundtable of the International Centre for Trade and Sustainable Development (ICTSD) at the WTO Trading Biofuel: Markets, Sustainability and Certification (**Biofuels markets and trade: overview of current developments**); XIIIth European Agricultural Economics Congress EAAE, Zurich (**Exploring Uncertainty of Indirect Land Use Change Estimates**); GTAP conference Venice (Indirect) land use change modeling evaluation and uncertainty: An application to EU biofuel options); International review panel of the report to the French Environment and Energy Management Agency (**Biofuels, land use and land use change: A quantitative literature review)**.

5) Land Use Systems

The land use systems group supports policymakers in developing rational, science-based and realistic national, regional and global strategies for the production of food, feed, and bio-energy to achieve sustainability of land and water resources, and safeguard food security while promoting rural development.

Core activities are based on an integrated modeling framework comprising a spatially detailed eco-physiological model and bottom-up assessment of land and water use options (food and feed crops; biomass for energy use; fodder crops and pastures) and a regionalized general equilibrium model featuring the food and agriculture economy and its linkages to other sectors and to human well-being. Downscaling/upscaling methodologies interact with these two types of models forming the basis for scenario evaluation, impact assessments and policy analysis of food, agriculture and land use options.

- **Global Grass- and Woodland characterization for ligno-cellulosic energy crop production**. The GAEZ v3.0 land resources database and land productivity potentials have been applied to quantify productivity and biomass potential for ligno-cellulosic energy crop production of global grass- and woodland areas and to characterize spatial concentration, accessibility, protection status, population density and presence of ruminant livestock.
- **Assessment of Brazil´s residual land potentials**. In 2011 Daimler AG launched a project in co-operation with IIASA and Technical University of Berlin to assess the biomass potential for biofuels on the basis of strict sustainability criteria. The study, using the AEZ framework, identified 37 million ha of residual land, which equates to 4.4% of Brazil's geographical area. Nearly one-third appeared as very suitable or suitable for crop production, including for specific biofuel feedstocks.
- **Agro-ecological assessment for the transition of the agricultural sector in the Ukraine**. In 2011 an AEZ – based assessment was made of land resources for current and future climatic conditions to provide the basis for further development and elaboration of integrated strategies and policies toward the sustainable management of natural resources and the environment while improving international economic competitiveness. The resulting report, published in 2011, was reviewed by the Ukrainian Academy of Sciences and published in the Ukrainian language. The study will be extended in 2012
- **Climate, Land, Energy and Water Strategies (CLEWS): an AEZ Assessment of Mauritius**. In 2011 IIASA collaborated with the IAEA, the Royal Swedish Institute of Technology, and the Agricultural Research & Extension Unit in Mauritius, to conduct an illustrative case study for this island. A WEAP water model, a LEAP energy model and the AEZ land production planning model were run in an integrated fashion to determine (a) crop suitability under rain-fed and irrigated, (b) potentials of bio-fuel feedstock crops, (c) the consequence of crop changes, and (d) measures to ensure adequate water supplies in the face of climate change. The CLEWS approach was presented in a capacity building workshop at ICTP-Trieste and at the Bonn Nexus Conference.
- **The impact of EU food and non-food imports on deforestation**. This EU DG-Environment project, coordinated by VITO, analyzed the impacts of EU consumption – primary products as well as processed or manufactured goods–on past deforestation and is proposing policies on how to reduce EU consumption impacts. IIASA's key contribution was on systems analysis of the EU consumption links concerning deforestation, with a focus on the land-intensive agriculture and forestry sector commodities. For this purpose, the LANDFLOW model developed at IIASA has been extended in 2011 and applied to track deforested land embodied in trade and final use of agricultural and forestry products. The LANDFLOW analysis has generated a large time series database recording for each country physical quantities, land areas and deforested land content embodied in agricultural products and associated 'virtual' land flows between major trading blocks of the world.

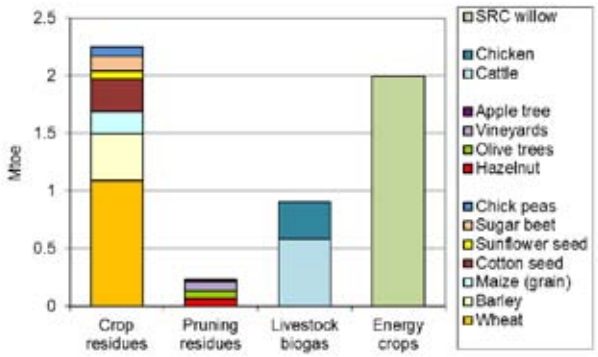

Figure 4. Bioenergy potential in Turkey, by 2020.

- **Biofuels Baseline 2008.** This project supported the European Commission in assessing the sustainability impacts resulting from the use of biofuels in the EU. Results from the scenario analysis with the IIASA World Food System model indicate that biofuel production expansion contributed to widening the demand-supply gap in 2008 and can in part explain the observed historical price increases. Utilization of crops as feedstocks for first-generation biofuels has increased the integration of energy and agricultural markets, with significant effects on land utilization.
- **Assessing the Market for Commercial Use of Biomass for Heat and Power Generation in Bulgaria, Romania, Ukraine, Belarus, and Turkey**. The European Bank for Reconstruction and Development (EBRD) commissioned the ÖBf AG and Pöyry Energy GmbH to produce an assessment of the market potential of biomass fuels for heat and power generation (see *Figure 4*). Expertise on the agricultural content of the five country studies was provided by IIASA.
- **In-Stream**. Sustainability issues were at the core of the EU FP7 research project "Integration of Mainstream Economic Indicators with Sustainable Development Objectives" (INSTREAM), which was successfully completed in 2011. Main contributions by IIASA were: (a) to assess the quantitative relationships among different commonly used social, environmental and economic indicators by employing a set of statistical tools; and (b) to analyze the economic effects of sustainability scenarios in land-use and agriculture (see http://www.in-stream.eu/).
- **GAEZ Data Portals**. Data sets generated with the latest GAEZ v3.0 are now available from specially designated GAEZ Data Portals accessible on the IIASA and FAO websites, featuring spatial and tabular data on (a) Land resources, including soils, terrain, and land cover; (b) Agro-climatic resources, including a variety of climatic indicators; (c) Agricultural suitability and potential yields under multiple management levels; (d) Downscaled actual yields and production of the main crop commodities; and (e) Yield and production gaps, in terms of ratios and differences between actual yield and production and potentials for the main crops.

- **GAEZ Technology transfer workshops project**. In 2011 a series of AEZ technology transfer workshops of the GAEZ v3.0 modeling framework and supporting climate, soil, terrain, and land cover databases for on site use at FAO HQ was carried out to enhance staff capacities in agro-ecological zoning and to facilitate application of the GAEZ modeling framework/software in FAO's project work and studies.
- IIASA experts participated in and contributed to **The State of the World's Land and Water Resources for Food and Agriculture** with their modeling expertise. This report was one of the flagship publications of FAO in 2011 and was widely featured in Nature.
- IIASA participated in the **EnRiMa Project** - on safe energy provision to public buildings: revision and implementation of the energy provision model under market (and other inherent) uncertainties. Researchers involved have been developing a stochastic energy provision model jointly with partners from University Madrid, London Business School, and the ASA Program at IIASA.

International Governance, Capacity Building, and NMO Interactions

- 2011 being the United Nations International Year of the Forest, ESM was requested by the World Wide Fund for Nature (WWF) to make a significant contribution through its integrated modeling cluster to the **WWF-flagship project The Living Forests Report** (*Figure 5*). The Report was released chapter-wise starting with Reducing Emissions from Deforestation and Degradation (REDD) in April, and thereafter Bioenergy and Biomaterials. The report received enormous attention from the media and policymakers. Peer-reviewed background articles are planned for publication in 2012.
- In September 2011, the **4-year ESM coordinated REDD-PAC project funded by the German International Climate Initiative (ICI)** started. The objective is to carry out REDD and biodiversity analyses with the ESM integrated modeling cluster in Brazil and the countries of the Congo Basin and in some tropical Asian countries such as Vietnam. The main partners in the consortium are INPE (Brazil), COMIFAC (Congo Basin) and UNEP-WCMC (UK). This €4.5 million project also contains a strong capacity building component to train Brazilian and African researchers with respect to using GLOBIOM.

Figure 5. Cover of WWF's The Living Forests Report, 2011

- ESM researchers also began work on an **EC Tender addressing REDD and the quantification of potentials and costs**. Results are expected in mid-2012. The project will support the European Commission on continuing international negotiation regarding REDD in various processes, mainly the UNFCCC.
- ESM Scientists also carried out a **REDD project for Democratic Republic of the Congo** with the aim of supporting the country's REDD team in designing their strategy for modeling reference levels of future deforestation. This project is expected to continue into 2012.
- Researchers from ESM using the GLOBIOM model, together with researchers from the International Food Policy Research Institute using their IMPACT model, became involved in quantification of the future development of agricultural sector in Eastern Africa: **CCAFS Scenarios for Eastern Africa**. This work is carried out in close collaboration with local stakeholders.
- Another ESM activity related to Africa was the participation of ESM researchers in a **modeling workshop to present the GLOBIOM model to African researchers in Dakar (June 2011) in the framework of AGRODEP**, an initiative aiming to position African experts to take a leading role in the study of strategic development questions and also the broader agricultural growth and policy debate facing African countries.
- ESM scientists took part in a collaborative project jointly funded by the IIASA-Brazilian NMO **Accounting for emissions from LUC embodied in the trade of biomass**. The focus of this project is on biomass embodied in trade. Horizontal transfer of biomass is of considerable relevance in an emissions-constrained world (beyond halted deforestation) where there is a need to quantify (measure and model) sustainability in the terrestrial biosphere in general and the LUC sector in particular.
- **ESM's natural hazard modelers participated in the AndesPlus project** by contributing to several work packages, deliverables, and workshops in 2011. The project aims to develop a comprehensive scientific baseline for climate change adaptation projects in mountainous regions of the Andes countries/South America in the context of defining strategies and guidelines supporting integrated and sustainable adaptation measures in developing countries.
- The ESM Program collaborated with the Indian NMO in providing assistance for building modeling tools in the project **Analyzing Forest Carbon Accounts for Sustainable Policy Options with Special Reference to Livelihood Issues**. The project assesses global change impacts on the forest sector in India in considering the socioeconomic aspects of and implications for planning and management of forest resources in two Himalayan states of India: Himachal Pradesh and Sikkim. Two meetings were held: in India and Austria. The project is part of ESM's globally consistent national C-modeling case studies and contains a large capac-

ity-building aspect. Three Indian researchers spent several months working with ESM modelers and receiving training in applying IIASA models and building national versions.

- ESM participated in the Norwegian-funded **PURELEC** project with involvement from Norwegian stakeholders both from industry and policy (regulators). Consortium partners in this project are CICERO and NTNU.
- ESM started the **Marie Curie Project, Geoinformation technologies, spatio-temporal approaches, and full carbon account for improving accuracy of GHG inventories (GESAPU)** together with researchers from Ukraine. The project aims to assess forest carbon cycling by applying ESM methodology. The research activity is mainly based on capacity building and exchange of researchers between IIASA and different scientific institutions in Ukraine. During 2011 six Ukrainian researchers spent several training months at IIASA and two ESM researchers visited Ukraine for project-related work, including the production of a book entitled **Carbon, Climate and Land Use in Ukraine: Forest Sector** which is planned to be published in 2012.
- Various projects with special emphasis on the agricultural sector in China have been applied for, together with Chinese partners. Inter alia, ESM and ASA applied for **"Integrated Analysis and Modeling of Land Use Efficiency and Security Under Rapid Agricultural Transformation Due to Urban-rural dynamics in China."** IIASA researchers, in collaboration with Chinese partners, are developing an integrated methodology to investigate the interplay between urban development and ecological stress in rural areas.
- Also with ASA and in collaboration with School of Economics and Management, Beihang University, Beijing, China, **an advanced methodology for earthquake-related catastrophe bond pricing** was developed and documented relying on IIASA experience in the field of integrated catastrophe modeling and management and on novel approaches to discounting catastrophe mitigation projects.
- The joint NSFC-IIASA project **Assessing the Impact of Climate Change and Intensive Human Activities on China's Agro-Ecosystem and its Supply Potentials** (3 years, start 2010), coordinated by Shanghai Meteorological Bureau, includes five work blocks on climate modeling: AEZ and DSSAT model fusion; land use change and multi-cropping index; demography, urbanization and labor force trends; and economic modeling of food demand and climate change impacts. In 2011, a broad range of results was presented in a workshop at IIASA. The project produced four publications in international peer-reviewed journals, as well as seven articles in Chinese and three policy briefings in China.
- Furthermore, in 2011 the model and the results of **The Integrated Nitrogen Management in China (INMIC)** project were documented. The project was established by IIASA jointly with the National Science Foundation (NSF) of China to support the integrated planning of production regimes for crops and livestock in China and to address the dilemma of production intensification and the need to preserve local air, water, and soil quality. The project integrates other IIASA projects, using the CATSEI and GAINS methodologies to account for nutrient flows and GHG emissions from agricultural practices to the environment.
- With respect to agriculture-related **water research**, the conclusions of the EC-funded **Chinese Agricultural Transition: Trade, Social and Environmental Impacts (CATSEI)** project were documented. The project was implemented by six prominent European, Chinese, and USA-based partners to investigate the impact of rapid economic transition on China's agricultural economy, with special reference to the consequences of trade liberalization and changing trade flows. The research components led by IIASA focus on five components: water scarcity; emissions; climate change; non-point pollution from cropping and livestock; and environmental policies.
- **Agro-ecological assessment for the transition of the agricultural sector in the Ukraine**. Based on the AEZ modeling framework, the project produced a comprehensive picture of land use and agriculture in Ukraine, including an assessment of land resources under current and future climatic conditions, to provide the basis for further development and elaboration of integrated strategies and policies towards maintaining the sustainability of natural resources and the environment while improving international economic competitiveness. The resulting report was peer-reviewed by the Ukrainian Academy of Sciences and published in Ukrainian language. The NMO of Ukraine has expressed strong interest in continuation of the collaboration in 2012 with an AEZ climate change application.
- As a contribution to the IIASA – Ukrainian NMO (NASU) project on **Integrated modeling of food, energy and water security for sustainable social, economic and environmental developments** in 2011, a model-based scenario analysis was undertaken toward sustainable agriculture intensification pathways in Ukraine under globalization, trade liberalization, and reform of agricultural land

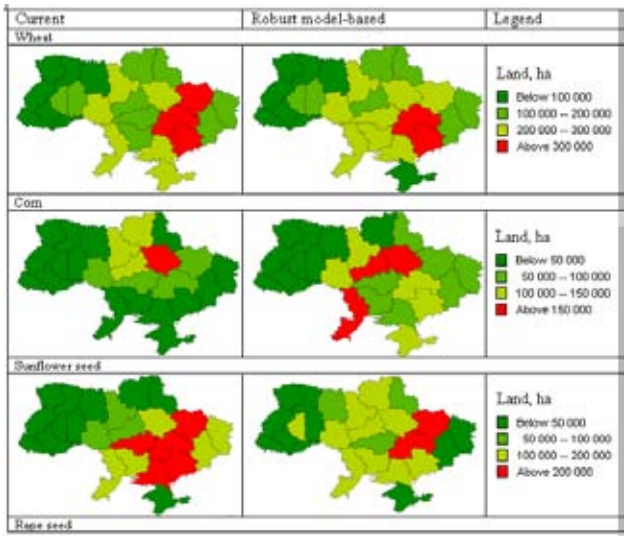

Figure 6. Comparison of current and model-derived robust spatial allocation of crop production in Ukraine.

ownership. Model-derived robust crop production allocation met the criteria of the national Program on sustainable rural development (see *Figure 6*).

- ESM scientists supervised **18 YSSP** participants from 11 countries (NMO and non-NMO) in 2011. It also (co-)supervised **5 Post-Docs** (IIASA, Kempe, other funding) and supervised **6 PhD** students (ESM staff) as well as **2 MSc** students of the Erasmus Mundus European Forestry Master Program (from Indonesia and Brazil) who investigated the importance of woodfuel as a source of energy and compiled a report that provides an overview of woodfuel production, consumption, and use in four regions (Brazil, Congo Basin, India and Indonesia).

Policy Impact in 2011

Policy briefings/articles/publications (written/oral)

Hannes Böttcher:

- The work of IIASA under European Commission service contracts contributed to finding an agreement on the treatment of LULUCF (land use, land use change and forestry) in the second commitment period under the Kyoto Protocol. Since 2008, the AWG-KP (the Ad hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (KP)) has discussed on how to revise carbon accounting rules for LULUCF. As decided at UNFCCC - COP 17 in Durban, accounting of forest management will be mandatory and will now be calculated relative to a baseline reference level which was estimated by IIASA ESM models. Parties will gain credits if reported removals are higher or be debited if reported removals are lower than the IIASA baseline reference level.

Günther Fischer

- IIASA applied the global agro-ecological zoning (GAEZ) modeling framework in a World Bank Report entitled "Rising Global Interest in Farmland–Can it Yield Sustainable and Equitable Benefits" to assess crop production potentials outside current cultivated land for major agricultural commodities as related to a number of socioeconomic indicators such as population and livestock density, land protection status, estimated land value, market access and transport costs to nearest seaport.

Günther Fischer, Eva Hiznyik, Sylvia Prieler, David Wiberg

- IIASA used its global databases and GAEZ modeling framework in 2011 to contribute to a thematic report "Scarcity and abundance of land resources: competing uses and the shrinking land resource base" under FAO's State of the World's Land and Water Resources for Food and Agriculture (SOLAW) activity.

Günther Fischer, Eva Hiznyik, Sylvia Prieler, Harrij van Velthuizen

- IIASA results were also included into the "Special Report on Renewable Energy Sources and Climate Change Mitigation" (SRREN), released by the Intergovernmental Panel on Climate Change (IPCC) in May 2011. The report assesses existing literature on the future potential of renewable energy for the mitigation of climate change.

Florian Kraxner:

- Invited speaker to Japan National Science and Technology Agency (JST) to present IIASA-ESM and joint research ideas with the National Institute for Environmental Studies, Tokyo, Japan
- Invited expert to the International Forum for Ecosystem Adaptability Science III, Adaptability of Human Societies to Perturbation, Sendai, Japan
- Invited Speaker to 2 Side Events (Bellona – on BECCS; NWF – on Forest Certification Schemes), UNFCCC - COP 17, Durban, South Africa

Junguo Liu:

- Water and ecosystem service research for sustainable development, ProSPER.Net-Scopus Young Scientist Award Symposium and Award Ceremony, The University of the Philippines, Manila, Philippines
- Understanding water-agriculture-human interrelations with an ecosystem service approach, 3rd International Multidisciplinary Conference on Hydrology and Ecology, Vienna, Austria
- Water footprint in the governmental context: a case study of China, International Resource Panel 'Water Footprint and Accounting' Writing Workshop, Copenhagen, Denmark
- A high-resolution assessment on global nitrogen flows in cropland, Workshop on Agriculture and the planetary boundaries, Stockholm University, Stockholm, Sweden

Michael Obersteiner:

- Attending the UNCCD Meeting: (High Level Segment (HSL) of the Tenth Session of the Conference of the Parties (COP 10) to the United Nations Convention to the Combat Desertification (UNCCD), to meet with the Korean Ministry and Korean Forest Service to follow up on the MoU with the Minister and Chin Min. The MoU is regarding the collaboration with the Korean Forest Service inter alia discuss a joint afforestation project with North Korea, Changwon, Gyeongnam Province, Republic of Korea
- Side Event participations (5) on RED+ Policies, Food Security and Global Land use, UNFCCC - COP17, Durban, South Africa

Anatoly Shvidenko:

- Position Paper for the World Bank on The Role of ECA's (WB East Europe-Central Asia region) Forest Resources in Climate Change Mitigation
- Participation in the preparation of The Russian Forest Sector Outlook Study, 2011-2013, initiated by FAO of the UN
- Position Paper requested by the office of Prime Minister of Finland

Laixiang Sun, Gui-Ying Cao, Günther Fischer

- IIASA researchers produced various policy briefings for China on topics such as livestock-feed, or fertilizer application and its environmental impact, which were well received and commented by Chinese policy makers.

Policy-relevant workshops

Stefan Frank:

- Contrasting the Biomass Futures Modelling results with NREAP targets, Biomass Futures Supply Workshop, Berlin, Germany

Steffen Fritz:

- Chair and convenor of workshop on Characterizing and Validating Global Agricultural Landcover, workshop hosted by IIASA and CGIAR CSI (Consortium for Spatial Information), in close collaboration with the Group on Earth Observation (GEO), the Agricultural Monitoring Communities of Practice (COP), GOFC-GOLD and the Joint Research Centre of the European Commission (JRC). The workshop was funded by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the JRC, IIASA, Austria 13-15 June, 2011
- Representation of ESM as lead partners in the EC FP7-funded EuroGEOSS project, through which IIASA (Participating Organization in GEO) participated in the high-level GEO VIII Plenary in Istanbul (16-18 Nov 2011). In particular the Plenary praised the EuroGEOSS broker as the most significant innovation introduced in the GEOSS Common Infrastructure in 2011, making it possible to increase the number of data sets and progress searchable in the GCI from a few hundred in 2010 to more than 25 million in 2011
- Steffen Fritz and Ian McCallum, together with H.P. Plag of Nevada U, were co-leads of the GEO Science and Technology Committee, ST-09-02, in 2011

Florian Kraxner:

- BECCS country studies, Invited present IIASA's BECCS research to the CCS Unit and Bioenergy Unit at International Energy Agency (IEA), Paris , France
- Invited BECCS expert to the Expert Meeting on Global Technology Roadmap for Industrial CCS, UNIDO/IEA, Rio de Janeiro, Brazil
- Participate in the Forests Dialogue's multi-stakeholder scoping dialogue on the new initiative for Food, Fuel, Fiber and Forests (4F), hosted by WWF, WWF Headquarters, Washington DC, US
- Biomass use and renewable energies – global aspects, invited seminar speaker for the Forest Policy and Economics Seminar at Forestry Faculty, Belgrade University, Belgrade, Serbia

Junguo Liu:

- Participation in the Outlook Feasibility Study, CCICCED Writing Workshop on China's Environment and Development, Stockholm Environment Institute, Stockholm, Sweden
- CCICCED Workshop on China's Environment and Development Outlook Feasibility Study, OECD, Paris, France, May 2011.

Michael Obersteiner:

- Modalities for Reference Levels for REDD+: Technical, Procedural, and Institutional Issues. Organized by Meridian with Sponsorship of Gov. of Norway, Washington DC, US
- Consortium members' meeting and workshop, AGRODEP's invitation for IIASA to participate at the African Growth and Development Policy (AGRODEP) Modeling, Dakar, Senegal
- participate in the CCAFS Science Workshop, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Bonn, Germany

Anatoly Shvidenko:

- Expert participation in Forest Europe - Ministerial Conference on the Protection of Forests in Europe, Oslo, Norway

Hugo Valin:

- ANIMALCHANGE Executive Committee, Stakeholder Platform & Policy Committee Meeting (with policy makers from EC, Brazil, and other countries), Brussels, Belgium
- AgMIP (The Agricultural Model Intercomparison and Improvement Project) Global Workshop, San Antonio, USA

Marijn van der Velde:

- Session chair on the assessment of weather-related risk on agricultural production and agribusiness, EGU 2011, Vienna, Austria

Membership of policy-relevant committees

- IIASA-ESM is active member of the Geo-AG task on Agricultural Monitoring. IIASA-ESM is leading the sub-task: An improved global land use map. This task is part of the Geo-GLAM initiative. The agriculture ministers of the G20 countries adopted a ministerial declaration on 23 June 2011 in Paris launching a Global Agricultural Geo-Monitoring Initiative (GEO-GLAM). The aim of this GEO-led international monitoring network is to produce more accurate crop forecast data in order to promote food security.
- IIASA is a Participating Organization of GEO, represented by ESM researchers.

Activities planned for 2012

ESM will focus on building analytical capacity to

- improve modeling of global scale food and fibre supply scenarios by crowd sourcing of agricultural and forestry driver data using our geo-wiki platform.
  - Kick off meeting of Farmsupport: Funded by the Austrian Science Foundation
  - Start of the GEOSAF project: Funded by the European Space Agency
- work on integrated management strategies for large scale ecosystem disturbances in view of their impact on global ecosystem services.
  - Include/further develop/validate EPIC applications in ongoing projects such as C-Extreme, LC-Impact, ProSUITE, ISAC, FarmSupport, GEOSAF
  - Concentrate on EPIC activities on European and global scale
  - Nutrient scarcity assessments with focus on P cycling
  - Improve the interlinkage between GEO activities at ESM (GEO-WIKI etc) and EPIC (Crop trial analysis, combined Geo-wiki analysis)
  - Further improvement on the European side in GLOBIOM (new data sets and spatial infrastructure from CCTAME)

  - Implementation of soil carbon accounting in GLOBIOM
  - GUI technical support (for GLOBIOM, G4M, EPIC)
  - Development of stochastic recursive downscaling procedures for the GLOBIOM model.
  - Documentation of the downscaling and risk adjusted robust data harmonization procedures for the GLOBIOM model. Two draft papers are prepared.
  - Quantitative and qualitative comparison of production planning and downscaling procedures e.g., with deterministic planning models. Paper preparation on the value of robust stochastic solutions for land use planning models related to GLOBIOM model
- provide globally consistent national policy impact assessments focusing on 6 Congo basin countries, Brazil and Europe.
- Further develop regional/national model development inter alia with NMO countries China, India, Russia, Japan, Sweden
- contribute SSP/RCP scenarios of the global terrestrial biosphere to the IPCC process in cooperation with ENE.
  - The GLOBIOM model joined in early 2012 the ISI-MIP project lead by PIK and IIASA. This community driven initiative will provide a cross-sectoral evaluation of climate change impacts, in the perspective of the next IPCC Assessment Report (Working Group II & III). www.isi-mip.org
  - CCAFS scenario work to be continued in Western Africa and Indo-Gangetic plains
  - Contributing to new scenarios for the IPCC AR5 with IIASA ENE MESSAGE
- develop high resolution assessments of a set of selected commodities and their role in managing natural resources and food security in a volatile economic environment.
  - The FoodSecure project has been launched in March 2012. This 4 years FP7 project led by LEI (Netherlands) will improve understanding of food and nutrition security drivers and develop tools for short term and long term mitigation of food insecurity. The GLOBIOM model will provide support for the analysis of the long term scenarios.
- Continue the IIASA-Brazil collaborative project aiming at a 'LUC Vision Workshop'
- ESM Joint input to the IIASA 40 Anniversary conference
- Continued policy/research work on BECCS together with IEA and other partners targeted at NMO countries including a workshop planned on BECCS in Indonesia
- COST Action: Projecting land use related greenhouse gas emissions and removals:. This Action will involve national and international experts and scientists in the fields of modelling, reporting, climate and land use policy and facilitate the exchange of information on current approaches, models and data sets. It facilitates the development of transparent guidelines and scientifically robust methods to enable decision making based on state-of-the-art projections of emissions from afforestation, deforestation, forest management, cropland and grassland management and other relevant activities.
- development of the BeWhere model towards a BeWhere-Sweden, a BeWhere-Brazil focused on emissions and LCA, a BeWhere-Algae and further BECCS applications.
- prepare a full set of relevant documents on Terrestrial Ecosystems Full Greenhouse Gas Account methodology.
- Targeted proposal conducting with special focus on integrated modeling tool development and policy relevance.

Personnel Resources

Scientific Staff

Michael Obersteiner (Austria), Program Leader
Florian Kraxner (Austria), Deputy Program Leader
Franziska Albrecht (Germany)
Kentaro Aoki (Japan)*
Anna Bais (Philippines)*
Hannes Böttcher (Germany)
Andriy Bun (Ukraine) (25% p-t)
Gui-Ying Cao (China) (90% p-t)
Lars Eriksson (Sweden) (60% p-t)*
Tatiana Ermolieva (Austria)
Günther Fischer (Austria)
Stefan Frank (Austria)
Karl Franklin (Sweden)
Steffen Fritz (Germany)
Sabine Fuß (Germany)
Alejandro Gonzalez del Valle Albares (Spain)
Mykola Gusti (Ukraine) (70% p-t)
Sarah Hall (Sweden)*
Petr Havlik (Czech Republic)
Matthias Jonas (Germany)
Nikolay Khabarov (Russia)
Georg Kindermann (Austria) (40% p-t)
Pekka Lauri (Finland)
Sylvain Leduc (France)
Nils Lindroos (Sweden)*
Junguo Liu (China) (8% p-t)
Anders Lunnan (Norway)*
Ian McCallum (Canada) (80% p-t)
Elena Moltchanova (Finland)
Aline Mosnier (France)
Liudmila Mukhortova (Russia)*
Yuriy Myklush (Ukraine)*
Sten Nilsson (Sweden) (50% p-t)*
Oriana Carolina Ovalle Rivera (Columbia)
Mariah Pereira Vargas (Brazil)*
Christoph Perger (Austria) (50% p-t)
Sylvia Prieler (Austria)
Wolf Reuter (Germany) (20% p-t)
Felicjan Rydzak (Poland) (20%p-t)
Carl Salk (USA)
Linda See (United Kingdom) (80% p-t)
Dmitry Shchepashchenko (Russia)
Anatoly Shvidenko (Russia)

Alexey Smirnov (Russia) (50% p-t)
Laixiang Sun (United Kingdom) (30% p-t)
Jana Szolgayova (Slovakia) (40% p-t)
Elena Tarnavsky (Bulgaria)
Edmar Teixeira (Brazil)*
Zhan Tian (China)
Geza Toth (Hungary) (50% p-t)
Ferenc Toth (Hungary) (10% p-t)*
Eva Tothne Hizsnyik (Hungary) (67% p-t)
Hugo Valin (France) (40% p-t)
Marijn van der Velde (Netherlands)
Harrij van Velthuizen (Netherlands)
Maria Wetterlund (Sweden)
David Wiberg (USA)
Larry Willmore (Canada)*

YSSP

Syeda Absar (Pakistan)
Inbal Becker Reshef (USA)
Marcela Doubkova (Czech Republic)
Oleksiy Frayer (Ukraine)
Viktoria Gass (Austria)
Mary King (USA)
Julian Matzenberger (Austria)
Ahmed Mohamed Harb Rabia Hammad (Egypt)
Anna Olsson (Sweden)
Anna Repo Finland
Lucia Seebach (Germany)
Tatyana Shutkina (Russia)
Petronella Slegers (Netherlands)
Renats Trubins Latvia
Aiko Yano (Japan)
Chuanfu Zang (China)
Honglin Zhong (China)
Lei Zhou (China)

Administrative Support

Cynthia Festin (USA)
Elisabeth Preihs (Canada)
Demetrio Soto Martinez (Austria)

p-t = part time; *Guest Research Scholar

Publications[1]

Journal Articles

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Book Chapters

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Books

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Other Publications

Bird DN, Zanchi G, Pena N, Havlik P & Frieden D (2011). Analysis of the potential of sustainable forest-based bioenergy for climate change mitigation. Working Paper 59, CIFOR - Center for International Forestry Research, Bogor, Indonesia.

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IIASA (2011). Flexibility in livestock systems: More from less. *Options* (IIASA, Laxenburg, Austria), Summer 2011.

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Shvidenko AV, Klimont Z, Kupiainen K, Rao S & Schepaschenko D (2011). The effects of climate change and abatement policies on the value of natural resources in Northern Europe and in the Arctic Sea area. *Prime Minister's Office Reports*, 1/2011; Helsinki, Finland (18 January 2011). [ENE, MAG]

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Schepaschenko D, Fritz S, McCallum I, Perger C, Schill C, Shvidenko A, Kraxner F & Obersteiner M (2011). A platform to visualize, analyze and improve Biomass datasets: http://biomass.geo-wiki.org. In: *CarboForest Conference*. 21-23 September 2011, Forest Research Institute, Sekocin Stary, Poland.

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Schmullius C, Thiel C, Bartalev S, Emelyanov K, Korets M, Shvidenko A, Skudin V & Vashchouk L (2011). Assessment and monitoring of forest resources in the framework of the EU-Russian space dialogue - The ZAPAS project. In: of Forest SB RAS Sukachev Institute (ed.), *Boreal Forests in a Changing World: Challenges and Needs for Action. Proceedings of the international conference IBFRA*. 15-21 August 2011, Krasnoyarsk, Russia.

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Interim Reports

Bun A, Hamal K & Jonas M (2011). Preparatory Signal Detection for the EU-27 Member States Under EU Burden Sharing - Advanced Monitoring Including Uncertainty (1990-2006). IIASA Interim Report IR-11-004.

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Scientific Recognition

Invited lectures

Hannes Böttcher:

- Projection of the future EU forest CO2 sink as affected by recent bioenergy policies, COST-ESF High-Level Research Conference
- The Future Role of Bio-energy from Tree Biomass in Europe, 6-11 November 2011, Europahaus, Vienna/Austria

Günther Fischer

- Invited keynote speech "Will there be sufficient water for the production of food" at the symposium "Heiliges Wasser - Hochwasser - Niederig Wasser and Giftwasser", at the Austrian Academy of Sciences in Vienna, 21 January 2011.
- Invited presentation "Water shortage and food production", at the workshop on "Water resources under pressure: Challenges for Central European regions", at Brandenburgische Akademie, Berlin, 31 March – 1 April 2011.
- Invited presentation "Food security and responsible agricultural investments: Methodology and global estimation of 'fair' land values", Annual Bank Conference on Land and Pverty, World Bank, Washington DC, 18-21 April 2011.
- Invited presentation "The GAEZ v3.0 Update and applications to global/regional food system assessments", University of Maryland, 13 April 2011.
- Invited presentation "AEZ land assessments and applications in global/regional/national analyses", Joint ICTP-IAEA Workshop, Trieste, 30 May – 3 June 2011.

- Invited presentation "Economic effects of sustainability scenarios in land-use and agriculture", at the conference "Beyond GDP - Sustainability Indicators for Policy Making", Brussels, 27 - 28 September 2011
- Invited presentation "Global land availability for responsible agricultural investments: Methodology and global estimation of 'fair' land values", at 5th Academia Belgica-Francqui Foundation Rome Conference in partnership with Societa Geografica Italiana "The global land reserve: Where is it? What are the constraints? A hectare-by-hectare approach", Academia Belgica, Rome, 26-28 October 2011.
- Invited presentation "Grenzen des Wachstums der landwirtschaftlichen Produktion", ÖVAF Wissenschaftliche Tagung, Landtagssitzungssaal, St. Pölten, 7 -8 November 2011.
- Invited presentation "A methodology to assess the capabilities and alternative uses of land" in Hot-Topic-Session "Sustainable Energy for All – What does it mean for Water and Food Security?", at the conference 'The Water, Energy and Food Security Nexus -- Solutions for the Green Economy', organized by the German Federal Government in Bonn, 16 - 18 November 2011.
- Invited keynote speech "Conflicting Objectives affecting bioenergy development" at the Workshop on Sustainable Bioenergy Production in Austria, organized by the Austrian Ministry for Environment, 28 November 2011.

Stefan Frank:

- Linking global biophysical and economic models for assessment of extra-European environmental effects of the Common Agricultural Policy, (CAP) EAAE, Zurich, Switzerland

Sabine Fuss:

- Investment in wind power & pumped storage in a Real Options Model - A policy analysis, World Renewable Energy Congress (WREC) 2011, Linkoeping, Sweden
- Renewable energy investment: Policy and market impacts, Energy Solutions for a Sustainable World, Third International Conference on Applied Energy (ICAE2011), Perugia, Italy
- Large Scale Modeling of Bioenergy Mandates under Volatile Crop Yields, International Energy Workshop (IEW), Stanford, US

Mathias Jonas:

- Providing a framework for moving to a low C world, 11th Global Carbon Project Scientific Steering Committee Meeting, Shepherdstown, West Virginia, US

Nikolay Khabarov:

- Value of Earth Observations: Forest Fires, Earthquakes, and Landslides, International Workshop on Socio-Economic Benefits from the Use of Earth Observation, JRC, Ispra, Italy
- Climate Change Impacts on Agriculture and the Economics of Adaptation, 4th Regional consultation meeting on Economics of Climate Change and Low Carbon Growth, Strategies in Northeast Asia, Ministry of Environment, Tokyo, Japan
- Simple Standalone Forest Fire Model, Technical workshop on European research projects on forest fires and climate change, JRC, Ispra, Italy

Florian Kraxner

- BECCS in Europe and Asia, UNECE/FAO Forest Communicators Team of Specialists Annual Meeting 2011, Budapest, Hungary
- BECCS in South Korea – An Analysis of Negative Emissions Potential for Bioenergy as a Mitigation Tool, World Renewable Energy Congress (WREC) 2011, Linkoeping, Sweden
- Innovation Spread in Austria's Bioenergy Sector – A Qualitative Spatiotemporal Analysis, Third International Conference on Applied Energy (ICAE2011), Perugia, Italy
- Bioenergy Innovation in Central Europe - A Spatiotemporal Policy Analysis, Pre-IUFRO/UNECE conference for forest products marketing, Oregon State University, Oregon Wood innovation Center, Corvallis, Oregon, USA
- Responsible Global Integrated Forest Management Strategies, International Conference on Response of Forests and Adaptation Management to Climate Change (Session Chair), Yichun, China
- Forest-based Bioenergy in the Eurasian Context, 15th International Boreal Forest Research Association –Conference (IBFRA), Krasnoyarsk, Russia
- Future Forests - understanding processes shaping future forest use. An overview of ecological, social and economic drivers and trends, invited seminar speaker for Future Forests Program by SLU: Forests in a changing World - integrating values, interests and trade-offs, Jokkmock, Sweden
- Global shifts of land use: Natural resources and the future, invited seminar speaker for the Future Agriculture Program by SLU: livestock, crops and land use, Uppsala, Sweden
- Forest-based feed stocks - a global outlook, invited seminar speaker at Norwegian University of Life Sciences, Oslo, Norway
- BECCS in Japan - An Analysis of Negative Emissions Potential for Bioenergy as a Mitigation Tool, Second international workshop on biomass & carbon capture and storage, Cardiff, Wales, UK
- Future Scenarios for Global Forest Development, Invited speaker at the International FORMATH Forum 2011, Forest Resource Management and Mathematical Modeling, GRIPS, Tokyo, Japan

Junguo Liu:

- A high-resolution assessment on global nitrogen flows in cropland, Science Forum 2011: The Agriculture-Environment Nexus, Beijing, China
- Efficient Water and Fertilizer Management for Global Food Security, the Hebrew University of Jerusalem, Israel
- Colorful water research in the context of global water scarcity, University of Twente, the Netherlands
- Blue and green water uses in the context of climate change, the 8th International Association of Landscape Ecology World Congress, Beijing, China
- Colorful water research in the context of global water scarcity, Max Planck Institute for Meteorology, Hamburg, Germany

Aline Mosnier:

- Impacts of improved transportation infrastructure on agricultural sector in the Congo Basin, International CIALCA Conference, Kigali, Rwanda
- Potential and Impact Assessment of biofuels with the GLOBIOM model, 3rd International Conference on biofuels in Africa, Ouagadougou, Burkina Faso

Michael Obersteiner

- Invited Speaker at the World Forest Dialogue Geneva, GEO Secretariat, Geneva, Switzerland
- Presenting "Integrated Assessment of REDD+ policies" in various side events at the SBSTA 34 (UNFCCC), Bonn, Germany
- REDD+ Policy, The Role of Commodity Roundtables & Avoided Forest, Conversion in Subnational REDD+1: Agriculture, Food Security & Greenhouse Gas (GHG) Accounting. Organized by the National Wildlife Federation, San Diego, US
- Synergies and trade-offs in Land-sparing – A global modeling perspective, Biennial Science Forum of the Consultative Group on International Agricultural Research (CGIAR), organized by CGIAR, the Global Forum on Agricultural Research (GFAR) and the Chinese Academy of Agricultural Sciences, Beijing, China
- Keynote on Trade-offs between food, fuel and fibre, National Science conference, organized by the Indonesian Institute of Science (LIPI), Jakarta, Indonesia
- Keynote speaker at the GLP workshop on "Land Use Transitions in South America : framing the present, preparing the future towards regional sustainability" Organized by Global Land Project, National Institute for Space Research and IGBP Brazil Regional Office, Ilhabela, Brazil
- Key note speaker at the Launch of the SA YSSP, Durban, South Africa

Linda See:

- Building a crowd-sourcing tool for the validation of urban extent and gridded population, International Conference on Computational Science and its Applications (ICCSA 2011), University of Calabria, Santander, Spain
- Improving global land cover through crowd-sourcing and map integration, GeoComputation 2011. UCL, London, UK
- Crowdsourcing and biofuels: a match made in heaven? Seminar series of UCL, London, UK

Dimitry Schepaschenko:

- Biomass Geo-Wiki, Soil science conference, St Petersburg, Russia
- Geo-Wiki, Carboforest conference, Warszawa, Poland
- Biomass Geo-Wiki, AGU fall meeting, San Francisco, US

Anatoly Shvidenko:

- Changing world, boreal forests and IBFRA. Key-note at the International Conference Boreal Forests in a Changing World; Challenges and Needs for Actions, Krasnoyarsk, Russia
- Impacts of wildfire in Russia between 1998-2010 on ecosystems and the global carbon budget, International Conference Wildfire-2011, Sun City, South Africa
- Adaptation and mitigation strategies in Northern Eurasian boreal forests, International Conference on Response of Forests and Adaptation Management to Climate Change, Yichun, Heilongjiang, China
- Carbon budget of circumpolar boreal forests: an attempt of synthesis, International Science Conference on Carbon Pools and Fluxes in Boreal Forest and Peatland Ecosystems, Syktyvkar, Russia
- Full carbon account for Russia, GEO-Carbon Conference, ESA, Rome, Italy

Laixiang Sun:

- Distinguished Guest Lecture "Food, Feed, and Fuel: Prospects for China based on Simulations of Chinagro-II Model through 2030", University of Rome Tor Vergata, Rome, 1 June 2011.
- Distinguished Guest Lecture "Food, Feed, and Fuel: Prospects for China based on Simulations of Chinagro-II Model through 2030", University of Nottingham, UK, 5 October 2011.
- Distinguished Guest Lecture "Chinese Agriculture in 2030: Impacts on Trade, Society and Environment", University of Maryland, USA, 13 October 2011.

Hugo Valin:

- GLOBIOM - Global land use modeling (1); Livestock, Land use and GHG (2), Invited key note presentations at the General Assembly of INRA (France), Department of Economics and Social Sciences (SAE2) with the perspective of closer collaboration between INRA and IIASA, Paris, France
- Global Perspectives on Agriculture and Forest Mitigation with Emphasis on Induced Land Use, Change Invited presentation at the Forestry and Agriculture Greenhouse Gas Modeling Forum, Sponsored by US EPA, West Virginia, US

Marijn van der Velde :

- Integrated water resources management in Small Island Developing States: managing ENSO climate variability, agricultural intensification and economic development, EGU 2011, Vienna, Austria

David Wiberg:

- Invited presentation "Scenarios for Driving Forces : Employing a Participatory Scenario Development Process. Future of European Waters". Hungarian Academy of Sciences, Budapest, 23 March 2011.

Larry Willmore:

- Universal pensions and universal minimum pensions: the experience of Mexico City, Chile and Norway, the International Experience of Universal Pensions, Polytechnic University of Hong Kong, (see photo: HK2afternoon.jpg)
- Testimony before the Subcommittee on Retirement Protection, Legislative Council, Hong Kong, 28 November 2011. (see photo: HK3LegCo.jpg)

Awards

Günther Fischer:

- has been appointed as an Adjunct Professor in the Department of Geography, University of Maryland (UMD), USA. The UMD Geography was ranked 3rd in the 2010 National Research Council Rankings of the USA.

Sabine Fuss:

- 2011 Best paper presentation by a young scientist at the IBFRA congress, Krasnoyarsk, Russia

Junguo Liu:

- ProSPER.Net-Scopus Young Scientist Award & Winner in the field Biodiversity and Natural Resources Management
- The Person of the Year and Outstanding Young Scientist Award of Scientific Chinese
- Winner of the most influencing 100 international research articles in China

Wolf Heinrich Reuter:

- 2011 Scientific award of the German Federal Statistical Office (Destatis), for the bachelor thesis in information systems (GER)
- 2011 "Grand Prix of the Competition of Master Degree Theses on Economy and Finance" of the Centre des Professions Financières, Paris, for the diploma thesis in economics (FRA)

Anatoly Shvidenko:

- A. Shvidenko was awarded by a gold medal of the UN International Informatization Academy as a Laureate of the International Competition "Elite of the Informationologists of the World 2011"

Laixiang Sun

- In the March 2011 issue of "China Scholars Abroad", Professor Laixiang Sun was the cover figure, for highlighting his significant contributions in development economics, comparative economics, and interdisciplinary systems analysis.

Honglin Zhong, YSSP:

- Honglin Zhong, from the Department of Geography at East China Normal University, China, YSSP participant, won the Peccei Award of 2011 Young Scientists Summer Program.

Advisory boards/groups

Steffen Fritz:

- Scientific committee of the 'Sentinel-2 preparatory symposium', Frascati, Italy

Florian Kraxner:

- Austrian Delegate to the UNECE/FAO Team of Specialists on Forest Communication/Communicators Network (FCN), http://timber.unece.org/ Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
- Austrian Delegate to the UNECE/FAO Team of Specialists on Forest Products, Markets and Marketing (FPM), http://timber.unece.org/ Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management

- IIASA Coordinator of Foresight – UK-based Science-Policy Maker Interface Activity, http://www.foresight.gov.uk, Government Office for Science, Department of Innovation, Universities and Skills, Kingsgate House, 66–74 Victoria Street, London, SW1E 6SW
- IIASA Representative to SCOPE, the Scientific Committee on Problems of the Environment; established by the International Council for Science (ICSU), http://www.icsu-scope.org/ SCOPE - 5, Rue Auguste Vacquerie - 75116 Paris - France

Junguo Liu:

- Organization committee member, the 5th Annual International Ecosystem Services Partnership Conference
- Key expert of UNEP Water Footprint Project
- Chinese expert for China Council for International Cooperation on Environment and Development (CCICED)
- Advisory Expert for WWF-China, IUCN-China and Thirst4Water

Michael Obersteiner:

- Member of the Strategic Advisory group for Norway's International Climate and Forest Initiative (NICFI)

Dmitry Schepaschenko:

- Member of Academic Council, Moscow State Forest University, Russia.

Larry Willmore:

- Larry Willmore. Member, Task Force on Pension Reform and Social Insurance, Initiative for Policy Dialogue, Columbia University.

Editorships

Steffen Fritz:

- Guest Editor: of the open access journal 'Remote Sensing; Special Issue "Remote Sensing on Earth Observation and Ecosystem Services

Mathias Jonas:

- White, T., M. Jonas, Z. Nahorski, and S. Nilsson (eds.) 2011: Greenhouse Gas Inventories: Dealing with Uncertainty. Springer, Dordrecht, Netherlands, pp. 260, ISBN: 978-94-007-1669-8. Available at: http://www.springer.com/environment/global+change+-+climate+change/book/978-94-007-1669-8.
- A book "Catastrophe risk modeling: supporting policy processes" has been edited jointly with RAV and ASA (A. Amendola, T. Ermolieva, J. Linerooth-Bayer, R. Mechler). The book summarizes practical and methodological achievements of IIASA in the field of integrated modeling and management of catastrophic risks which has been conducted since 1997 for such natural disasters as earth floods, hurricanes, earthquakes, etc.

Jungou Liu:

- Editor of Hydrology and Earth System Sciences (HESS)

Michael Obersteiner:

- Editorial board member of the Journal of Applied Energy
- Editorial board member of the Journal of Carbon Balance and Management

Linda See:

- Associate Editor of Hydrological Sciences Journal

Anatoly Shvidenko:

- Editorial board member of international journals "Mitigation and Adaptation Strategies for Global Changes", "Scientific Gerald of the Siberian Federal University", "Forest Inventory and Forest Management"
- Advisory Committee Member of "Eurasian Journal of Forest Research"

Larry Willmore:

- Contributing Editor, Pension Reforms (www.PensionReforms.com), Retirement Policy & Research Centre, University of Auckland.

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"NitroEurope (together with MAG) The nitrogen cycle and its influence on the European greenhouse gas balance"	European Commission, DG Research	01.02.2006	30.04.2011	87,188.00	8,972.00
"EC4 MACS (together with MAG) European Consortium for Modelling of Air Pollution and Climate Strategies"	European Commission, DG Environment, LIFE	01.02.2007	31.01.2013	250,707.00	62,403.00
"WATCH Water and Global Change"	European Commission, DG Research	01.02.2007	31.07.2011	471,000.00	28,336.00
"ClimateCost (together with MAG) Full Costs of Climate Change"	European Commission, DG Research	01.12.2008	31.07.2011	85,291.00	4,806.00
"CCTAME Climate Change - Terrestrial Adaption and Mitigation in Europe"	European Commission, DG Research	01.06.2008	31.08.2011	724,891.00	686,896.00
"IN-STREAM INtegrating MainSTREAM Economic Indicators with those of Sustainable Development"	European Commission, DG Research	01.08.2008	30.09.2011	146,320.00	28,728.00
"WTZ Poland Scientific-Technical Agreement with Poland 2009-2010"	Austrian Exchange Service (OeAD)	01.01.2009	31.12.2011	6,400.00	3,039.00
"CARBO Extreme The terrestrial Carbon cycle under Climate Variability and Extremes - a Pan-European synthesis"	European Commission, DG Research	01.06.2009	31.05.2013	70,000.00	30,969.00
"BIOMASS FUTURES Biomass role in achieving the Climate Change & Renewables EU policy targets. Demand and Supply dynamics under the perspective stakeholders"	European Commission, Executive Agency for Competitiveness and Innovation (EACI)	01.06.2009	31.03.2012	195,002.00	75,049.00
"EuroGEOSS a European Approach to GEOSS"	European Commission, DG Research	01.05.2009	30.04.2012	442,525.00	187,138.00
CCTAME - Supplementary Funding	Bundesministerium für Wissenschaft und Forschung (BMWF)	25.11.2009	30.12.2011	67,312.20	20,520.00
"GHG Europe Greenhouse gas management in European land use systems"	European Commission, DG Research	01.12.2009	31.05.2013	300,000.00	71,465.00
"LC-IMPACT Development and application of environmental Life Cycle Impact assessment Methods for imProved sustAinability Characterisation of Technologies"	European Commission, DG Research	01.12.2009	30.11.2012	308,063.00	90,609.00
"PROSUITE Development and application of standardized methodology for the PROspective SUstaInability assessment of TEchnologies "	European Commission, DG Research	01.11.2009	31.10.2013	289,525.00	58,711.00
"EnerGEO (together with ENE and MAG) Energy Observation for monitoring and assessment of the environmental impact of energy use"	European Commission, DG Research	01.11.2009	31.10.2013	382,182.00	61,079.00
"PASHMINA Paradigm Shifts Modelling and Innovative Approaches "	European Commission, DG Research	01.11.2009	31.10.2012	319,300.00	54,730.00
"Packard Greenhouse Gas & Nitrogen Emissions Scenarios for US Agriculture and Global Biofuels"	Duke University	07.12.2009	30.09.2011	96,873.70	60,206.00
"BioSpaceOpt Regional integrative assessment of bioenergy utilisation paths based on spatial aspects - development of a model framework and a case study"	Austrian Research Promotion Agency (FFG)	01.03.2010	29.02.2012	50,002.00	10,404.00
Model Based Assessment of EU energy and climate change policies for post-2012 regime	Institute of Communication and Computer Systems, National Technical University of Athens	01.04.2010	31.12.2011	44,991.00	24,771.00
"RAMCUB Regional Assessing the Market for Commercial Use of Biomass for Heat and Power Generation in Bulgaria, Romania, Ukraine, Belarus and Turkey"	Österreichische Bundesforste AG	01.08.2010	30.06.2012	68,774.00	62,420.00

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"BIOFUELS Provide support activities for the development of baseline data and methodology for reporting requirements for biofuels"	Ecofys Netherlands B.V.	20.01.2010	31.08.2011	87,559.00	0.00
Collaboration project on "Sustainable Futures of Livestock Systems" (four months per year of Dr. Havlik's expert time in 2010, 2011 and 2012)	The International Livestock Research Institute (ILRI)	01.08.2010	31.12.2012	95,820.00	26,758.00
Subcontract Agreement to support organization of three-day workshop at IIASA between 6-28 February 2011	The International Livestock Research Institute (ILRI)	01.09.2010	30.06.2012	87,567.50	43,184.00
"PURELEC Investment in renewable electricity under policy uncertainty"	Norwegian University of Science and Technology (NTNU)	01.11.2010	31.12.2013	30,626.00	9,342.00
"GESAPU Geoinformation technologies, spatio-temporal approaches, and full carbon account for improving accuracy of GHG inventories"	European Commission, Research Executive Agency (REA)	24.06.2010	23.06.2014	37,800.00	9,034.00
"EGIDA Coordinating Earth and Environmental cross-disciplinary projects to promote GEOSS"	European Commission, DG Research	01.09.2010	01.09.2012	81,320.00	22,080.00
"Balkan GEO Network Towards Inclusion of Balkan Countries into Global Earth Observation Initiatives"	European Commission, DG Research	01.11.2010	31.10.2013	44,672.00	21,051.00
WTZ Ukraine 2011-2012	Austrian Agency for International Cooperation in Education and Research (OeAD-GmbH)	01.01.2011	31.12.2012	9,942.00	4,008.00
"ISAC Information Service on Agricultural Change"	European Commission, Research Executive Agency (REA)	01.01.2011	30.06.2013	268,179.00	37,161.00
The impacts of EU consumption of food and non-food imports on deforestation	VITO NV	01.01.2011	30.06.2012	115,649.00	91,767.00
"LULUCF II Long-term analyses of LULUCF options at EU level"	European Commission, DG Clima	01.01.2011	31.12.2011	124,500.00	124,501.00
"DECC emissions Provision of Forestry business as usual emissions projections and abatement cost data to the Department of Energy and Climate Change"	Department of Energy and Climate Change (DECC)	11.01.2011	31.03.2011	51,030.00	51,030.00
"LandSpotting Collecting in-situ data for Earth Observation product validation via social games"	Austrian Research Promotion Agency (FFG)	01.02.2011	31.07.2012	87,272.00	19,437.00
"Mitigation of climate change (together with MAG) Continued model capacity to support international policy objectives"	Entec UK Ltd	01.01.2011	31.03.2012	25,063.00	19,583.00
"Carbon fluxes Mitigation of climate change: continued model capacity to support international policy objectives"	Swedish University of Agricultural Sciences (SLU)	01.01.2011	31.12.2011	27,340.00	27,340.00
"PostCopUncertainty ACRP3 - Uncertainty in an Emissions Constrained World: Case Austria"	Kommunalkredit Public Consulting GmbH	01.01.2011	31.12.2011	58,764.00	58,773.00
ACM - Agriculture and Carbon Markets	Department for International Development (DFID)	01.01.2011	31.03.2011	15,080.00	15,080.00
"Animal Change AN Integration of Mitigation and Adaptation options for sustainable Livestock production under climate CHANGE"	European Commission, DG Research	01.03.2011	28.02.2015	380,004.00	39,898.00
The Role of ECA's Forest Resources in Climate Change Mitigation	The World Bank	05.05.2011	30.09.2011	31,500.00	31,500.00
"DEA tender Global Forestry Emissions Projections and Abatement Costs (2)"	The Danish Energy Agency	16.06.2011	15.09.2011	33,480.00	33,480.00
"REDD Reducing Emissions from Deforestation and Forest Degradation"	AMEC Environment & Infrastructure UK Ltd	01.02.2011	01.04.2012	93,590.00	27,570.00
"Global IQ Impacts Quantification of global changes"	European Commission	01.08.2011	31.07.2014	404,125.00	19,941.00

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"ZAPAS Assessment and Monitoring of the Forest Resources in the Framework of the EU-Russia Space Dialogue"	Commission of the European Communities (EC)	01.08.2011	31.07.2014	75,000.00	0.00
"LIMITS (together with ENE) Low climate Impact scenarios and the Implications of required Tight emission control Strategies"	European Commission, DG Research & Innovation	01.10.2011	30.09.2014	112,500.00	6,759.00
Proposal for Collaboration between Brazil and IIASA	Center for Strategic Studies and Management (CGEE)	01.10.2011	30.04.2012	80,750.00	21,423.00
"IMPACT2C (together with RPV) Quantifying projected impacts under 2degC warming"	European Commission, DG Research & Innovation	01.10.2011	30.09.2015	196,633.00	10,989.00
"EUCLIMIT (together with MAG) Development and application of EU economy-wide climate change mitigation modelling capacity (all greenhouse gas emission and removals)"	Institute of Communication and Computer Systems	07.09.2011	06.09.2013	70,302.00	13,893.00
"GEOCARBON Operational Global Carbon Observing System"	European Commission, DG Research & Innovation	01.10.2011	30.09.2014	142,415.00	9,720.00
GAEZ technology transfer workshops at FAO Headquarters	Food and Agriculture Organization of the United Nations(FAO)	08.11.2011	31.03.2012	69,640.00	27,857.00
"REDD-PAC REDD+ Policy Assessment Center "	Federal Minister for the Environment, Nature Conservation and Nuclear Safety (BMU)	01.11.2011	31.10.2015	4,542,089.61	22,451.00
"AndesPlus Adaptation to the impact of rapid Glacier retreat in Tropical Andes"	World Bank	01.08.2011	30.09.2012	48,600.00	13,257.00

Energy Program

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Objectives

The overarching goal of the Energy (ENE) Program is to provide scientific and strategic analysis to foster a better understanding of the dynamics of future energy transformations, their main driving forces, enabling factors and barriers, and their consequences for the social, economic, and environmental dimensions of human wellbeing.

The Program's aim is to identify viable policy mechanisms, leverages, and technology portfolios that would permit the transformation of the present energy system to a cleaner and more sustainable one. This comprises i) scenario analysis based on systems engineering and integrated assessment modeling to explore synergies between diverse policy objectives (e.g., climate change, air pollution, and energy security), and ii) the development of new methodologies for the explicit representation of uncertainty, heterogeneity, and inequality.

In addition to the core research activities, ENE is hosting and coordinating the Global Energy Assessment (GEA) with the aim of facilitating exchange among energy experts and leading businesses, governments, and international organizations, and also of promoting the dissemination of leading-edge technical, policy, and strategic advice. GEA involves some 300 Lead Analysts and 200 anonymous Reviewers from around the world, working together on a comprehensive and integrated assessment of major energy challenges and the ways forward in terms of embarking on more sustainable development pathways.

Alignment with Strategic Plan

ENE research areas are at the core of a number of central research themes at IIASA, in particular the integrated assessment of climate change, the analysis of the energy dimensions of poverty, and the role of energy services in supporting economic development.

Scientific Achievements in 2011

Integrated solutions for climate change, energy security, and air pollution

In 2011 ENE continued to push the boundaries of the integrated assessment modeling field by broadening its scope and simultaneously exploring the relationship between three key energy sustainability objectives: energy security improvement, climate change mitigation, and the reduction of air pollution and its human health impacts. In a paper published in *Nature Climate Change* (Dec. 2011), ENE researchers **David McCollum**, **Volker Krey**, and **Keywan Riahi** explain how the common practice of narrowly focusing on single policy issues ignores potentially enormous synergies, quite often leading to the implementation of short-sighted solutions that may have unnecessarily costly, long-term consequences. The paper, which served as an input to the United Nations Climate Change Conference in Durban (COP17), argues for a paradigm shift toward more holistic policy approaches supported by a new generation of integrated decision-making tools. On the basis of these tools, an example of which was developed jointly by the ENE researchers in collaboration with the ASA Program (Marek Makowski, Hongtao Ren), a reconsideration of the traditional, fragmented energy policy framework (*Figure 1*) is merited.

This research adopts a holistic and integrated perspective in a large ensemble of integrated assessment scenarios – one that addresses all of the sustainability objectives simultaneously. It indicates that cost-effective climate-pollution-security policies are likely to lead to substantial co-benefits, in terms of costs avoided and the achievement of societal objectives for sustainability. Key findings of the analysis were summarized in a policy report to UNIDO and the Global Environment Facility (GEF), and an additional scientific paper has been submitted to the *Journal of Climatic Change*.

Long-term ENE collaborator **Jessica Jewell**, developer of the Model of Short-term Energy Security (MOSES), which was presented at the 2011 IEA Ministerial meeting, joined ENE in 2011, strengthening the team working on energy security issues.

Energy Poverty, Energy Access, and Well-being in Developing Regions

In 2011 ENE built on earlier work to produce new results that deepen our understanding of the causes of energy poverty, modeling policy scenarios for improving modern energy access globally, assessing the impacts of new access policies and transitions, and developing a new Web-based interactive energy access policy analysis tool (ENACT).

Two journal special issues published in 2011, *Current Opinion in Environmental Sustainability (COSUST)* and *Energy Policy*, were co-edited by ENE researcher **Shonali Pachauri**. Papers in *COSUST* on "energy security and energy access - interconnected global challenges" explore the scale of the energy access challenge, its gender dimensions, the challenges of rural electrification, and financing to ensure sustainable energy access. Contributions in *Energy Policy* on "household cooking fuels and technologies in developing countries" further our understanding of the issues surrounding clean cooking fuels and stove adoption, and their impacts in developing economies, as well as of policies to make the provision of these a central component of development strategies.

Further development of and refinements to the MESSAGE-Access model in 2011 focused on incorporating a wider range of technical options for decentralized electricity supply in South Asia, and expanding regional coverage to China to explore policy scenarios for improved modern cooking fuel and stove access. Results from these model extensions have been submitted to international scientific journals for publication.

In 2011 ENE researchers **Yu Nagai**, **Peter Kolp**, **Shonali Pachauri**, and **Keywan Riahi** also developed a new Web-

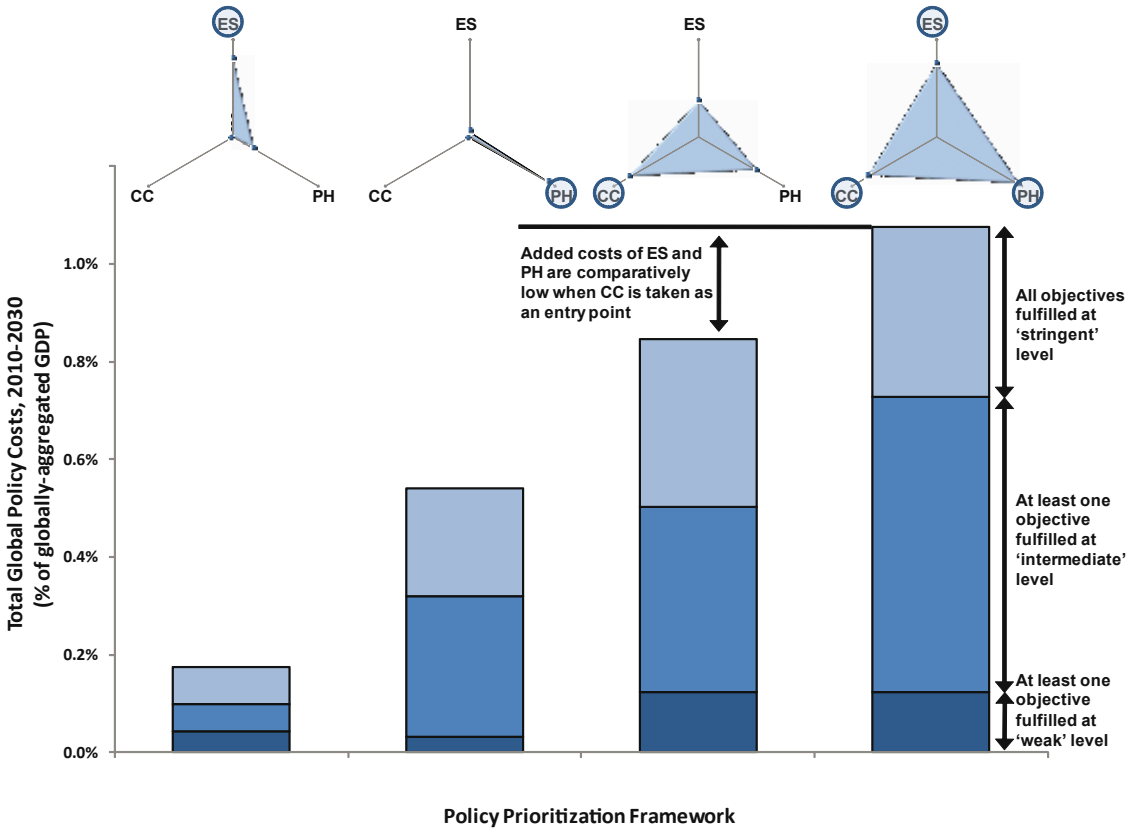

Figure 1. Costs of achieving societal objectives for energy sustainability under different policy prioritization frameworks. Policy costs represent the net financial requirements (energy-system and pollution-control investments, variable, and operations and maintenance costs) over and above baseline energy-system development. Triangular schematics summarize the performance of scenarios that achieve 'stringent' fulfillment only for the objective(s) targeted under the corresponding policy frameworks (axis values normalized from 0 to 1 based on the full range of scenario ensemble outcomes; CC = Climate Change, ES = Energy Security, PH = Air Pollution and Health). [Source: McCollum et al., 2011, *Journal of Nature Climate Change*]

based interactive energy access policy analysis tool (ENACT, see *Figure 2*). The central purpose of the tool is to aid decision makers in their assessments of future policy choices and their effectiveness in achieving universal modern energy access goals by 2030. The tool has been specifically designed for policy advice and the communication of scenario results, allowing users to visualize the costs and benefits of specific policy choices and to better understand the impacts of policies on the likely development of future residential energy access and demands.

Finally, **Narasimha Rao** joined ENE in 2011 as a Postdoctoral Scholar, strengthening the ENE team working in the domain of energy poverty.

Modeling of Technology Diffusion

Future scenarios of the energy system in general and specifically under ambitious carbon constraints often depict dramatic growth in a range of energy technologies, on the demand as well as the supply side. Many integrated assessment and energy-economic models employ expansion constraints to limit diffusion of new technologies to "reasonable" rates.

Jointly with the TNT Program and the Research Institute of Innovative Technology for the Earth (RITE), Japan, a framework is being developed that puts technology-specific expansion constraints on a more solid theoretical foundation, drawing on technology systems, scaling, and diffusion theory and backed up by empirical analysis of historical examples of technological change in energy systems. In a parallel research project with TEPCO, Japan, technology diffusion patterns of a number of key power generation technologies were analyzed and driving forces for regional diffusion patterns were identified. A first version of the conceptual technology diffusion framework was then implemented into ENE's MESSAGE model. An improved and more empirically-founded representation of technology diffusion or upscaling constraints may allow for a qualification of what may be achievable and what may be out of reach in ambitious climate change mitigation scenarios.

The research was motivated by previous work on the part of TNT, ENE, and the University of East Anglia (UEA) that analyzed the historical growth patterns of a set of energy-related technologies, covering a wide range from energy supply technologies such as oil refineries and different types of power plants (fossil, nuclear, wind, photovoltaics) to end-use technologies of various kinds (e.g., passenger aircraft, cars, compact fluorescent light bulbs, and mobile phones). A comparison of the historical growth dynamics to the technology diffusion speed in cli-

mate change stabilization scenarios from integrated assessment models suggested that, despite the projected deployment levels appearing substantial at first glance, the models tend to be conservative in their projected technology diffusion rates compared to what has been observed historically.

Integrated Assessment Community Activities

As in previous years, ENE is actively participating in a number of multi-model studies as part of the Integrated Assessment Modeling community. In 2011 two large European model-comparison projects, AMPERE and LIMITS, both co-led by ENE, started.

AMPERE involves more than 20 partners and aims at a broad exploration of mitigation pathways and associated mitigation costs, while at the same time generating a better understanding of the differences across integrated assessment models and the relation to historical trends. Uncertainties about the costs of mitigation originate from the entire causal chain ranging from economic activity to emissions and related technologies, and the response of the carbon cycle and climate system to greenhouse gas emissions.

LIMITS is focusing particularly on the economic, technical, and political feasibility of attaining stringent climate targets. Central research topics include the stimulation of investments and innovation into clean energy technologies, the role of policies in promoting mitigation and adaptation, recognizing the diversity of regional and national interests, and the role of technologies and advances in technologies in meeting changes in the energy infrastructure. In addition, the Asian Modeling Exercise (AME) and the Stanford-based Energy Modeling Forum (EMF 27) study continued throughout 2011 and will be finalized in 2012.

The development of Web databases as a service for the scientific community and as a dissemination tool for scenario analyses has been expanded with several additional databases hosted for modeling comparison projects (the aforementioned AMPERE and LIMITS projects, the EMF 24, 27 & 28 exercises, and AME). This activity feeds directly into efforts to improve coordination within the scientific community by the Integrated Assessment Modeling Consortium (IAMC), the annual meeting of which was hosted by the ENE program in October 2011.

IPCC Fifth Assessment Report (AR5)

Two sets of scenarios are planned to serve as an integrating thread between the different research communities that are involved in the IPCC's Fifth Assessment Report. ENE has continued to play a critical role in the development and coordination of both of these scenario sets. The first set, the so-called RCPs (Representative Concentration Pathways), was completed in 2011 and published in a Special Issue by the *Journal of Climatic Change* with Keywan Riahi from ENE serving as co-editor of the issue. The second set, the SSPs (Shared Socioeconomic Pathways), which will eventually replace the scenarios from the Special Report on Emission Scenarios (SRES), is currently under development.

The development of the SSPs is a truly grassroots effort by the mitigation, adaptation, and impacts communities. During this process, ENE hosted a coordination meeting of the IAM community in October 2011 and served on the organizing committee

Figure 2. Screenshot of ENACT, a Web-based Energy Access Tool, developed within the ENE program in 2011 to aid decision makers in their assessments of future policy choices and their effectiveness in achieving universal modern energy access goals by 2030.

of the second SSP meeting at NCAR in Boulder, Colorado, USA, in November. From the scientific side, ENE's MESSAGE modeling team is also contributing with the quantification of one out of five SSPs, and is spearheading the IIASA cross-program collaboration with IIASA's POP and ESM Programs for the development of integrated SSP scenarios covering energy, land-use, and the social dimension of future transformations. In addition, ENE is supporting the process by hosting the SSP database, which serves also at the moment as a working environment for the modeling teams, but will become the major dissemination tool for the SSP data for the community, once the SSPs are finalized. The wide recognition of ENE within the scientific community is also illustrated by four ENE scientists, Luis Gomez Echeverri, Volker Krey, Nebojsa Nakicenovic, and Keywan Riahi, serving as Lead Authors for the IPCC AR5. Volker Krey is, in addition, a Coordinating Lead Author of AR5 and has served as Lead Author for two chapters and the Summary for Policymakers (SPM) of the IPCC Special Report on Renewable Energy, which was also completed in 2011.

Global Energy Assessment

The Global Energy Assessment (GEA) is a multi-stakeholder initiative that seeks to assess and identify options and strategies for addressing, in a comprehensive and integrated manner, the major global challenges of our century requiring action on energy. These challenges include poverty alleviation, economic growth and development, climate change mitigation, security, and ecosystem and human health, to name just a few. The GEA has involved some 300 Lead Authors and about 200 anonymous Reviewers. These Lead Authors and Reviewers are independent scientific and technical experts from academia, business, governments, and inter-governmental and non-governmental organizations, selected from some 75 countries from all regions of the world. The analysis of GEA is designed to provide a reference and background for a broad range of stakeholders, analysts, policymakers, and decision makers in governments, businesses, and civil society who have a stake in the transition to energy for sustainable development. The main product of GEA will be a major analytical report divided in four thematic clusters.

The year 2011 was dedicated to the completion of the whole manuscript, namely, the 25 chapters of the report and the front document consisting of the Key Messages, Summary for Policymakers, and Technical Summary. This has been a critical period for GEA in that it has involved principally the peer review of the entire manuscript and the revision of all of its content to address the views, comments, and suggestions of some 200 experts from throughout the world. GEA was also a leading participant in a high profile energy event in Vienna co-hosted by the Government of Austria, UNIDO, and IIASA. This event – the Vienna Energy Forum – involved participants from countries of all regions. GEA was an active participant and leader in most of the sessions of this key event. In addition, GEA hosted meetings of the Executive Committee as well as meetings of the Council of GEA. During the last stage of GEA, the Council followed the process closely to help address the challenges that, not surprisingly, emerge in this type of very large and complex project involving many people.

The year 2011 was also dedicated to maintaining the support of sponsors and partners of GEA throughout the last stages and to ensuring that full recognition was given to each for their support throughout the years. Negotiations were completed with Cambridge University Press, which agreed to publish the report. Discussions were initiated and feedback was received from the publisher. Altogether, this has been helpful in crafting the report into its final form. At the beginning of 2012, the manuscript was finalized and submitted to the publisher. Launch is planned at the Rio+20 Conference in June 2012 in Brazil.

Strategic collaborations

In the area of air pollution and health, ENE intensified collaborations with the Mitigation of Air Pollution and Greenhouse Gases (MAG) Program at IIASA, the Joint Research Centre in Ispra, Italy (part of the European Commission), and Columbia University in the USA to explore the health benefits of climate and pollution control scenarios. In addition, a collaboration was established with L'Institut National de l'Environnement Industriel et des Risques (INERIS) in France to develop future scenarios of air pollution in Europe. A policy report has been completed and was planned to be launched during the Planet under Pressure Conference in London in 2012.

Two ENE collaborations with a focus on Asia were successfully completed in 2011. A report in collaboration with IRADe (Integrated Research and Action for Development, India) on India's energy future was completed and provided input for the Indian NMO of IIASA, TIFAC (Technology, Information, Forecasting and Assessment Council). In addition, a joint report with the Grantham Institute for Climate Change, Imperial College London, explores the potential for greenhouse gas emission reductions in China.

Finally, a collaboration with the Japanese NMO to IIASA, the Institute for Global Environmental Strategies (IGES), was launched in the area of water. Plans involve visits of IGES researchers in 2012 to use ENE's energy model, MESSAGE, to assess energy-related water scenarios for Asia.

Policy Impact in 2011

The ENE Program and the GEA have been highly successful in engaging a range of key stakeholders from government and civil society, including the energy industry, through one-on-one consultations with key decision makers and presentations at international conferences. Research from ENE and GEA was presented at, among others, the following events: Stakeholder's Consultation, Global Environment Facility (GEF) (11 Jan; Washington), the Austrian Foreign Ministry (6 May; Vienna), Austrian Ministry of Science, Technology and Productive Innovation (MINCYT) (24 May; Argentina), Vienna Energy Forum (21 June; Vienna), Presidential Committee on Green Growth (9 July; Korea), United Nations Office for Sustainable Development (UN-OSD) (25 Aug; Korea); Secretary-General's High-Level Group on Sustainable Energy for All (19 Sep; New York), the World Resources Institute (21 Oct; Washington), the Inter-American Development Bank (22 Oct; Washington), the American Association for the Advancement of Science (AAAS) (31 Oct; Washington), the United Nations Framework Convention on Climate Change (UNFCCC)

Conference 2011 (5 Dec; Durban), 19th OSCE Economic and Environmental Forum (14 Sep; Prague), Ministerial Dialogue on "Green Economy and Inclusive Growth" (28 Sep; New Delhi), and Ministry of Foreign Affairs and International Energy Agency, (10 Oct; Oslo).

ENE provided in 2011 critical input to the United Nations Secretary-General's "Sustainable Energy for All" Initiative (SE4ALL). ENE and GEA findings helped to define aspirational yet feasible objectives for SE4ALL, including ensuring universal access to modern energy services, doubling the rate of improvement in energy efficiency, and doubling the share of renewable energy in the global energy mix, all by 2030. The Energy Group's research is also framing the SE4ALL's "Action Agenda" within a systems-based view of transformational change. **Nebojsa Nakicenovic**, supported by Jessica Jewell, serves as a lead drafter on the Initiative's Task Force on energy efficiency and renewable energy. Nakicenovic also provided key scientific insights at the High-level Group meeting in Abu Dhabi attended by Ban-Ki Moon, CEOs of major companies, and other key players.

The year 2011 was also a highly successful year in terms of the completion of policy reports and interactive policy tools for the United Nations Industrial Development Agency (UNIDO) and the Global Environment Facility (GEF). The tools and policy reports are going to be launched in a series of regional workshops in Africa, India, and Armenia during 2012. Furthermore, ENE Program Leader **Keywan Riahi** contributed to the Emissions GAP Report of UNEP, and co-authored the summary of the report in the prestigious journal *Nature Climate Change* in 2011.

ENE staff and GEA Director **Nebojsa Nakicenovic** continued to serve on the Scientific Steering Committee of the Global Carbon Project, which helps the international science community to establish a common, mutually agreed knowledge base supporting policy debate and action to slow the rate of increase of greenhouse gases in the atmosphere. Nakicenovic also continued to serve on the Committee on Scientific Planning and Review of ICSU, the International Council for Science. In his capacity as member of ICSU's foresight team, Nakicenovic was instrumental in the development of ICSU's Strategic Plan 2012–2017, which will guide the long-term strategic choices aimed at building ICSU's value in strengthening international science for the benefit of society and advising the Executive Board on priorities for such initiatives. In 2011 Nakicenovic also served on the Steering Committee of the Renewable Energy Policy Network for the 21st Century (REN21) that convenes international multi-stakeholder leadership to enable a rapid global transition to renewable energy. Finally, in addition to being on various other scientific advisory boards, Nakicenovic and Riahi continued to take an active role in the Organizational Committee of the Austrian Panel on Climate Change Assessment Report (APCC).

Scientific Recognition

ENE researchers Krey, McCollum, Nakicenovic, Pachauri, Riahi, and Zhu have been appointed to altogether more than 40 external advisory and steering committees and serve on the editorial boards of 12 scientific journals reflecting their wide peer recognition.

Summary Activities 2011

ENE's in-house research effort in 2010 amounted to 90 person-months. ENE Program researchers taught classes at three universities, delivered more than 150 lectures, published 26 peer-reviewed papers including two articles in the prestigious Journal *Nature Climate Change*, published an additional 18 other publications, and contributed to six major policy reports.

Activities for 2012

A main focus of the activities in 2012 will be the launch of the Global Energy Assessment and the dissemination of ENE policy tools and interactive databases. The international modeling comparison projects co-led by ENE (EMF27, AMPERE, and LIMITS) will continue in 2012, and it is planned to complete a Special Issue on the IPCC-SSP scenarios. Dissemination activities will include three regional workshops in India, Africa, and Armenia to publicize ENE's new policy tools. In terms of methodology development, emphasis will be given to the development of new coupled modeling frameworks for energy and land use jointly with the ESM program.

Personnel Resources

Scientific Staff

Keywan Riahi (Austria), Program Leader
Hamed Ghoddusi (Iran) (25% p-t)
Jessica Jewell (USA)
Yuji Kobayashi (Japan)
Volker Krey (Germany)
David McCollum (USA)
Yu Nagai (Japan)
Nebojsa Nakicenovic (Austria) (60% p-t)
Shonali Pachauri (India)
Shilpa Rao-Skirbekk (India) (63% p-t)
Andreas Reisinger (Germany)*
Manfred Strubegger (Austria) (50% p-t)
Oscar van Vliet (Netherlands)
Bing Zhu (China) (10% p-t)*

Postdoctoral Scholar

Narasimha Rao (USA)

Scientific Support

Peter Kolp (Austria) (90% p-t)

YSSP

Danielle Davidian (USA)
Munsu Lee (Korea, Republic of)
Brijesh Mainali (Nepal)
Kapil Narula (India)
Joeri Rogelj (Belgium)

Administrative Support

Elizabeth Lewis (United Kingdom)
Eri Nagai (Japan)
Patricia Wagner (USA)

p-t = part time; *Guest Research Scholar

Publications[1]

Journal Articles

*Foell W, Pachauri S, Spreng D & Zerriffi H (Guest Editors) (2011). Foreword. *Energy Policy*, 39(12):7485-7486. Special Issue: Clean Cooking Fuels and Technologies in Developing Economies (December 2011) (Published online 15 September 2011).

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*Liu X, Zhu B, Zhou W, Hu S, Chen D & Griffy-Brown C (2011). CO_2 emissions in calcium carbide industry: An analysis of China's mitigation potential. *International Journal of Greenhouse Gas Control*, 5(5):1240-1249 (September 2011) (Published online 25 June 2011).

*McCollum DL, Krey V & Riahi K (2011). An integrated approach to energy sustainability. *Nature Climate Change*, 1(9):428-429 (December 2011) (Published online 13 November 2011). [TNT]

*Meinshausen M, Smith SJ, Calvin K, Daniel JS, Kainuma MLT, Lamarque J-F, Matsumoto K, Montzka SA, Raper SCB, Riahi K, Thomson A, Velders GJM & van Vuuren DPP (2011). The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. *Climatic Change*, 109(1-2):213-241 (November 2011) (Published online 9 August 2011). [TNT]

*Nakicenovic N & Nordhaus W (eds) (2011). The Economics of Technologies to Combat Global Warming. *Energy Economics*, 33(4):565-708. Special Issue: The Economics of Technologies to Combat Global Warming (July 2011). [TNT]

*Nakicenovic N & Nordhaus W (2011). Editors' introduction: The economics of technologies to combat global warming. *Energy Economics*, 33(4):565-571 (July 2011) (Published online 4 February 2011). [TNT]

*Pachauri S (2011). Reaching an international consensus on defining modern energy access. *Current Opinion in Environmental Sustainability*, 3(4):235-240 (September 2011) (Published online 18 August 2011).

*Pachauri S & Cherp A (2011). Editorial Overview - Energy security and energy access: Distinct and interconnected challenges. *Current Opinion in Environmental Sustainability*, 3(4):199-201 (September 2011) (Published online 4 August 2011).

*Pachauri S & Cherp A (Editors) (2011). Special Issue: Energy Systems. *Current Opinion in Environmental Sustainability*, 3(4):199-278 (September 2011).

*Pachauri S & Spreng D (2011). Measuring and monitoring energy poverty. *Energy Policy*, 39(12):7497-7504 (December 2011) (Published online 30 July 2011).

*Pachauri S, Zerriffi H, Foell W & Spreng D (eds) (2011). Clean cooking fuels and technologies in developing economies. *Energy Policy*, 39(12):7485-8202 (December 2012).

*Riahi K, Rao S, Krey V, Cho C, Chirkov V, Fischer G, Kindermann G, Nakicenovic N & Rafaj P (2011). RCP 8.5 - A scenario of comparatively high greenhouse gas emissions. *Climatic Change*, 109(1-2):33-57 (November 2011) (Published online 13 August 2011). [ESM, MAG, TNT]

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*van Vuuren DP, Edmonds JA, Kainuma M, Riahi K & Weyant J (2011). A special issue on the RCPs. *Climatic Change*, 109(1-2):1-4 (November 2011) (Published online 5 August 2011). [TNT]

*van Vuuren DP, Edmonds JA, Kainuma M, Riahi K, Weyant J (Guest Editors) (2011). Special Issue: The Representative Concentration Pathways in Climatic Change. Climatic Change, 109(1-2) (November 2011) (Published online 5 August 2011). [TNT]

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

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*Zhou W, Zhu B, Chen D, Zhao F & Fei W (2011). Technoeconomic assessment of China's indirect coal liquefaction projects with different CO_2 capture alternatives. *Energy*, 36(11):6559-6566 (November 2011) (Published online 29 September 2011).

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*Arvizu D, Bruckner T, Christensen J, Chum H & Krey V et al. (Lead Authors) (2011). Summary for policymakers (SPM). In: Edenhofer O, Pichs-Madruga R, Sokona Y, Seyboth K, Matschoss P, et al. (eds), *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*. Cambridge University Press, Cambridge, UK and New York, USA.

*Bruckner T, Jaeger-Waldau A & Krey V et al. (Contributing Authors) (2011). Renewable energy and climate change. In: Edenhofer O, Pichs-Madruga R, Sokona Y, Seyboth K, Matschoss P, et al. (eds), *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*. Cambridge University Press, Cambridge, UK and New York, USA.

*Keirstead SAJ, Dhakal S, Mitchell J, Colley M, Connell R, Gonzales R, Herve-Mignucci M, Parshall L, Schulz NB & Hyams M (2011). Climate change and urban energy systems. In: Rosenzweig C, Solecki WD, Hammer SA & Mehrotra S (eds), *Climate Change and Cities*. Cambridge University Press, Cambridge, UK. [TNT]

*Pachauri S (2011). The energy poverty dimension of energy security. In: Sovacool BK (ed.), *The Routledge Handbook of Energy Security*. Routledge, London, UK (February 2011).

*Riahi K, Rose S, Urge-Vorsatz D & van Vuuren DP et al. (Contributing Authors) (2011). How to bridge the gap - What the scenarios and studies say. In: *Bridging the Emissions Gap: A UNEP Synthesis Report*. United Nations Environment Programme, Nairobi, Kenya (November 2011). [TNT]

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Rao S, Chirkov V, Dentener F, Van Dingen R, Pachauri S, Purohit P, Amann M, Heyes C, Kinney P, Kolp P, Klimont Z, Riahi K & Schoepp W (2011). Estimation of the Global Health Impacts of Air Pollution. IIASA Interim Report IR-11-035. [MAG]

Scientific Recognition

Advisory Boards and Steering Committees

Luis Gomez Echeverri

- Lead Author of the IPCC 5th Assessment Report (Working Group III, Chapter 16: Finance for Mitigation)
- Member of the Core Writing Team of the Synthesis Report (SYR) of the IPCC 5th Assessment Report
- Member of the Team of Authors of the Glossary of Working Group III of the IPCC 5th Assessment Report
- Advisor to the Executive Office of the Secretary General on the Sustainable Energy For All Initiative
- Advisor on climate change, China through UN Resident Coordinator in Beijing
- Member of the Leadership Council of Yale University's School of Forestry and Environmental Studies

Volker Krey

- Lead Author of the IPCC 5th Assessment Report (Working Group III, Chapter 6: Assessing Transformation Pathways)
- Member of the IPCC Task Group on Data and Scenario Support for Impact and Climate Analysis (TGICA) for the 5th Assessment Report cycle
- Member of the Steering Committee of the Energy Modeling Forum (EMF) 27 Exercise at Stanford University
- Member of the Steering Committee of the Asian Modeling Exercise (AME) at Pacific Northwest National Laboratory (PNNL)
- Lead Author of the Global Energy Assessment (Chapter 17: The GEA Scenario: Energy Transition Pathways for Sustainable Development)
- Teaching appointment, MSc Program Renewable Energy in Central and Eastern Europe at the Technical University of Vienna (Austria)
- Lead Author of the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (Summary for Policymakers and Chapter 10: Mitigation Potential and Costs)

David McCollum

- Chair of Fossil, Nuclear and CCS Subgroup in EMF-27 international modeling comparison project
- Chair of Resources Subgroup in AMPERE international modeling comparison project
- Co-Chair of IIASA Day 2012 Committee (planning the 40th anniversary celebration to be held at IIASA in October 2012)

Nebojsa Nakicenovic

- Member of the United Nations Secretary General Technical Group on Sustainable for Energy for All
- Member, Advisory Council of the German Government on Global Change (WBGU), Berlin, Germany
- Member, International Council for Science (ICSU) Working Group "Energy and Sustainable Societies," Paris, France
- Council Member, Integrated Assessment Modeling Consortium (IAMC), coordinated by the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, Energy Modeling Forum (EMF), Stanford University, USA, National Institute for Environmental Studies (NIES), Japan
- Lead Author of the IPCC 5th Assessment Report (Working Group III, Chapter 5: Drivers, Trends and Mitigation)
- Member of the Mitigation Board of the Global network for climate Solutions (GNCS) at the hosted at the Earth Institute of Columbia University
- Member of the Board, Climate Change Centre Austria (CCCA).
- Member of the Organizational Committee and Co-chair of the Austrian Panel on Climate Change Assessment Report (APCC)
- Member of the Renewable Energy Policy Network for the 21st Century (REN21) Steering Committee
- Member, Global Energy International Prize Committee, Russian Research Center "Kurchatov Institute," Moscow, Russia
- Scientific Steering Committee Member, The Global Carbon Project, CSIRO, Canberra, Australia
- Steering Committee Member, International Programme on the Economics of Atmospheric Stabilization (IPEAS), London, UK
- Member of the International Advisory Board of the Helmholtz Programme on Technology
- Member, Organizing Committee of International Energy Economics Conferences (IEWT), Vienna University of Technology, Vienna, Austria
- Member, Working Group on Coupled Modeling, Joint Scientific Committee for the World Climate Research Programme (JSC/WCRP) and CLIVAR Scientific Steering Group, Geneva, Switzerland
- Expert for Energy Economics of WEC Austrian National Committee
- Member of the International Advisory Board on Climate Change Policy Project of the Korean Government

Shonali Pachauri

- Panel Member for the SH3–Environment, space and population in the Starting Grant 2011 evaluation for the European Research Council

- Executive Committee Member, Global Energy Assessment, IIASA, Laxenburg, Austria

Keywan Riahi

- Lead Author of the IPCC 5th Assessment Report (Working Group III, Chapter 7: Energy Systems)
- Steering Group Member, Integrated Assessment Modeling Consortium (IAMC)
- Scientific Steering Group Member, Energy Modeling Forum Study 27
- Steering Group Member, AMPERE, FP7-Research Project, European Commission
- Member of the Organizational Committee of the Austrian Panel on Climate Change Assessment Report (APCC)
- Steering Committee Member, LIMITS, FP7-Research Project, European Commission
- Co-chair of the SSP Scenario Development for the IPCC AR5
- Visiting Professor at the Graz University of Technology, Austria
- Executive Committee Member, Global Energy Assessment, IIASA, Laxenburg, Austria
- Member of the Evaluation Committee of the Laboratory for Energy Systems Analysis at the Paul Scherrer Institut, ETH Zuerich, Switzerland
- Member of the Scientific Organizing Committee of the IPCC-SSP meeting, The Hague, Netherlands

Bing Zhu

- Member, Technical Committee of Optimal Control, International Federation of Automatic Control (IFAC)
- Vice Chair, Chinese Association of Chemical Techno-Economics
- Member, Steering Committee, Chinese Society of Technology Economics
- Member, Economics Committee, Chinese Petroleum Society
- Member, Industrial Ecological Economics and Technology Committee, Chinese Society of Ecological Economics

Editorships of Journals

Volker Krey

- Associate Deputy Editor of *Climatic Change*

Nebojsa Nakicenovic

- *Climate Policy*, Advisory Board member
- *Current Opinion in Environmental Sustainability*, Editorial Board Member
- *Energy Strategy Reviews*, Editorial Board
- *International Journal of the Institution of Civil Engineers* (ICE), Editorial Manager
- *International Journal of Energy Sector Management*, Editorial Board Member
- *Technological Forecasting and Social Change*, Editorial Board Member
- Co-editor of the *Special Issue on Technological Change and Global Warming of the Journal of Energy Economics*

Shonali Pachauri

- Member editorial board for *Economics of Energy & Environmental Policy* published by the International Association for Energy Economics (IAEE)
- Co-editor of the Special Issue on "energy security and energy access - interconnected global challenges" in the *Journal of Current Opinion in Environmental Sustainability (COSUST)*
- Co-editor of the Special Issue on "household cooking fuels and technologies in developing countries" of the *Journal of Energy Policy*

Keywan Riahi

- *Energy Economics*, Associate Editor
- Co-editor of the Special Issue on Representative Concentration Pathways (RCPs) in the *Journal of Climatic Change*

Bing Zhu

- Member of Editorial Board, *Technology in Society*
- Member of Editorial Board, *Chemical Industry* (Chinese Journal)
- Member of Editorial Board, *Energy Conservation and Emission Reduction in Petroleum and Petrochemical Industry* (Chinese Journal)

External Research Contracts above €10,000: ENE

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"EnerGEO (together with ESM and MAG) Energy Observation for monitoring and assessment of the environmental impact of energy use"	European Commission, DG Research	01.11.2009	31.10.2013	115,380.00	25,497.00
"ALPS Project (together with MAG) Alternative Pathways toward Sustainable Development and climate Stabilization"	Research Institute of Innovative Technology for the Earth (RITE)	01.06.2010	31.01.2011	100,252.00	20,833.00
"Technology trade and technology transfer under GHG emission reduction policies"	Tokyo Electric Power Company (TEPCO)	09.08.2010	31.08.2011	73,282.00	37,767.00
"AMPERE (together with MAG) Assessment of Climate Change Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates"	European Commission, DG Research & Innovation	01.02.2011	31.01.2014	368,680.00	47,634.00
"AVOID China Technology options for CO2 savings to 2050 (non-agricultural)"	Imperial College London	01.01.2011	30.04.2011	34,457.00	34,457.00
"ALPS2 (together with TNT) Alternative Pathways toward Sustainable Development and climate Stabilization"	Research Institute of Innovative Technology for the Earth (RITE)	20.06.2011	31.01.2012	96,112.00	64,199.00
"AirQuality (together with MAG) Impacts of climate change policies on future air quality in Europe"	INERIS	01.06.2011	30.09.2011	10,000.00	10,000.00
"APCC Austrian Panel on Climate Change Assessment Report "	Kommunalkredit Public Consulting GmBH	01.07.2011	30.06.2014	44,195.00	6,318.00
"LIMITS (together with ESM) Low climate IMpact scenarios and the Implications of required Tight emission control Strategies"	European Commission, DG Research & Innovation	01.10.2011	30.09.2014	452,659.00	18,056.00
"ENE SE4ALL Rio+20 Assessment on Sustainable Energy for All"	The Stockholm Environment Institute (SEI)	01.10.2011	31.08.2012	14,800.00	4,036.00

External Research Contracts above €10,000: GEA

Title	Funder	Date from	Date to	Total (€)	2011 (€)
Provision of services relating to the cooperation with Global Energy Assessment (GEA) on the development of the industrial sector energy end-use module	United Nations Industrial Development Organization (UNIDO)	01.06.2009	30.04.2012	175,000.00	50,795.00
Global Energy Assessment: Developing policy tools for jointly reducing energy poverty and Greenhouse Gas Emissions	United Nations Industrial Development Organization (UNIDO)	01.07.2010	31.12.2011	750,000.00	501,070.00
Swedish contribution to GEA	FORMAS & Swedish Energy Agency	01.01.2011	31.12.2011	224,200.00	224,200.00
Norwegian contribution to GEA	The Research Council of Norway	01.01.2011	31.12.2011	63,170.00	63,170.00
Energy Politics - Support to GEA	Deutsche Gesellschaft für International Zusammenarbeit (GIZ) GmbH	15.03.2011	28.02.2012	200,000.00	131,735.00

Evolution and Ecology Program

Ulf Dieckmann, Program Leader
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Objectives

Developing new methods and pioneering their applications, the Evolution and Ecology Program (EEP) analyzes and forecasts how ecological and evolutionary dynamics shape populations, communities, and ecosystems.

Modern approaches to describing complex adaptive systems need to account for nonlinear feed-backs, non-equilibrium dynamics, discontinuities and break points, collective phenomena, systemic transitions, behavioral dynamics, as well as multi-level and multi-scale interactions among processes and agents.

Ecology is the quintessential systems science, dealing with such complex challenges in a holistic way. This approach is complemented by studies of adaptation and evolution, which account for the ubiquitous capacity of agents to alter their features and interactions in response to environmental change. Theoretical physics contributes advanced mathematical and computational tools to the mix of methodologies that is characteristic of EEP's research.

EEP is building bridges between fundamental and policy-oriented, theoretical and empirical, biological and mathematical, and analytical and numerical approaches to the systems analysis of living systems:

- Research on *Evolutionarily sustainable consumption* and the *Integrated assessment of fishery systems* examine options and challenges for the development of aquatic food resources (Food and Water).
- Work on the *Equitable governance of common goods* investigate how top-down regulations for managing common goods or open-access resources can be improved by integrative assessments of stakeholder conflicts and by scaling up successful characteristics of self-organized and resilient bottom-up governance (Poverty and Equity).
- Studies on the *Eco-evolutionary dynamics of living systems*, on *Systemic risk and network dynamics*, and on *Evolutionary vegetation modeling and management* open up new methodological avenues for the applied systems analysis of biodiversity, tangled interactions, and ecosystem dynamics (Advanced Systems Analysis).
- Furthermore, the last project's process-based modeling approach will enable novel features in next-generation dynamic global vegetation models, which are instrumental for assessing climate impacts (Energy and Climate Change).

Together, these projects show how innovative methods inspired by the dynamics of living systems can invigorate and integrate key facets of modern applied systems analysis.

Scientific Achievements in 2011

Evolutionarily sustainable consumption

EEP's research on exploitation-induced evolution is designed to overcome a blind spot in the management of living natural resources, particularly fish but also other wild animal and plant resources, namely, that exploitation not only changes the abundance of targets, but also their heritable traits. In pursuit of this goal, EEP adopts a threefold approach, as summarized below.

A first element is the development of tools suitable for tackling exploitation-induced evolution. To predict the future ecology and evolution of exploited fish stocks, to understand observed past changes, and to evaluate the merits of alternative management strategies, eco-genetic models (Dun-lop *et al.*, in revision) and adaptive dynamics models (Ernande *et al.*, in revision) are being developed. To understand the effects that fishing exerts on adaptive traits, methods to quantify selection pressures have been refined (Matsumura *et al.*, 2011). To analyze trends in the maturation schedules of exploited fish stocks, so-called probabilistic maturation reaction norms have been introduced and estimated from data (Heino *et al.*, in revision – b).

As a second element, these new tools are being applied to case studies focusing on particular populations. The steady pace of work along this line of research continued in 2011, with dedicated studies targeting captive Atlantic salmon in Norway (Skilbrei and Heino, 2011), haddock in the Barents Sea (Devine and Heino, 2011), northern pike in Europe (Matsumura *et al.*, 2011), Atlantic cod in Iceland (Pardoe *et al.*, in preparation), Atlantic cod in the Barents Sea (Eikeset *et al.*, in revision), European plaice in the North Sea (Mollet *et al.*, in revision), and chum salmon in Korea (Urbach *et al.*, in revision). Additionally, information derived from these and other studies have been collated and synthesized in a meta-analysis (Devine *et al.*, in press).

A third element is provided by strategic studies designed to address basic open questions about exploitation-induced evolution. Recent progress in this line of work includes an investigation of the fundamental determinants of reaction-norm evolution (Marty *et al.*, 2011), systematic investigations of the ecological and evolutionary aspects of size-selective harvesting (Matsumura *et al.*, 2011; Poos *et al.*, 2011), an assessment of the practical implications of sex structure and mate choice for fisheries-induced evolution (Mollet *et al.*, in revision), and a discussion of key factors determining the evolution of growth (Enberg *et al.*, 2012). At a more fundamental level, investigations have examined the role of maternal effects in the evolutionary ecology of fishes (Kotrschal *et al.*, 2012), the mechanisms of compensatory growth in larval fish (Segers *et al.*, 2012), gene flow between closely related fish species (Nevado *et al.*, 2011), secondary sexual characteristics in codfishes (Skjæraasen *et al.* 2012), population structure and ecology of important coastal fish species (Heino *et al.*, 2012b), and how information from different sampling gears can be combined to yield a better picture of marine ecosystems (Heino *et al.*, 2011).

Integrated assessment of fishery systems

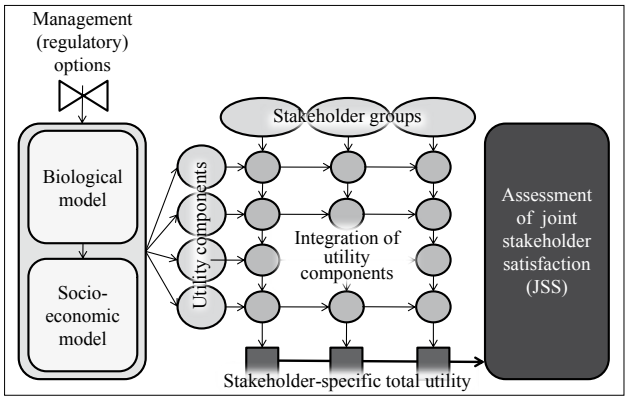
Today, most aquatic food resources around the world are not considered sustainable and face higher exploitation levels than is rational under a diversity of criteria. Among other concerns, research at EEP has shown that fishing might induce undesirable evolutionary changes, prompting questions about how management systems should respond to this challenge. However, addressing single concerns one at a time cannot succeed; instead, holistic approaches are needed. Therefore, EEP has started to pursue studies facilitating the integrated assessment of fishery systems.

Opening up this new line in EEP's research, two new studies highlight how the performance of harvesting strategies can be evaluated jointly based on socio-economical and biological criteria (Eikeset *et al.*, in press; Eikeset *et al.*, in preparation). Assessing management practices also needs to account for natural differences in the productivity and natural variability of aquatic systems (Boukal *et al.*, 2012). Two studies have highlighted the importance of considering the body size of fish, a characteristic of basic biological and economic importance, in such assessments (Zimmermann *et al.*, 2011a, 2011b). Another study is addressing the costs and benefits of collecting detailed information on stock abundance in support of robust harvesting strategies (Myrseth *et al.*, 2011).

Evolutionary impact assessments (EvoIAs; Laugen *et al.*, in revision) offer a comprehensive framework for assessing consequences of alternative management policies through the integration of eco-evolutionary and socio-economic perspectives. Ultimately, managing aquatic systems requires a dialogue with all stakeholders having an interest in the resources and services these systems can provide. To facilitate discussions on how to reconcile conflicting stakeholder preferences in fisheries management, EEP is developing a framework for the evaluation of joint stakeholder satisfaction based on multi-criteria utility functions (Dankel *et al.*, in preparation).

Equitable governance of common goods

EEP's research on the evolution of cooperation analyzes cooperation in joint enterprises and re-source management, with particular emphasis on the nature and impact of incentives. The bulk of this work applies the mathematical techniques of evolutionary game theory and adaptive dynamics. A complementary study, investigating social choice between different types of social contracts from an experimental perspective, has been prepared for an economics journal (Zhang *et al.*, submitted).



Framework for evaluating joint stakeholder satisfaction based on multi-criteria utility functions

Liu *et al.* (2011) have investigated the role of aspiration-based learning (also known as the win-stay, lose-shift principle) for games of the prisoner's dilemma type (i.e., the most basic kind of social dilemma) unfolding in spatially distributed populations. Brännström *et al.* (2011a) presented a systematic investigation elucidating the often underestimated consequences of fluctuating group sizes for the evolution of cooperation.

An important mechanism affecting the sizes of cooperating groups is provided by voluntary participation. Sasaki and Unemi (2011) have analysed its role for positive incentives (rewards), by means of replicator dynamics. Sigmund *et al.* (2011) compared several types of public good games and several types of mechanisms for implementing negative incentives (penalties). In particular, they compared punishment directly occurring in pairwise interactions among peers (which is adequate for describing populations without internal social organization) with punishment based on a resource pool to which all peers contribute (a more advanced and realistic form of punishment that requires the existence of simple social institutions). At equilibrium, peer punishment is more efficient than pool punishment. At the same time, pool punishment is more stable than peer punishment, provided that peers who do not contribute to the pool are also punished. Extending this approach, a new study by Sasaki *et al.* (2012) in the *Proceedings of the National Academy of Science of the USA* shows that in more developed societies featuring efficient institutions, voluntary contracts among peers joining a collaborative enterprise (as opposed to systems requiring obligatory participation) can considerably lessen the incentive levels that suffice to ensure full cooperation. This study thus takes an important first step towards a 'mechanism design' approach for maximizing the prosocial impact of incentives.

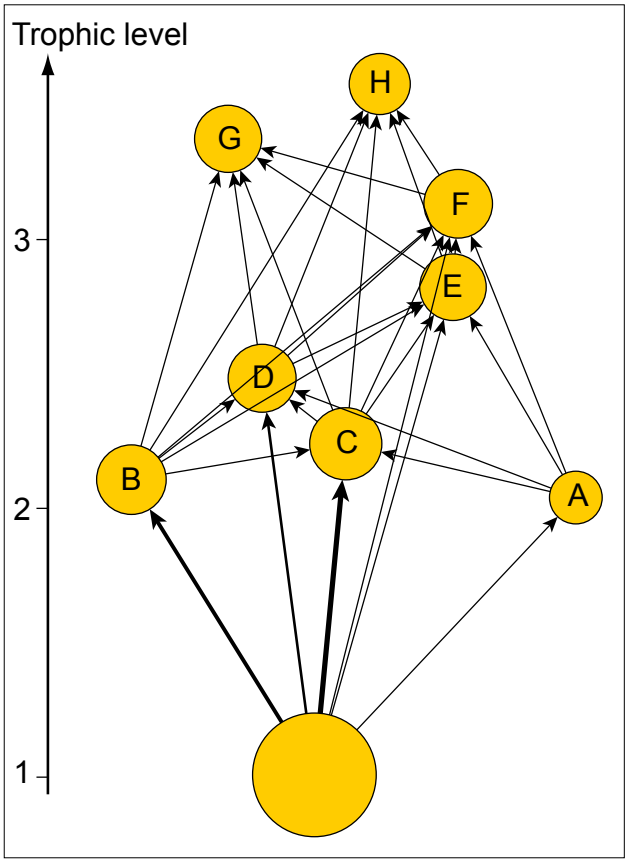
The American Mathematical Society has published a state-of-the-art book on evolutionary game dynamics edited by EEP's Karl Sigmund (2011a, 2011b), which showcases the impressive progress that has been made in this field during the last decade. Sigmund and Hilbe (2011) used these techniques to couch Darwin's ideas on human cooperation in a modern and more precise form. Finally, Rankin *et al.* (2011) analyzed one of the most basic tragedies of the commons, arising between males and females through sexual conflict (owing to their, respectively, low and high investments into joint progeny), and identified features of ecological systems that mitigate the detrimental impacts of such conflicts on a population's viability.

Eco-evolutionary dynamics of living systems

Advancing the frontiers of contemporary eco-evolutionary theory, two studies published in the edited volume *The Mathematics of Darwin's Legacy* are highlighting the limited applicability of optimization arguments in evolution (Gyllenberg *et al.*, 2011), explaining how, instead, adaptive dynamics theory serves as a versatile approach for facilitating the interpretation of evolutionary pat-terns (Metz, 2011). Specifically, adaptive dynamics theory is enabling the natural extension of ecological modeling

into the evolutionary realm: a related contribution to the *Sourcebook in Theoretical Ecology* summarizes this theory for a wider audience (Metz, 2012).

In this context, two studies have extended adaptive dynamics theory by introducing a new proxy for fitness in structured populations (Metz and Leimar, 2011) and by developing a new method for analyzing the quantitative genetics of adaptive speciation. Drawing on eco-evolutionary theory, Fischer *et al.* (2011) elucidated conditions under which organisms benefit from storing energy in uncertain environments, Marty *et al.* (2011) clarified the role of environmental covariation in growth and mortality for the evolution of maturation reaction norms, and Rueffler *et al.* (2012) took a first step towards a comprehensive classification of the evolutionary dynamics of simple life histories. Set against a background of theoretical studies in evolutionary ecology often having to sacrifice genetic detail to achieve analytical and computational tractability, a new study by Rettelbach *et al.* (2011) is noteworthy for investigating the effects of more realistic genetic architectures on speciation processes. In a similar vein, Sasaki and Dieckmann (2012) introduced a novel approximation technique for modeling the emergence of species diversity. Among other benefits, the latter study is making such complex eco-evolutionary dynamics amenable to bifurcation analyses (Dercole and Rinaldi 2011).



Complex model food web naturally emerging through body-size evolution under interference competition and trophic interactions

As all species are embedded in ecosystems, it is important to understand the effects of interspecific interactions in eco-evolutionary dynamics. Yamamichi *et al.* (2011) contrasted the impacts of rapid evolution and phenotypic plasticity on predator-prey dynamics, resulting in one of only few investigations in which these disparate means of adaptation are being directly compared. Iseki *et al.* (2011) bridged between the empirical and theoretical domain in a study of plant-insect interactions (Della Rossa *et al.*, 2012), comparing measurements and predictions of weevil rostrum length and camellia pericarp thickness along a geographical cline. Brännström *et al.* (2011c) considered multi-species communities and demonstrated how diverse food webs, characterizing complex networks of trophic interactions, can emerge as a consequence of interference competition and trophic interactions based on body size. Brännström *et al.* (2011b) studied a broader class of food-web models and elucidated conditions under which a widespread empirical pattern known as food-web intervality is expected. Takahashi *et al.* (2011) used an individual-based model to investigate the formation of species-rich communities and discovered how extinction cascades can be triggered endogenously through eco-evolutionary dynamics.

Spatial structure is a ubiquitous feature of all ecosystems, and several publications in 2011 advanced current understanding of the role of space in eco-evolutionary dynamics. In a study published in *Nature*, M'Gonigle *et al.* (2012) present a novel explanation for the maintenance of species diversity, based on ubiquitous ecological features such as resource heterogeneity and selective mating. Fasani and Rinaldi (2011) discovered that the widely used Rosenzweig-MacArthur predator-prey model becomes structurally unstable once space is incorporated: this means that an arbitrarily small change in model assumptions can either induce or destroy spatial patterns that emerge intrinsically as a consequence of individual-based movements and interactions. Rinaldi (2012) investigated pest outbreaks in forests and identified conditions under which such outbreaks are triggered by endogenous or exogenous events. Payne *et al.* (2011) considered conditions under which new species can form and found that sufficiently steep environmental gradients may be required if dispersal conditional on local environmental conditions can evolve. As studies involving spatially structured populations are computationally demanding, Raghib *et al.* (2011) developed a novel approximation method, based on a maximum-entropy moment closure, and illustrated how this can facilitate studying plant population dynamics.

Epidemiology is a field in which spatial structure frequently plays an important role. Fukuyo *et al.* (2012) showed that a suicidal defense strategy against infections can prevent epidemics, but only when the population is spatially structured. In spatial settings, it is often difficult to determine when a pathogen can invade: motivated by the need for methods to predict epidemics, Jesse *et al.* (2011) developed and introduced a broadly applicable indicator for pathogen invasion and persistence in spatially fragmented populations. Suzuki and Sasaki (2011) showed that the threshold below which invasions occur for crops is significantly lower than predicted by simpler models lacking spatial structure. In addition to spatial structure, other factors can potentially increase the susceptibility of a population to pathogen invasions: van den Berg *et al.* (2011) demonstrated that periodic

host absence can cause a pathogen to evolve higher transmission rates. Intracellular replication and within-host evolution are also important for determining the success of an infectious agent: Nakabayashi and Sasaki (2011) modeled these processes for the hepatitis B virus and provided mechanistic ex-planations for the exacerbation of hepatitis and for chronic infections without exacerbation.

Evolutionary vegetation modeling and management

A major share of the earth's biosphere relies directly or indirectly on the presence of vegetation. Worldwide vegetation exhibits a tremendous diversity in species composition, which has emerged through physiological, ecological, and evolutionary processes at different scales. Understanding these processes is thus a central challenge in biodiversity research. Falster *et al.* (2011) considered how variation in plant functional traits influences the aggregate properties of vegetation. A complementary study (Falster *et al.*, in preparation) builds on the same methodological foundation and shows how species-diverse communities can arise as a consequence of variation and selection in two salient functional traits.

Two further manuscripts (Burin *et al.*, in preparation; Comboul *et al.*, in preparation) are exploring the impacts of disparate disturbance regimes and temperature changes on the eco-evolutionary dynamics of vegetation. A key challenge in vegetation modeling is the accurate representation of salient physiological processes: to this end, Franklin *et al.* (2011) reviewed different modeling frameworks for describing carbon allocation.

Another important challenge is to identify efficient and sustainable forest-management practices. Rovenskaya *et al.* (in preparation) and Cammarano *et al.* (in preparation) consider the optimal harvesting of forest stands under the influential perfect-plasticity approximation recently developed by Stephen Pacala and colleagues. EEP's efforts in evolutionary vegetation modeling and management are carried out in close collaboration with ASA and ESM.

Policy Impact in 2011

EEP's long-lasting investments into elucidating the evolutionary implications of fishing (Dieckmann *et al.*, in preparation) are attracting increasing attention among scientists charged with providing advice to fisheries managers. First, EEP is recurrently receiving invitations to cover this topic in publications targeting broader groups of fisheries scientists, managers, and policymakers (Heino *et al.*, 2012a), as well as at a range of conferences, including the *Applied Evolution Summit* (Hendry *et al.*, 2011) and the workshop on *Selective Fishing and Balanced Harvest in Relation to Fisheries and Ecosystem Sustainability* (Garcia *et al.*, 2011, 2012). The last study, on reconsidering the con-sequences of selective fisheries, was published in the Policy Forum of Science.

Second, EEP is working closely with the International Council for the Exploration of the Sea (ICES; headquartered in Copenhagen, Denmark), which is not only the main advisory agency for managing the North Atlantic Ocean and adjacent seas, but also the world's oldest intergovernmental organization concerned with marine and fisheries science. In particular, the ICES Working Group on Fisheries-Induced Evolution (WGEVO) convened for a second time in 2011 co-chaired by two of EEP's senior scientists. Addressing scientific and applied dimensions of fisheries-induced evolution, this expert group works on designing protocols and tools for evolutionary impact assessments (EvoIAs; Laugen *et al.*, in revision) and on the influence of fisheries-induced evolution on reference points for fisheries management (Heino *et al.*, submitted). Through WGEVO, EEP has moreover initiated a new collaborative international study on estimating fisheries-induced selection differentials across a large number of stocks.

Third, EEP has taken the lead in organizing the workshop *Management Implications of Fisheries-induced Evolution*, which brought together scientists and fisheries managers. A broad consensus about the importance of considering fisheries-induced evolution in fisheries management has emerged and will be published in a multi-authored article (Heino *et al.*, in revision – a).

Activities for 2012

The five aforementioned projects will provide the platform for EEP's diverse research efforts to continue in 2012. In addition, EEP will gradually phase in work on *Systemic risk and network dynamics*, a project pursued in collaboration with ASA to identify indicators of systemic risk and resilience across different network-structured natural and anthropogenic systems.

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Publications[1]

Journal Articles

*Brännström A, Carlsson L & Rossberg AG (2011). Rigorous conditions for food-web intervality in high-dimensional trophic niche spaces. *Journal of Mathematical Biology* 63(3):575–592 (September 2011; published online 16 November 2010).
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Book Chapters

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Other Publications

Dieckmann U (2011). Assessing the impacts of fisheries-induced evolution. *Options* (IIASA, Laxenburg, Austria), Summer 2011.
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Fischer B, Taborsky B & Dieckmann U (2011). When to store energy in a stochastic environment. IIASA Interim Report IR-11-010.
Gyllenberg M, Metz JAJ & Service R (2011). When do optimisation arguments make evolutionary sense? IIASA Interim Report IR-11-011.
Heino M, Porteiro FM, Sutton TT, Falkenhaug T, Godoe OR & Piatkowski U (2011). Catchability of pelagic trawls for sampling deep-living nekton in the mid North Atlantic. IIASA Interim Report IR-11-012.
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Matsumura S, Arlinghaus R & Dieckmann U (2011). Assessing evolutionary consequences of size-selective recreational fishing on multiple life-history traits, with an application to northern pike (*Esox lucius*). IIASA Interim Report IR-11-009.
Metz JAJ (2011). Thoughts on the geometry of meso-evolution: Collecting mathematical elements for a post-modern synthesis. IIASA Interim Report IR-11-015.
Metz JAJ & Leimar O (2011). A simple fitness proxy for structured populations with continuous traits, with case studies on the evolution of haplodiploids and genetic dimorphisms. IIASA Interim Report IR-11-014.
Nakabayashi J & Sasaki A (2011). A mathematical model of the intracellular replication and within host evolution of hepatitis type B virus: Understanding the long time course of chronic hepatitis. IIASA Interim Report IR-11-016.
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Payne JL, Mazzucco R & Dieckmann U (2011). The evolution of conditional dispersal and reproductive isolation along environmental gradients. IIASA Interim Report IR-11-017.
Rankin DJ, Dieckmann U & Kokko H (2011). Sexual conflict and the tragedy of the commons. IIASA Interim Report IR-11-018.
Rettelbach A, Hermisson J, Dieckmann U & Kopp M (2011). Effects of genetic architecture on the evolution of assortative mating under frequency-dependent disruptive selection. IIASA Interim Report IR-11-019.
Sasaki A & Dieckmann U (2011). Oligomorphic dynamics for analyzing the quantitative genetics of adaptive speciation. IIASA Interim Report IR-11-020.
Skilbrei OT & Heino M (2011). Reduced daylength stimulates size-dependent precocious maturity in 0-plus male Atlantic salmon parr. IIASA Interim Report IR-11-013.
van den Berg F, Bacaer N, Metz JAJ, Lannou C & van den Bosch F (2011). Periodic host absence can select for higher or lower parasite transmission rates. IIASA Interim Report IR-11-021.

Scientific Recognition

Editorships

Ulf Dieckmann

- Journal of Evolutionary Medicine

Mikko Heino

- Ecology Letters

Hans Metz

- Acta Biotheoretica

Sergio Rinaldi

- International Journal of Bifurcation and Chaos

Akira Sasaki

- Journal of Theoretical Biology

Karl Sigmund

- Journal of Theoretical Biology
- Theoretical Population Biology
- International Journal of Bifurcation and Chaos
- International Journal of Biomathematics
- Philosophical Transactions of the Royal Society B
- Dynamic Games and Applications

Invited Lectures

Åke Brännström

- Abisko Science Station, Sweden, Winter School "Eco-evolutionary Modeling of Speciation": Biodiversity evolution in food-web models
- Stockholm, Sweden, Swedish-Korean Meeting "Mathematical Science for Biological Systems" organized by the Royal Swedish Academy of Sciences: A mathematical theory of food-web intervality
- Keszthely, Lake Balaton, Hungary, "Niche Theory and Speciation" Workshop: Food-web intervality and the dimensionality of trophic niche space

Ulf Dieckmann

- Cape Town, South Africa: An integrative approach to expanding capacity building at IIASA
- Abisko Science Station, Sweden, Winter School "Eco-evolutionary Modeling of Speciation": Adaptive speciation and evolutionary community assembly
- Alfred Wegener Institute for Polar and Marine Research, Biological Institute Helgoland (BAH), Germany, AWI/BAH Colloquium: The overlooked evolutionary dimension of modern fisheries
- Keszthely, Lake Balaton, Hungary, "Niche Theory and Speciation" Workshop: Towards an eco-evolutionary niche theory

- Bergen, Norway, Workshop "Management Implications of Fisheries-induced Evolution": (1) History of research on fisheries-induced evolution; (2) Theoretical expectations regarding fisheries-induced evolution; (3) Evolutionary impact assessments

Mikko Heino

- Bergen, Norway, Workshop "Management Implications of Fisheries-induced Evolution": (1) Evidence for fisheries-induced evolution: Evidence from the wild; (2) Can fisheries-induced evolution shift reference points for fisheries management?; (3) Evidence for fisheries-induced evolution: Experimental evidence
- Aberdeen, Scotland, World Conference on Marine Biodiversity: (1) Seasonal dynamics of growth and mortality suggest contrasting population structures for cod, pollack and saithe; (2) Life-history variation in Atlantic cod along the Norwegian coast. Evidence for local adaptation?
- School of Biological Sciences, University of Aberdeen, Scotland: Shrinking cod: Plasticity or genetics?
- Department of Biology, University of Bergen, Norway: Diversity of cod along the Norwegian coast

Hiroshi Ito

- Keszthely, Lake Balaton, Hungary, "Niche Theory and Speciation" Workshop: Repeated evolutionary diversifications and extinctions induced by gradual innovation

Rupert Mazzucco

- Abisko Science Station, Sweden, Winter School "Eco-evolutionary Modeling of Speciation": Lecture series "Individual-based models in speciation research"
- Keszthely, Lake Balaton, Hungary, "Niche Theory and Speciation" Workshop: Spatial segregation through sexual selection allows the long-term coexistence of ecologically equivalent species

Hans Metz

- Department of Mathematics and Statistics, University of Helsinki, Finland: Adaptive dynamics of disease strains with partial cross-immunity
- Evora, Portugal, Summer School "Dynamical Models in the Life Sciences": (1) When do optimization arguments make evolutionary sense?; (2) The canonical equation of adaptive dynamics; (3) The geometry of macro-evolution: Linking the elements of a postmodern synthesis
- Groningen, The Netherlands, "Mathematical Models in Ecology and Evolution 2011" Conference: The geometry of meso-evolution
- Vienna, Austria, European Conference on Complex Systems, Satellite Meeting on Game Theory: Unfolding matrix game ESSs
- Department of Mathematics, Delft University of Technology, The Netherlands: Unfolding matrix game ESSs
- Mathematical Bioscience Institute, Columbus, USA, "Stochastic Processes in Cell and Population Biology" Workshop: Effective population sizes and the canonical equation of adaptive dynamics

Akira Sasaki

- Osaka Prefecture University, Japan, Special Seminar at the 64th Bacteriology Society Annual Meeting: (1) Evolutionary projection of influenza virus; (2) Multidimensional scaling and host-parasite coevolution
- Okayama University, Japan, 27th Population Ecology Society Meeting, Symposium "Evolution and Diversity of Parasites": Frontiers of the mathematical modeling of host-parasite coevolution
- Krakow, Poland, 8th European Conference on Mathematical Biology (ECMTB 2011): Resistance threshold in spatially explicit epidemic model: Finite size scaling applied to dynamic percolation in epidemic processes with mixed cultivar planting
- Ohio State University, Columbus, USA, Mathematical Biosciences Institute, "Coevolution and the Ecological Structure of Plant-insect Communities" Workshop: Applying theories of arms races of plants and their parasites: Camellia-weevil system and rice blast disease
- Abisko Science Station, Sweden, Winter School "Eco-evolutionary Modeling of Speciation": Lecture series "Theory of species packing"

Karl Sigmund

- New Orleans, USA, American Mathematical Society Short Course: Short course on evolutionary game theory
- Vorarlberg, Austria, Schloss Dagstuhl, Dagstuhl Seminar on the Theory of Evolutionary Algorithms: The emergence of cooperation
- Lisbon, Portugal: Mini-course on evolutionary games and reciprocity
- Louvain, Belgium: Lecture series "Evolutionary game theory"
- Wageningen University, The Netherlands: Evolutionary games, cooperation and coercion
- École Normale Supérieure, Paris, France, Spring School: Evolutionary game theory
- Lipari, Italy, Summer School: Lecture series "A game theoretic approach to computational complex systems"

- Swiss Federal Institute of Technology (ETH), Zürich, Switzerland: A theoretical approach to institutionalized incentives in public good games
- University Pierre and Marie Curie, Paris, France: Evolutionary games and the emergence of cooperation
- University of Zürich, Switzerland: Evolutionary games, cooperation and coercion
- European Academy of Sciences, Liège, Belgium: Evolutionary game theory

Organized Events

Åke Brännström

- Winter School "Eco-evolutionary Modeling of Speciation", Abisko Science Station, Sweden, March 7-11, 2011
- "Niche Theory and Speciation" Workshop, Keszthely, Lake Balaton, Hungary, August 29-31, 2011
- 3rd Swedish Meeting on Mathematics in Biology, Umeå, Sweden, December 14-16, 2011

Ulf Dieckmann

- Winter School "Eco-evolutionary Modeling of Speciation", Abisko Science Station, Sweden, March 7-11, 2011
- Working Group on Fisheries-induced Evolution (WGEVO) of the International Council for the Exploration of the Sea, ICES Headquarters, Copenhagen, Denmark, May 3-5, 2011
- "Niche Theory and Speciation" Workshop, Keszthely, Lake Balaton, Hungary, August 29-31, 2011
- "Hybridisation and speciation" Workshop, Greynog Hall, Wales, UK, October 23-26, 2011

Mikko Heino

- Working Group on Fisheries-induced Evolution (WGEVO) of the International Council for the Exploration of the Sea, ICES Headquarters, Copenhagen, Denmark, May 3-5, 2011
- "Management Implications of Fisheries-induced Evolution" Workshop, Bergen, Norway, September 12-14, 2011

Sergio Rinaldi

- "La corruzione politica nelle società democratiche", Politecnico di Milano, Italy, December 21, 2011

Awards

Akira Sasaki

- PRESTO (Embryonic Science and Technology) Researcher; Japan Science and Technology Agency

Karl Sigmund

- Science Award of Lower Austria (Würdigungspreis für Wissenschaften durch das Land Niederösterreich)
- Blaise Pascal Medal for Mathematics of the European Academy of Science

Advisory Boards

Åke Brännström

- Vice-Chair of the Research Networking Programme Frontiers of Speciation Research (FroSpects) of the European Science Foundation, ESF (2008–2013)

Ulf Dieckmann

- Chair of the Research Networking Programme Frontiers of Speciation Research (FroSpects) of the European Science Foundation, ESF (2008–2013)
- Chair of the Working Group on Fisheries-induced Evolution (WGEVO) of the International Council for the Exploration of the Sea (ICES)

Mikko Heino

- Chair of the Working Group on Fisheries-induced Evolution (WGEVO) of the International Council for the Exploration of the Sea (ICES)

Hans Metz

- École Normale Supérieure, Paris, France, Biology Department Scientific Committee

Sergio Rinaldi

- Fellow of ASP (Alta Scuola Politecnica)

Akira Sasaki

- Japanese Society for Mathematical Biology, Governing Board
- Council for University Chartering, Japan

- Japan Society for the Promotion of Science, Reviewing Board of Grant-in-Aid for Scientific Research

Karl Sigmund

- European Research Council, Advanced Grant Jury
- Vienna Science and Technology Fund (WWTF), Advisory Board
- Austrian Academy of Sciences, Akademierat OEAW

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"ADAPTFISH Adaptive Dynamics and Management of Coupled Social-Ecological Recreational Fisheries"	Forschungsverbund Berlin e.V.	01.12.2006	31.05.2011	216,156.00	4,085.00
"BIOCONTRACT Mutualisms, Contracts, Space and Dispersal"	Fonds zur Förderung der wissenschaftlichen Forschung (FWF)	01.05.2008	30.04.2013	194,640.00	52,634.00
"FroSpects Admin Frontiers of Speciation Research - External Administrative Costs"	European Science Foundation (ESF)	01.05.2008	30.04.2013	45,543.10	7,328.00
Salary contribution for Agnes Rettelbach for research on formation of biodiversity in spatially heterogeneous ecological enviroments	Max F. Perutz Laboratories GmbH	01.01.09	31.01.11	28,247.00	1,161.00

Mitigation of Air Pollution and Greenhouse Gases

Markus Amann, Program Leader
amann@iiasa.ac.at

Background

Greenhouse gas mitigation measures are often perceived as being in direct conflict with domestic policy objectives like development, economic growth, and competitiveness. This is true not only for developing countries, but also for highly industrialized nations. In both cases, while public opinion may express concern about Earth's climate in the long term, it may also show a reluctance to make the sacrifices needed to reduce them in the near term.

For national climate change policy discussions and international negotiations to be successful, there needs to be a policy framework, along with associated analyses, that connects global climate change policy objectives to other national policy objectives. This would allow us to quantify the ways in which climate mitigation and adaptation measures interact with other policies.

Objectives

IIASA's Mitigation of Air Pollution and Greenhouse Gases (MAG) Program develops and applies systems analytical tools to inform national and international policy decisions with the aim of streamlining global climate concerns with local and near-term policy priorities.

In particular, MAG (i) explores how concepts such as green growth, sustainable development, and resource-efficient economies could be materialized to foster greenhouse gas mitigation, and (ii) identifies the implications for near-term action at the local scale of long-term transformation strategies to create low carbon societies.

Alignment with Strategic Plan

MAG's work addresses key topics of the Energy and Climate area, for instance, reframing the greenhouse gas debate, the transformation of the global energy system to achieve a low-carbon world, and managing energy and research and development investments. It also provides quantitative linkages to the Food and Water area, in particular, by including land use and agricultural management choices in the GAINS integrated assessment tool, and providing feedbacks on agricultural productivity losses from air pollution.

Social aspects addressed by the Poverty and Equity area are also considered. MAG assesses the health impacts of indoor and outdoor pollution in developing countries and explores the practical measures that yield such local benefits while maximizing the co-benefits with respect to climate. The methodology for a dynamic version of the GAINS model is being developed in cooperation with IIASA's Advanced Systems Analysis Program.

Scientific Achievements in 2011

Measures to improve air quality that also benefit climate change

In recent years, MAG's work has demonstrated that controlling long-lived greenhouse gases (GHGs) has significant near-term co-benefits for controlling air pollution at the local scale, including cutting air pollution control costs. However, there is a problem, namely, that if air pollution control measures are seen only as ancillary benefits, they can seem less relevant in societies where climate change mitigation ranks low on the policy agenda.

One way of countering this perception is to focus on air quality measures that, as a side effect, also reduce climate change. As most air pollutants also act as climate forcers, although at a shorter time scale than long-lived greenhouse gases such as CO_2 and N_2O, tackling these short-lived climate forcers—especially black carbon (soot), tropospheric ozone, and methane—could lead to a lower rate of temperature increase in the near term, slowing Arctic ice thaw, avoiding irreversible damage to sensitive ecosystems, and avoiding changes in rainfall patterns.

A systems approach

To explore potential approaches to maximizing the co-benefits of air pollution control for climate change, MAG has extended its GAINS (Greenhouse gas—Air pollution interactions and synergies) model to include all the components necessary for a comprehensive global assessment of the sources, mitigation potentials, and effects of the short-lived climate forcers. GAINS, which now distinguishes 120 regions covering the entire world, includes emission inventories for black carbon, organic carbon, and carbon monoxide, in addition to the inventories of the six Kyoto gases and five air pollutants. This enables assessment not only of the mitigation potentials and costs for these substances but also of the benefits of mitigation for human health, the Earth's vegetation, and climate change.

Sixteen measures that improve human welfare and simultaneously limit temperature increase

In 2011 MAG used the updated GAINS model to explore practical means for improving human welfare while simultaneously limiting temperature increases, especially in the near-term.

Of the more than 2,000 mitigation options considered in GAINS for improving air quality, the research team identified 16 readily available measures that, together, could reduce the global warming potential of short-lived pollutants by up to 60 percent compared to a baseline projection. These options include 13 technical measures aimed at reducing methane and black carbon emissions, such as the extended recovery of coal mine gas, the wide-scale introduction of pellet stoves and boilers in the

residential sector, replacing traditional coke ovens with modern recovery ovens, and installing particle filters on diesel engines. Measures with a strong regulatory context included the replacement of traditional biomass cook stoves in developing countries with clean and modern fuel stoves, a ban on the open burning of agricultural waste, and enforcing existing legislation to eliminate high-emitting diesel vehicles.

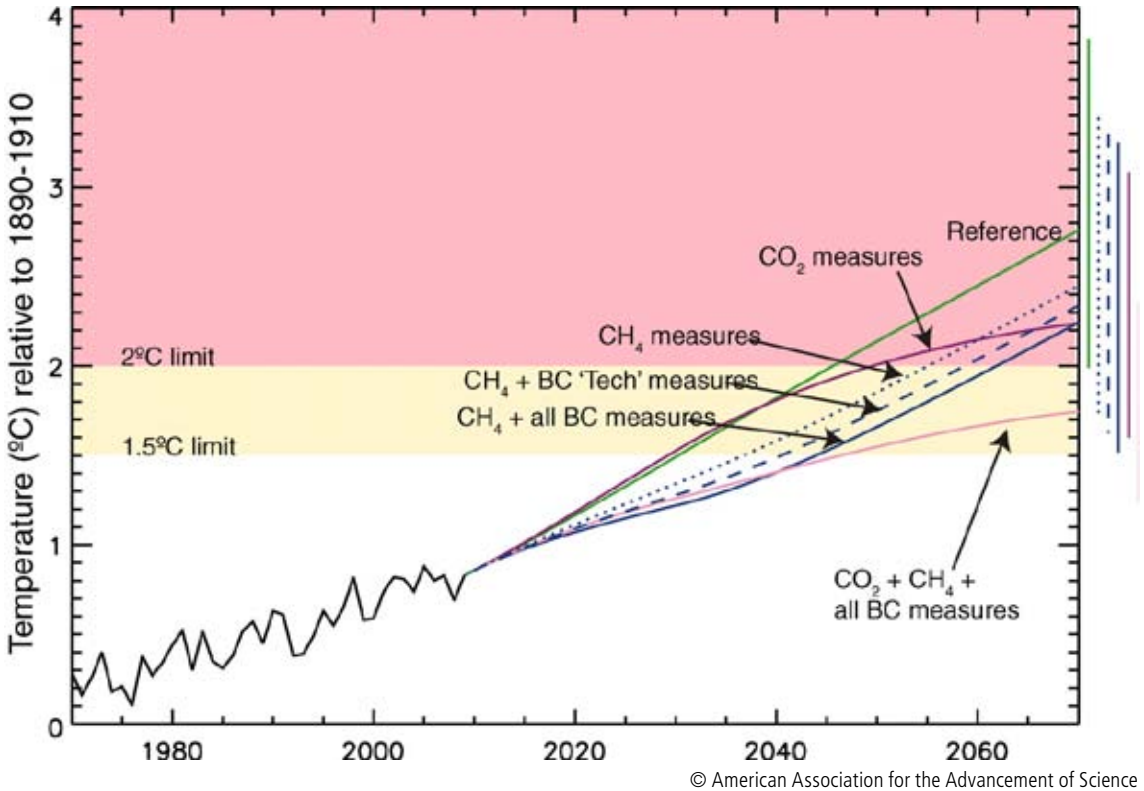
MAG contributed these new findings to the comprehensive scientific assessment of "Measures to Limit Near-Term Climate Change and Improve Air Quality" (UNEP/WMO, 2011) (http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf) organized by the United Nations Environment Program (UNEP) together with the World Meteorological Organization (WMO). The impacts of these 16 measures on temperature were explored using the climate modeling tools of NASA and ECHAM. It was found that full implementation of these measures could slow the rate of temperature increase by 0.54 ± 0.05°C in the coming decades (see graph), and help keep warming 2°C below the pre-industrial level in the near-term. This would provide enhanced warming mitigation potential in the Arctic and the Himalayas and reduce regional disruptions to traditional rainfall patterns.

Most relevant for local policy agendas, however, these measures would also increase human wellbeing through reduced local air pollution, improve local environmental quality, increase security of food and energy supply, and reduce water demand. In many cases, these measures would also result in more efficient energy use and thus also reduce emissions of long-lived greenhouse gases. Results were published in *Science* (Shindell et al., 2012).

Economics offer an additional benefit

In February 2011 the Summary for Decision Makers of the UNEP Integrated Assessment of Black Carbon and Tropospheric Ozone UNEP/WMO, 2011a), was released (http://www.unep.org/dewa/Portals/67/pdf/Black_Carbon.pdf). From a subset of about 2,000 separate measures in the GAINS model that can be applied to mitigate the sources of these pollutants, the Assessment identified the 16 measures that were most likely to provide combined benefits for limiting near-term climate changes and improving air quality,

These findings were at the center of a follow-up report of UNEP released in November 2011), which laid out practical steps toward implementing the 16 measures around the world. For this, MAG enhanced its previous analysis by estimating the costs of implementing these measures.



Observed temperatures (42) through 2009 and projected temperatures thereafter under various scenarios, all relative to the 1890–1910 mean. Results for future scenarios are the central values from analytical equations estimating the response to forcings calculated from composition-climate modeling and literature assessments (7). The rightmost bars give 2070 ranges, including uncertainty in radiative forcing and climate sensitivity. A portion of the uncertainty is systematic, so that overlapping ranges do not mean there is no significant difference (for example, if climate sensitivity is large, it is large regardless of the scenario, so that all temperatures would be toward the high end of their ranges; see www.giss.nasa.gov/staff/dshindell/Sci2012).

MAG found that all the measures selected would enhance development and result in economic benefits to societies . It also found that around half the emission reduction potential could be achieved by measures that bring cost-savings to societies in the long run.

MAG's analysis further showed that 20 percent of the mitigation potential would be competitive in a global carbon market under current carbon prices. Another 20 percent of mitigation potential, which emerges as side effects of other development objectives, such as proper waste management, ground-water protection, etc., and 10 percent (ban of agricultural waste burning, high-emitting vehicles), would require improved governance, which would benefit societies in many ways. The measures can thus be seen as "win-win-win" situations, with simultaneous benefits for air quality, climate, and (economic) development.

The downside, however, is that despite these benefits, markets often lack incentives to stimulate the up-front investments needed.

A global policy initiative to implement the measures

On 16 February 2012 the US Secretary of State Hillary Rodham Clinton announced the Climate and Clean Air Coalition, a new global initiative to reduce short-lived climate pollutants. The founding coalition partners are Bangladesh, Canada, Ghana, Mexico, Sweden, and the United States, together with the UN Environment Programme. The Coalition's aim is to reduce short-lived climate pollutants, particularly the 16 measures identified by IIASA by, inter alia, (i) driving the development of national action plans and the adoption of policy priorities; (ii) mobilizing public and private funds for action; and (iii) improving scientific understanding of pollutant impacts and mitigation.

GAINS-City: A practical tool for urban planners in developing countries to maximize climate co-benefits

While global action is important for awareness raising and preparing the economic environment, policy decisions on specific measures that maximize climate the co-benefits of air quality policies need to be taken at the local/urban scale. In 2011 the MAG team, together with Tsinghua University (Beijing), developed a city-scale implementation of the GAINS model that enables urban planners to systematically identify concrete investments into clean air measures that yield the largest co-benefits with respect to greenhouse gas emissions. Prototypes of this "GAINS-City" model have been implemented for Beijing and Jinan (Shandong province, China) and were presented at the workshop organized by the Energy Foundation and Tsinghua University (Beijing, China, 11 November 2011).

Co-benefits for the environmental nitrogen cycle

The critical interactions between the control of food security, nitrogen emissions, the environmental nitrogen cycle, and global climate change offer the potential for harvesting multiple co-benefits from nitrogen management. This was highlighted in the final report of the European Nitrogen Assessment (Cambridge University Press, 2011) in which MAG participated (Sutton, Oenema, Erisman, Leip, van Grinsven, Winiwarter, *Nature* 472, 159ff, 2011). Work carried out using IIASA's GAINS model also revealed the economic cost-effectiveness of nitrogen controls, based on recent evidence about the actual costs of measures in the agricultural sector. This new information was fed into the model calculations to support the revision of the Gothenburg Protocol, highlighting the pivotal role of mitigation of emissions from agricultural sources.

Support of European Climate and Air Quality Policies

The European implementation of GAINS is now an established tool for policy analyses for the European Commission and the UNECE Convention on Long-range Transboundary Air Pollution (CLTAP).

In 2011 the CLTAP, which has officially designated IIASA as its Centre for Integrated Assessment Modelling, negotiated the revision of its Gothenburg multi-pollutant/multi-effect Protocol. Based on calculations with the GAINS model, MAG at three negotiating sessions presented dedicated analyses of the scope for, and cost-effectiveness of, further emission reductions, and how to maximize co-benefits with climate change.

The European Commission has contracted IIASA to conduct the core model analyses for the forthcoming review of the EU clean air legislation. The current state of GAINS calculations was presented to the first meeting of the Expert Stakeholder Group in June 2011.

Policy Impact in 2011

Convention on Long-range Transboundary Air Pollution:

Since 1991 MAG has been hosting the EMEP Centre for Integrated Assessment Modelling (CIAM) of the Convention on Long-range Transboundary Air Pollution (LRTAP)

Policy briefings in 2011:

- WHO/UNECE LRTAP Task Force on Health (Bonn, 12-13 May 2011) Presentation of Markus Amann: "Calculation of cause-specific mortality impacts of fine particulate matter in GAINS"
- 35th Session of the EMEP Steering Body (Geneva, 5-7 Sep 2011) Presentation of Markus Amann: "An outlook to future air quality in Europe: Priorities for EMEP and WGE from an Integrated Assessment perspective"
- UNECE LRTAP Task Force on Hemispheric Transport (Arona, Italy, 6-8 June 2011) Presentation of Markus Amann: "Global emission scenarios -ongoing work at IIASA"
- 48th Session of the UNECE LRTAP Working Group on Strategies and Review (Geneva, 11-14 April 2011) Presentation of Markus Amann: "Scenarios for the Negotiations on the Revision of the Gothenburg Protocol"
- 49th Session of the UNECE LRTAP Working Group on Strategies and Review (Geneva, 12-15 September 2011) Presenta-

tion of Markus Amann: "Updated Scenarios for the Negotiations on the Revision of the Gothenburg Protocol"
- 39th Meeting of the UNECE LRTAP Task Force for Integrated Assessment Modelling (Stockholm, 23-25 February 2011) Presentation of Markus Amann: "Scenarios for the Negotiations on the Revision of the Gothenburg Protocol"
- 40th Meeting of the UNECE LRTAP Task Force for Integrated Assessment Modelling (Oslo, 18-20 May, 2011) Presentation of Markus Amann: "Cost-effective measures to achieve further improvements of air quality in Europe"

European Commission:

- EU Stakeholder Expert Group on the Review of the EU Air Policy (Brussels, 6-7 June 2011): Presentation of Markus Amann: "Updating the Baseline and Maximum Control scenarios"

Others

- Joint Bangladesh-Sweden Policy Seminar for the South Asian region: Near-term Air quality and Climate benefits – Promoting international co-operation and facilitating action (Dhaka, Bangladesh, 17-18 October 2011) Presentations of Zig Klimont: "Measures to reduce emissions of SLCFs: Opportunities and challenges for implementation"; "Opportunities for methane reduction from the fossil fuel industry, waste and agriculture"

Activities for 2012

In 2012 MAG will address the trade-offs of measures that improve air quality but accelerate climate change. This is particularly relevant for regions with high SO_2 emissions and other aerosols, which reflect incoming solar radiation and lead to cooling. MAG will explore how the reduction of SO_2 emissions to safeguard local air quality might be achieved through measures that also reduce SO_2 emissions, so that the negative climate impact of lower SO_2 could be compensated for.

MAG will also develop global scenarios for greenhouse gas and air pollutant emissions as an input to numerous atmospheric chemistry and climate modeling exercises. In contrast to many scenarios in the literature, which assume the autonomous introduction of stricter emission control measures with increasing levels of affluence (following the Kuznetsk hypothesis), these scenarios will explicitly quantify the impacts of dedicated air quality policies and, in so doing, provide a basis for subsequent cost-effectiveness analyses of further air quality policy interventions.

MAG will continue to develop a new dynamic version of the GAINS model system that captures the time dependencies of a transformation to low carbon societies to mid-century.

Personnel Resources

Scientific Staff

Markus Amann (Austria), Program Leader
Young Hwan Ahn (Korea, Republic of)
Hans Benzinger (Germany)
Imrich Bertok (Slovakia)
Jens Borken-Kleefeld (Germany)
Janusz Cofala (Poland)
Karin Maria Gunther Axelsson (Sweden) (65% p-t)
Christopher Heyes (United Kingdom)
Lena Höglund Isaksson (Sweden)
Gregor Kiesewetter (Austria)
Zbigniew Klimont (Poland)
Kaarle Kupiainen (Finland)
Fei Liu (China)
Binh Nguyen (Vietnam)
Pallav Purohit (India)
Peter Rafaj (Slovakia)
Robert Sander (Austria)
Wolfgang Schöpp (Austria)
Fabian Wagner (Germany)
Wilfried Winiwarter (Austria) (75% p-t)

YSSP

Borgar Aamaas (Norway)
Hans Gils (Germany)
Fei Liu (China)
Pallavi Marrapu (India)
Fang Yan (China)

Administrative Support

Margret Gottsleben (Germany)
Maria del Carmen Marcos Sanchez (Spain)

p-t = part time; *Guest Research Scholar

Publications[1]

Journal Articles

*Amann M, Bertok I, Borken-Kleefeld J, Cofala J, Heyes C, Hoeglund-Isaksson L, Klimont Z, Nguyen TB, Posch M, Rafaj P, Sandler R, Schoepp W, Wagner F & Winiwarter W (2011). Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling & Software*, 26(12):1489-1501 (December 2011) (Published online 15 September 2011).

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

*Borken-Kleefeld J, Berntsen T & Fuglestvedt J (2011). Times matter! - Response to Wallington et al. *Environmental Science and Technology*, 45(7):3167-3168 (April 2011) (Published online 2 March 2011).
*Granier C, Bessagnet B, Bond T, Klimont Z & Riahi K (et al.) (2011). Evolution of anthropogenic and biomass burning emissions of air pollutants at global and regional scales during the 1980-2010 period. *Climatic Change*, 109(1-2):163-190 (November 2011) (Published online 9 August 2011). [ENE, TNT]
*Kulmala M, Asmi A, Lappalainen HK, Amann M, Klimont Z, et al. (2011). General overview: European integrated project on Aerosol Cloud Climate and Air Quality Interactions (EUCAARI) - Integrating aerosol research from nano to global scales. *Atmospheric Chemistry and Physics*, 11(24):13061-130143 (5 December 2011).
*Kupiainen KJ & Pirjola L (2011). Vehicle non-exhaust emissions from the tyre-road interface - Effect of stud properties, traction sanding and resuspension. *Atmospheric Environment*, 45(25):4141-4146 (August 2011) (Published online 13 May 2011).
*Leip A, Busto M & Winiwarter W (2011). Developing spatially stratified N2O emission factors for Europe. *Environmental Pollution*, 159(11):3223-3232 (November 2011) (Published online 25 December 2010).
*Myhre G, Shine KP, Raedel G, Gauss M, Isaksen ISA, Tang Q, Prather MJ, Williams JE, van Veltoven P, Dessens O, Koffi B, Hoor P, Grewe V, Borken-Kleefeld J, Berntsen TK & Fuglestvedt JS (2011). Radiative forcing due to changes in ozone and methane caused by the transport sector. *Atmospheric Environment*, 45(2):387-394 (January 2011) (Published online 15 October 2010).
*Newell P, Phillips J & Purohit P (2011). The political economy of clean development in India: CDM and beyond. *IDS Bulletin*, 42(3):89-96 (May 2011) (Published online 05 May 2011).
*Riahi K, Rao S, Krey V, Cho C, Chirkov V, Fischer G, Kindermann G, Nakicenovic N & Rafaj P (2011). RCP 8.5 - A scenario of comparatively high greenhouse gas emissions. *Climatic Change*, 109(1-2):33-57 (November 2011) (Published online 13 August 2011). [ENE, ESM, TNT]
*Saikawa E, Kurokawa J, Takigawa M, Borken-Kleefeld J, Mauzerall DL, Horowitz LW & Ohara T (2011). The impact of China's vehicle emissions on regional air quality in 2000 and 2020: A scenario analysis. *Atmospheric Chemistry and Physics*, 11:9465-9484(16 September 2011).
*Smith SJ, van Aardenne J, Klimont Z, Andres R, Volke A & Delgado Arias S (2011). Anthropogenic sulfur dioxide emissions: 1850-2005. *Atmospheric Chemistry and Physics*, 11(3):1101-1116 (9 February 2011).
*Tanaka K & Raddatz T (2011). Correlation between climate sensitivity and aerosol forcing and its implication for the "climate trap": A letter. *Climatic Change*, 109(3-4):815-825 (December 2011) (Published online 25 October 2011).
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Book Chapters

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*Butterbach-Bahl K, Winiwarter W & Sutton MA (et al.) (2011). Nitrogen as a threat to the European greenhouse balance. In: Sutton MA, Howard CM, Erisman JE, Billen G, Bleeker A, Grennfelt P, van Grinsven H & Grizzetti B (eds), *The European Nitrogen Assessment: Sources, Effects and Policy* 2011).
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*Amann M & Klimont Z (Contributing Authors) (2011). *Near-term Climate Protection and Clean Air Benefits: Actions for Controlling Short-lived Climate Forcers - A UNEP Synthesis Report*. UNEP, Nairobi, Kenya (November 2011).

*Amann M, Klimont Z & Kupiainen K (Contributing Authors) (2011). *Integrated Assessment of Black Carbon and Tropospheric Ozone*. UNEP, Nairobi, Kenya.

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Other Publications

Amann M, Bertok I, Borken-Kleefeld J, Cofala J, Heyes C, Hoeglund-Isaksson L, Klimont Z, Rafaj P, Schoepp W & Wagner F (2011). Cost-effective emission reductions to improve air quality in Europe in 2020: Analysis of policy options for the EU for the revision of the Gothenburg Protocol. Final Report submitted to the European Commission, DG Environment (July 2011).

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Amann M & Schoepp W (2011). Calculation of Cause-specific Mortality Impacts of Fine Particulate Matter in GAINS. *CIAM-Report 2/2011*, Draft Version 1. CIAM, IIASA, Laxenburg, Austria (12-13 May 2011).

Borken-Kleefeld J & Amann M (2011). Alternative Pathways Toward Sustainable Development and Climate Stabilization (ALPS) Project. Final Report submitted to Research Institute of Innovative Technology for the Earth (RITE), Kyoto, Japan (January 2011).

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Heyes C, Klimont Z, Wagner F & Amann M (2011). Extension of the GAINS model to include short-lived climate forcers.

*Holland M, Amann M, Heyes C, Rafal P, Schoepp W, Hunt A & Watkiss P (2011). The reduction in air quality impacts and associated economic benefits of mitigation policy: Summary of results from the EC RTD ClimateCost Project. In: P. Watkiss (ed.); *The ClimateCost Project*, Final Report. Volume 1: Europe; Stockholm Environment Institute; Stockholm, Sweden.

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Jonas M, Krey V, Rafaj P, Bachner G, Steininger K, Marland G & Nahorski Z (2011). Uncertainty in an emissions constrained world: Case Austria. Presented at "Climate, Climate Change, Impacts and Adaptation in Austria" (12th Austrian Climate Colloquium), 21-22 September 2011, Vienna, Austria.

Jonas M, Krey V, Wagner F, Marland G & Nahorski Z (2011). Providing a framework for moving to a low C world. Presented at *11th Global Carbon Project Scientific Steering Committee Meeting*, 28-29 May 2011, Shepherdstown, West Virginia, USA (May 2011). [ESM]

Klimont Z, Cofala J, Amann M, Schoepp W, Bertok I & Rafaj P (2011). IIASA-Toyota research agreement April 2010-March 2011: Phase III. Final Report submitted to Toyota Motor Corporation (March 2011).

Phillips J, Newell P & Purohit P (2011). Governing clean energy in India. GCD Working Paper 017; The Governance of Clean Development, University of East Anglia, Norwich, UK (October 2011).

Rafaj P, Schoepp W, Russ P, Heyes C & Amann M (2011). Co-benefits of post-2012 global GHG-mitigation policies. ClimateCost (The Full Costs of Climate Change) Work Package 5: Ancillary Benefits.

Wagner F, Winiwarter W, Klimont Z, Amann M & Sutton M (2011). Ammonia Reductions and Costs Implied By the Three Ambition Levels Proposed in the Draft Annex IX to the Gothenburg Protocol. *CIAM 5/2011*, Version 1.1. CIAM, IIASA, Laxenburg, Austria (4 November 2011).

Winiwarter W (2011). Work package 6.4 - Verification of official inventories and improvement of IPCC methodology. Activity Report, NitroEurope IP (June 2011).

Policy Reports

Shvidenko AV, Klimont Z, Kupiainen K, Rao S & Schepaschenko D (2011). The effects of climate change and abatement policies on the value of natural resources in Northern Europe and in the Arctic Sea area. *Prime Minister's Office Reports*, 1/2011; Helsinki, Finland (18 January 2011). [ENE, ESM]

Interim Reports

Asman WAH, Klimont Z & Winiwarter W (2011). A Simplified Model of Nitrogen Flows from Manure Management. IIASA Interim Report IR-11-030.

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Rao S, Chirkov V, Dentener F, Van Dingen R, Pachauri S, Purohit P, Amann M, Heyes C, Kinney P, Kolp P, Klimont Z, Riahi K & Schoepp W (2011). Estimation of the Global Health Impacts of Air Pollution. IIASA Interim Report IR-11-035. [ENE]

Scientific Recognition

Markus Amann

- Member of the Clean Air Commission of the Austrian Academy of Sciences
- Member of the Scientific Steering Group of the United Nations Environment Program (UNEP) Black Carbon Assessment
- Lead Author of the UNEP/WMO Black Carbon Assessment
- Lead Author of the WHO Global Burden of Disease Assessment
- Lead Author of the Global Energy Assessment (GEA)
- Member of the EU DG-Research Expert Group on the EU Air policy review

Invited and Keynote Lectures

- International Symposium of RITE (Research Institute of (Tokyo, 9 February 2011) 'Mitigation of long- and short-lived climate forcers: Co-benefits on non-climate policy objectives'
- Weston Roundtable Series, University of Wisconsin (Madison, WI, 17 February 2011) 'From Energy Use to Emissions – What Environmental Benefits Can Be Achieved Near-Term?'
- American Association for Advancement of Science (AAAS) Annual Meeting 2011 (Washington DC, 22 February 2011) 'Win-Win and Win-No-Lose: Control Measures for Black Carbon and Ozone'
- Acid Rain 2011 Conference (Beijing, 16-18 June 2011) 'Controlling acidification and
- near-term climate change – a trade-off or a chance for win-win solutions?' (Keynote)

- International Workshop on Air quality in East and South Asia (Beijing, China, 26-27May 2011) 'Key Results of the Toyota Ozone Project'
- High Level Meeting at the Chinese Academy of Engineering (Beijing, China, 27-28May 2011) 'Controls of air pollutants and greenhouse gases: Synergies or trade-offs?'
- Symposium 'One Atmosphere – making the connections: Air pollution, climate change, ecosystems services and biodiversity' (Paris, 29 September 2011) 'One atmosphere – one environment: A personal perspective on current challenges and opportunities' (Keynote)
- UK Royal Society Workshop on 'A Global Policy to regulate human use of fixed Nitrogen' (Royal Society Kavli centre, UK, 7-8 December 2011) 'Profiles of human nitrogen fixation during the 21st century'

Jens Borken

- Editor for Ecoinvent – Life Cycle Inventory Database, responsible for Surface Transport (http://www.ecoinvent.ch/)
- Featured reviewer in Elsevier's Journal 'Reviewer's Update' 12/2011

Janusz Cofala

- Member of the Editorial Advisory Board of the International *Journal of Climate Change Strategies and Management*

Invited and Keynote Lectures

- Silesian University of Technology, Department of Energy and Environmental Protection (Gliwice, Poland, March 2011) 'Air Pollution Control Policies in Europe and Other Major Countries in the World'

Lena Hoglund-Isaksson

Invited and Keynote Lectures

- 6th International Symposium on Non-CO2 Greenhouse Gases (Amsterdam, 2-4November 2011) 'Global anthropogenic methane emissions 2005 to 2030: technical mitigation potentials and costs'

Zbigniew Klimont

- Member of the GEIA (Global Emission Inventory Activity) Steering Committee of the IGBP programme.
- Lead Author of the UNEP/WMO Black Carbon Assessment
- Lead Author of the Arctic Council Black Carbon Assessment
- Lead Author of the Global Energy Assessment (GEA)
- Member of the conference committee for the 'Sixth International Symposium on Non-CO2 Greenhouse Gases (NCGG-6); Science, Policy and Integration', Amsterdam, the Netherlands, 2-4 November 2011.

Invited and Keynote Lectures

- 3rd International Workshop on Regional Air Quality Improvement in Rapidly Developing Economic Regions (Guangzhou, China, 12-13 November 2011). 'Towards Integration of Short-lived Climate Forcers Mitigation in Regional Air Quality and Climate Change Policy'

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"NitroEurope (together with ESM) The nitrogen cycle and its influence on the European greenhouse gas balance"	European Commission, DG Research	01.02.2006	30.04.2011	69,028.00	13,035.00
"EC4 MACS (together with ESM) European Consortium for Modelling of Air Pollution and Climate Strategies"	European Commission, DG Research	01.02.2007	31.01.2013	4,166,479.00	926,090.00
"ClimateCost (together with ESM) Full Costs of Climate Change"	European Commission, DG Research	01.12.2008	31.07.2011	81,836.00	0.00
"CITYZEN megaCITY - Zoom for the ENvironment"	European Commission, DG Environment	01.09.2008	31.08.2011	100,000.00	7,575.00
Further integrated assessment modelling for the NEC Directive and the Gothenburg protocol	European Commission, DG Environment	26.05.2009	25.05.2011	124,972.00	48,078.00
Contract for Upgrading RAINS_Italy to GAINS_ Italy and Related Maintenance Services	Italian Agency for New Technology Energy and the Environment (ENEA)	01.11.2009	31.10.2011	70,000.00	23,154.00

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"EnerGEO (together with ESM) Energy Observation for monitoring and assessment of the environmental impact of energy use"	European Commission, DG Research	01.11.2009	31.10.2013	250,228.00	50,301.00
Collaboration in the preparation of a black carbon handbook and provide consultation, review and critique in preparation of short-lived climate forcers curves	CATF - Clean Air Task Force	15.03.2010	14.03.2011	73,751.00	21,510.00
Model Based Assessment of EU energy and climate change policies for post-2012 regime	Institute of Communication and Computer Systems, National Technical University of Athens	01.04.2010	31.12.2011	120,001.00	74,129.00
"ALPS Project (together with ENE) Alternative Pathways toward Sustainable Development and Climate Stabilization "	Research Institute of Innovative Technology for the Earth (RITE)	01.06.2010	31.01.2011	99,749.00	42,131.00
"AirQualityAsia Reduction of Energy Consumption / CO2 Emission and Improvement of Air Quality in Asia (Phase III)"	Toyota Motor Corporation	01.04.2010	31.03.2011	65,439.00	16,359.00
Inclusion of short-lived climate forcers in the GAINS model	Netherlands Environmental Assessment Agency (PBL)	01.06.2010	31.01.2011	149,768.00	18,721.00
Support to access and use the GAINS Ireland Model	AP EnvEcon	01.11.2010	31.12.2013	60,000.00	18,947.00
"CIAM-2010 Integrated assessment modelling"	United Nations Economic Commission for Europe (UNECE)	01.11.2010	31.03.2011	77,700.00	75,361.00
Development and application of air pollutants and GHG emission model (GAINS-City) for Chinese cities	The China Sustainable Energy Program	01.11.2010	30.11.2011	34,935.00	30,598.00
Development of the GAINS-France interface and hosting	INERIS	01.01.2011	30.06.2012	50,000.00	33,333.00
"Mitigation of climate change (together with ESM) Continued model capacity to support international policy objectives"	Entec UK Ltd	01.01.2011	31.03.2012	99,608.00	0.00
"PEGASOS Mitigation of climate change: continued model capacity to support international policy objectives"	European Commission, DG Research	01.01.2011	31.12.2014	261,090.00	31,893.00
Agreement letter between CATF and IIASA to collaborate with TAMI Bond and CATF in the preparation of a black carbon data repository, investigation of emissions from commercial boiler emissions and investigation of coking activity in China.	CATF - Clean Air Task Force	20.02.2011	31.12.2011	73,750.00	73,750.00
"AMPERE (together with ENE) Assessment of Climate Change Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates"	European Commission, DG Research & Innovation	01.02.2011	31.01.2014	117,300.00	29,174.00
"WEO 2011 World Energy Outlook scenarios"	International Energy Agency (IEA)	01.04.2011	31.12.2011	20,000.00	20,000.00
"Energy scenario Creation of energy scenario in the future to improve air pollution (ozone) in East and south Asia"	Toyota Motor Corporation	01.04.2011	31.03.2012	61,648.00	46,236.00
"Vivid economics Consultancy UK to use GAINS model"	Vivid Economics Limited	23.03.2011	22.03.2012	10,000.00	6,200.00
"MACEB Mitigation of Arctic warming by controlling European black carbon emissions"	European Commission, DG Environment	01.01.2011	31.12.2013	121,731.00	33,010.00
"AirQuality (together with ENE) Impacts of climate change policies on future air quality in Europe"	INERIS	01.06.2011	30.09.2011	10,000.00	10,000.00
"CIAM-2011 Cooperative programme for Monitoring and EMEP"""	Norwegian Meteorological Institute (met.no)	01.01.2011	31.12.2011	108,500.00	108,498.00
"Monitoring Monitoring and assessment of sectorial implementation actions (notably related to transport, energy and agriculture)"	European Commission, DG Environment/Climate Action	01.09.2011	31.08.2013	749,911.00	62,907.00
"ECLIPSE Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants"	European Commission, DG Research	01.11.2011	31.10.2014	358,490.00	13,675.00

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"ECLAIRE Effects of climate change on air pollution impacts and response strategies for European ecosystems"	European Commission, DG Research	01.10.2011	30.09.2015	280,004.00	31,094.00
"EUCLIMIT (together with ESM) Development and application of EU economy-wide climate change mitigation modelling capacity (all greenhouse gas emission and removals)"	Institute of Communication and Computer Systems	07.09.2011	06.09.2013	177,938.00	20,225.00
"CIAM-2011 UNECE APPENDIX I - annual work plan under MoU (LUA Trust Fund for EMEP) to carry out effects-oriented and integrated modelling activities (year 2011-2015)"	United Nations Economic Commission for Europe (UNECE)	01.04.2011	31.12.2011	77,703.00	77,703.00

Risk, Policy, and Vulnerability

Joanne Bayer, Program Leader
bayer@iiasa.ac.at

RPV Research Objectives

RPV combines quantitative methods for modeling and analyzing systems with a suite of quantitative and qualitative approaches to policy analysis. Its objective is to contribute i) to decreasing the risk and vulnerability of economic, ecological, and social systems to stresses imposed by global change and ii) to policies that are designed to cope with global change. RPV places particular emphasis on reducing the vulnerability of the poor.

Alignment with Strategic Plan

RPV's work addresses key topics of the Energy and Climate area, in particular with i) empirical studies on differential adaptive capacity and examination of information needs of European planners, and ii) a close examination of the risks and feasibility of solar energy generation in North Africa. With regard to extreme events, RPV researchers contributed to reframing adaptation in terms of risk management rather than the ill-defined concept of vulnerability. The theme of coping also feeds through into the Poverty and Equity area, with RPV's pioneering past work in the field of risk pooling and the use of insurance providing input into ways to reduce the vulnerability of the poor. The Water and Resilience group's work also explores vulnerability to water scarcity and drought, looking at innovative management schemes as a way of driving forward development. These activities are an important adjunct to the Food and Water research field at IIASA.

Scientific Achievements in 2011

RPV informally comprises three working group: Disasters and Development; Decisions and Governance; and Water and Resilience. We highlight the scientific achievements in that order.

Disasters, Adaptation and Development (DAD)

Reinhard Mechler and Joanne Linnerooth-Bayer contributed as lead and review authors to IPCC's SREX report "Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (IPCC, 2011). This promises to become a landmark study, as it detects growing risks from extreme climate and weather events and attributes these to human-induced climate change. Importantly, by reframing adaptation to extreme weather in terms of risk management rather than the ill-defined concept of vulnerability, it provides a more robust platform for advancing policies on adaptation, such as early warning, land use, infrastructure planning, public health and insurance.

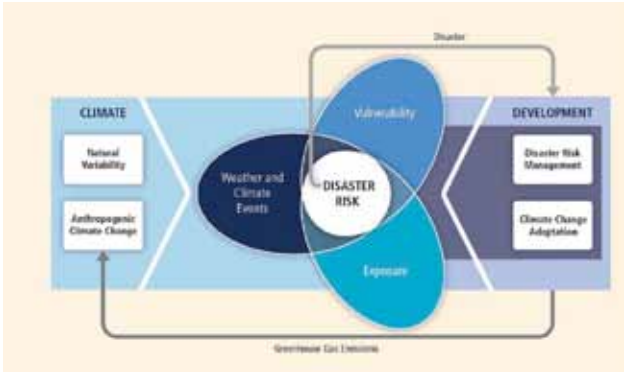
The SREX risk theme builds on RPV's history of risk modeling, assessment and policy formulation, particularly for highly vulnerable countries. In 2011 the focus was on Asian megacities,

where by 2030 some 500 million Asians are expected to live, and many of which are at risk from multiple hazards including earthquakes, cyclones, and flooding. In a paper in *Cities*, DAD researchers suggest that Asian megacities can pool risks using a model similar to one used by Caribbean nations.

The DAD group continued exploring poverty dynamics and poverty traps associated with extreme event risk. Hochrainer-Stigler et al. (2011) documented and assessed the household-level disaster-financing strategies of the poor in developing countries within the context of a poverty dynamics framework. The paper demonstrates that in the absence of formal insurance arrangements, the poor use many informal coping mechanisms; however, these may break down when large disaster events occur.

Strategies and measures for disaster risk reduction (DRR) are not being implemented at the scale called for by the 2005 Hyogo Framework of Action. Part of the problem is that it is risky to invest in something that reaps benefits only in the case of a relatively unlikely event (such as a hurricane or a drought). One way to circumvent this problem is by promoting DRR through incentives and other features embedded in market-based financial instruments. DAD researchers advised the European Commission on the applicability and effectiveness of risk financing and other economic instruments for climate adaptation.

As not all risks can be cost-effectively reduced, especially those that occur only very rarely, forward-thinking DRR stakeholders tend to seek options for financing the remaining or



Advancing disaster risk management as a part of climate change adaptation. Source: IPCC, 2011.

residual risks. In a background paper prepared for the 2011 Global Assessment Report on Disaster Risk Reduction, Joanne Linnerooth-Bayer and Pablo Suarez analyze whether—and how—insurance and other market-based risk transfer instruments can help increase resilience to disasters. While there are numerous publications addressing disaster risk financing, this paper is specifically directed to DRR practitioners.

Reinhard Mechler worked with climate scientists in a UNEP project, drafting guidelines on risk and economic assessment methodologies that will be used for screening and assessing climate policies in countries such as India and South Africa. This follows from extensive work on an adaptation toolbox that can be used to screen and identity tools, methods, and metrics for the analysis of climate impacts, vulnerability and adaptation (https://iiasadaptation.wikispaces.com/Tools).

Water and Resilience

The Water and Resilience Group pursued questions on governance, particularly resource management policies in social-ecological systems. This work was applied to governance systems in biomes where economic activity and ecosystem function are influenced by the dynamics of water supply. Questions of vulnerability to water scarcity and drought were addressed in the Sahelian biome of West Africa, and questions of vulnerability to both floods and droughts were addressed in Western and Central Europe.

One question underlying much of this research has to do with whether transitions from existing regimes to more innovative management regimes are non-linear, a question that was examined in the transition that is marked by the "regreening" or reforestation of the Sahel in Niger. Our research found that transition to sustainable agro-forestry can occur in less than a decade, even when more than 50 years of conventional export-driven agricultural policy had vastly increased vulnerability to drought through deforestation of agricultural areas. However, transition required the combination of international support for local innovations in technology and capacity building to produce economic progress impressive enough to shift national forestry policy from antagonism to support. This work contributed to a special issue on vulnerability to climate change in dryland systems that Jan Sendzimir co-edited for the journal *Ecology and Society*. The issue of whether current trends pushing toward tipping points in natural resource dynamics can be reversed by social and technical innovation was examined in partnership with a special research group within the Resilience Alliance headed by Frances Westley, Carl Folke, Thomas Homer-Dixon and Eric Lambin, among others. The results, published in the journal *Ambio*, support the use of social media (for example, "policy laboratories" to stimulate and integrate different innovative perspectives as a way forward from expert-driven top down and traditional, disciplinary-based research approaches.

With support from the EU FP7 project SCENES, the Water and Resilience group in partnership with the Alterra group at the University of Wageningen developed improved methods for generating scenarios that integrate different methodologies (conceptual and computer modeling outputs) and different perspectives (forecasting and backcasting) for envisioning potential sequences of policy and technology development in water policy in Europe up to 2050. These results have been published in *Technological Forecasting & Social Change*, and the methods have been applied on behalf of the United Nations European Economic Commission to create a scenario development process for the Republic of Georgia to explore alternative pathways to water policy development.

Regreening the Sahel in Niger.

The question of whether (or how) transition to new management regimes is influenced by historical sequences of co-development of institutions and knowledge was explored in collaboration with Claudia Pahl-Wostl and her group at the University of Osnabrück. This involved development of a relational database, the Management Transition Framework, to collect institutional data derived from field work performed under the NeWater and SCENES project in the Tisza river basin. This initiative is evolving in collaboration with Elinor Ostrom, Nobel Prize winner, and her team at the University of Indiana. The results have been submitted for review in PNAS. Another initiative emerging from this work is the field-tested development of a role-playing game for farmers and water managers in European river floodplains. This has been elaborated both as a research tool to facilitate knowledge elicitation about how management decisions are made as well as a decision-support tool to allow stakeholders to explore scenarios involving alternative ways of managing farms and water. The results, published in *Environmental Policy and Governance*, provided the methodological foundations for a successful National Science Foundation grant for computer-driven role-playing experiments with communities using forest resources in tropical rainforests in Uganda and Bolivia.

Decisions and Governance

The Decisions and Governance group addressed questions of how people and organizations respond to perceptions of risk, and how government policies influence those reactions. Continuing previous work, the group examined these issues in three areas: natural hazards management; climate adaptation; and

planning and investment in energy infrastructure. The work in these three areas led to the submission of 12 scientific articles to peer-reviewed journals. The results were as follows:

- Extensive fieldwork and stakeholder communication in Mozambique revealed a puzzle concerning the issue of differential vulnerability at the household level in agricultural communities. While most stakeholders suggested, and believed, that poor and disadvantaged households suffer more in the face of climate hazards, and are less able to adapt or prepare for those risks—all of which is was consistent with the existing literature—data collected at the household level found no such pattern, suggesting that these households may have had access to informal resources for coping or adaptation. Similar work in India identified a similar pattern, again suggesting that the existing literature, which is based largely on people's opinions rather than quantitative data analysis, may be flawed. The India study revealed, however, that the one factor that correlated with multiple yield-increasing adaptation strategies at the farmer household level was access to crop insurance.
- Several findings highlighted particularly low vulnerability associated with solar energy expansion in the Mediterranean basin.
- One study examined the vulnerability of solar energy infrastructure and electricity production to the anticipated effects of climate change, and found no discernible effects. This stands in contrast to results pointing to potential losses in production capacity in thermal power plants as a result of rising temperature and decreased river runoff.
- A second study focused on the vulnerability of water resources in North Africa to large scale development of concentrated solar power, which of all the renewable sources is the most water-intensive. The study identified a suite of water conservation technologies that could be added on to such plants, which would result in their large-scale development that did not create an excessive burden on sustainable water use, and that would come at very low additional costs.
- A third study examined the vulnerability of European energy security in the case of importing a great deal of electric power from Middle East and North African countries. This study examined the market structure to appraise the risk of supply interruptions, and found such risks to be lower than in the case of oil and gas. Furthermore, the buffering capacity of the current European power supply system would mean that all supplier countries would have to act in unison in order to create a significant energy security threat.

Other results were related to the links between hazard risk assessment and mitigation action.

- One study compared systems for mapping landslide risks across numerous jurisdictions in India and Italy and highlighted the importance of decentralized authority with respect to information gathering and sharing as a prerequisite for effective response strategies.
- A second study examined people's propensity to heed hazard warnings—based on case studies of cyclone warnings in India—as a function of their past experience with similar warnings. The results highlighted the importance of people's perceived risks associated with evacuation. Those who had experienced negative consequences in the past were unlikely to evacuate again, while those who had heard warnings before, but suffered no negative consequences associated with evacuation, became increasingly likely to evacuate.

Policy Impact in 2011

Reinhard Mechler, Joanne Linnerooth-Bayer, and Stefan Hochrainer-Stigler advised the European Commission on the applicability and effectiveness of economic instruments, with a focus on risk financing for climate adaptation. Reinhard Mechler presented the results at an EC conference on insurance instruments in Brussels.

Joanne Linnerooth-Bayer is on the board of the Munich Climate Insurance Initiative, which is active in proposing and negotiating insurance proposals as contributions to adaptation in developing countries.

Anthony Patt advised the Czech parliament on issues of European power system integration during their deliberations on updates to their national renewable energy law.

Activities for 2012

RPV is well positioned to address IIASA's new strategic areas: (1) the Poverty and Equity area through staff expertise on catastrophic risk management and analysis of poverty traps, the work of the Risk and Vulnerability (RAV) Program on building catastrophe safety nets for the most vulnerable, and its history of workshops and publications on equity and fairness;, (2) the Energy and Climate Change area by analyzing topical mitigation and adaptation issues with methodologies that combine systems modeling with the appraisal of economic, political, and institutional dynamics; and (3) the Food and Water area through its work on resilience and adaptive capacity of social-ecological systems.

More specifically, RPV will continue developing its integrated assessment framework based on the CATSIM model for assessing extreme event risk at multiple scales and in the context of multiple drivers and multiple sources of uncertainty. In 2012 RPV will work with the UN International Strategy on Disaster Risk Reduction (UNISDR) and on its global assessment report. Another activity with a global focus involves linking CATSIM to the Global Earthquake Model (GEM), a large modeling effort leading to a probabilistic open-source seismic risk model.

Another work stream focuses on the effects of systemic risk on incomes and livelihoods of low-income households and farmers. RPV will continue its collaboration with the Munich Climate Insurance Initiative and prepare a revised submission to the UNFCCC secretariat on risk transfer instruments as an adaptation instrument. The group is examining the interrelationships between economic growth, risks, and binding biophysical constraints (such as related to stabilizing at 2°C of warming). As a starting point the project, effectively questioning the Green Growth paradigm, studies these questions for the case of Austria. Finally, the group is modeling the security of the European power system in a world of increased reliance on renewable energy sources, taking into account potential drivers of supply in-

terruptions including adverse weather, hostile state action, and terrorism.

RPV staff will continue work on a number of ongoing EU projects such as MEDIATION (Methodology for Effective Decision-making on Impacts and AdaptaTION), RESPONSES (European responses to climate change: deep emissions reductions and mainstreaming of mitigation and adaptation), SAFELAND (Landslide analysis and response), MATRIX (Multi-hazard risk assessment and management), and most recently IMPACT 2c. RPV has projects funded by, among other sources, the European Climate Foundation, the US National Science Foundation and the Austrian Program for Climate Research. Finally, RPV is participating in the Marie Curie Training Network, CHANGES, and is hosting a PhD student linking climate change modeling to disaster management in Europe.

RPV will contribute to IPCC's Fifth Assessment Report's Working Groups II (impacts and adaptation) and III (climate mitigation).

Personnel Resources

Scientific Staff

Joanne Bayer (USA), Program Leader
Aniello Amendola (Italy) (13% p-t)
Jason Blackstock (Canada) (10% p-t)*
Kerstin Damerau (Germany)
Anna Dubel (Poland) (50% p-t)
S(USA)nne Hanger (Austria)
Stefan Hochrainer-Stigler (Austria)
Nadejda Komendantova-Amann (Austria) (75% p-t)
Karl Lilliestam (Sweden)
Ziga Malek Slovenia
Reinhard Mechler (Germany) (60% p-t)
Janosch Ondraczek (Germany)*
Anthony Patt (USA)
Stefan Pfenninger (Switzerland)
Georg Pflug (Austria) (20% p-t)
Isolde Prommer (Austria)*
Armon Rezai (Austria) (10% p-t)*
Dagmar Schröter (Germany) (20% p-t)*
Dagmar Schröter (Germany)
Jan Sendzimir (USA)
Upasna Sharma (India)
Michael Thompson (United Kingdom) (17% p-t)
Giacomo Trombi (Italy)*
Keith Williges (USA)
Masoud Yazdanpanah (Iran)*

Postdoctoral Scholar

Anna Scolobig (Italy)

YSSP

Javaria Ashraf (Pakistan)
Taufeeq Dhansay (South Africa)
Architesh Panda (India)
Xilei Pang (China)
Thiagu Ranganathan (India)
Anna Timonina (Russia)
Natallia Tratsiakova (Belarus)
Abonesh Tulu (Ethiopia)

Administrative Support

Jennifer Carvill (United Kingdom)
Jun Watabe (Japan)

p-t = part time; *Guest Research Scholar

Publications[1]

Journal Articles

*Beck MB, Thompson M, Ney S, Gyawali D & Jeffrey P (2011). On governance for re-engineering city infrastructure. *Proceedings of the ICE - Engineering Sustainability*, 164(2):129-142 (June 2011).

*Demerau K, Williges K, Patt A & Gauche P (2011). Costs of reducing water use of concentrating solar power to sustainable levels: Scenarios for North Africa. *Energy Policy*, 39(7):4391-4398 (July 2011) (Published online 14 May 2011).

*Dreyfus M & Patt A (2011). The European Commission White Paper on adaptation: Appraising its strategic success as an instrument of soft law. *Mitigation and Adaptation Strategies for Global Change*, Article in press(Published online 23 December 2011).

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1 *Peer Reviewed
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*Lilliestam J & Ellenbeck S (2011). Energy security and renewable electricity trade - Will Desertec make Europe vulnerable to the "energy weapon"? *Energy Policy*, 39(6):3380-3391 (June 2011) (Published online 7 April 2011).
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*Patt A, Komendantova N, Battaglini A & Lilliestam J (2011). Regional integration to support full renewable power deployment for Europe by 2050. *Environmental Politics*, 20(5):727-742 (September 2011).
*Sendzimir J, Reij CP & Magnuszewski P (2011). Rebuilding resilience in the Sahel: Regreening in the Maradi and Zinder regions of Niger. *Ecology and Society*, 16(3):1 (September 2011).
*Stefanska J, Magnuszewski P, Sendzimir J, Romaniuk P, Taillieu T, Dubel A, Flachner Z & Balogh P (2011). A gaming exercise to explore problem-solving versus relational activities for river floodplain management. *Environmental Policy and Governance*, 21(6):454-471 (November/December 2011) (Published online 27 November).
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Book Chapters

*Komendantova N & Patt A (2011). Could corruption pose a barrier to roll-out of renewable energy in North Africa? In: International Transparency (ed.), *Global Corruption Report: Climate Change*. Earthscan, London, UK.
*Verweij M, Ney S & Thompson M (2011). Clumsy solutions for a wicked world. In: Verwij Marco (ed.), *Clumsy Solutions for a Wicked World: How to Improve Global Governance*. Palgrave Macmillan, Basingstoke, Hampshire, UK.

Books

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Other Publications

Ackerman F, Chalabi Z, Mechler R & Scrieciu S (2011). New Climate Economics: Methodological Choices and Recommendations. Stockholm Environment Institute (May 2011).
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Scientific Recognition

- Reinhard Mechler (lead author) and Joanne Linnerooth-Bayer (lead author) participated in IPCC's special report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX);
- Reinhard Mechler was invited to join the core writing team of lead authors drafting and presenting the Summary for Policymakers of IPCC's SREX report.
- Anthony Patt (lead author, Working Group III), Reinhard Mechler (lead author author, Working Group II) and Joanne Linnerooth-Bayer (contributing author, Working Group III) were invited to be authors on IPCC's 5th Assessment Report. Anthony Patt was also invited to be a review editor (Working Group II).
- Jan Sendzimir, invited by Elinor Ostrom, participated in an international team, the Social-Ecological Systems Club, to facilitate collaboration between social and natural scientists.

Selected invited lectures

- Reinhard Mechler "Climate change and extremes: The IPCC SREX Report," Bank Austria Lectures on Sustainability,Vienna, December 6, 2011 and German Environmental Office (UBA), Berlin, November 22, 2011.
- Reinhard Mechler "Insurance Instruments for Adaptation to Climate Change," Conference 'Prevention and Insurance of Natural Catastrophes', European Commission, Brussels, October 18 2011.

- Joanne Linnerooth-Bayer "Climate change research for policy", Keynote address, Annual meeting Austrian Climate Research Program, Vienna, October, 2011.
- Anthony Patt "Progress towards 100% renewable power in Europe," Keynote address, special seminar of the Czech parliament, Prague, September, 2011.
- Anthony Patt "Vulnerable people," Keynote address, Tropentag Conference on International Development, University of Bonn, October 2011.
- Jan Sendzimir "Water Meta-Management: Developing and applying the means to adapt to uncertainty", Keynote address, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) special meeting, Wasser und Klimawandel – Being prepared for the uncertainty, November 2011.

Editorships

- Jan Sendzimir: Subject Editor for the on-line journal *Ecology and Society*
- Anthony Patt: *Global Environmental Change*, Editorial Board; *Regional Environmental Change*, Co-Editor; *Climate and Development*, Co-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
- Reinhard Mechler: *Mitigation and Adaptation Strategies for Climate Change*, Editorial Board; *Integrated Disaster Risk Management*, Editor; *Climate Risk Assessment* (forthcoming Elsevier 2012), Associate editor.

Advisory and executive boards

- Reinhard Mechler, Stefan Hochrainer, Joanne Linnerooth-Bayer: Executive board of the Society for Integrated Disaster Risk Management.
- Joanne Linnerooth-Bayer: EC Environment Advisory Group; Steering Committee of the Austrian Climate Research Program; Board of the Munich Climate Insurance Initiative; Executive Board of a special project on microinsurance instruments for the Caribbean region; Invited member of Science Committee of the Chinese Academy of Disaster Reduction and Emergency Management; Panel Review Committee of the US National Science Foundation.

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"SCENES (together with ESM) Water Scenarios for Europe amd for Neighbouring States"	European Commission, DG Research	01.11.2006	30.04.2011	423,584.00	17,643.00
"SafeLand Living with landslide risk in Europe: Assessment, effects of global change, and risk management strategies"	European Commission, DG Research	01.05.2009	30.04.2012	347,983.49	83,468.00
"RESPONSES European responses to climate change: deep emissions reductions and mainstreaming of mitigation and adaptation"	Commission of the European Communities (EC)	01.01.2010	31.12.2012	395,444.00	139,471.00
"MEDIATION Methodology for Effective Decision-making on Impacts and Adaptation "	European Commission, DG Research	01.01.2010	30.06.2013	387,656.00	136,102.00
"MATRIX Methodology for Effective Decision-making on Impacts and Adaptation "	European Commission, DG Research	01.10.2010	30.09.2013	299,964.00	86,076.00
"CHANGES Changing Hydro-Meteorological Risks- as Analyzed by A New Generation of European Scientists"	European Commission, Research Executive Agency (REA)	01.01.2011	31.12.2014	235,084.00	25,242.00
"META-1 March 2011 Progress Report - 100% Renewable Electricity"	Potsdam Institute for Climate Impact Research (PIK)	01.01.2011	31.12.2011	28,000.00	28,000.00
"META-2 META-2: Energy security in scenarios for Europe's future electricity supply"	Potsdam Institute for Climate Impact Research (PIK)	01.03.2011	01.03.2013	39,200.00	30,756.00
"IGERT Resilience and Adaptive Governance in Stressed Watersheds"	National Science Foundation	01.01.2011	30.06.2012	43,904.00	20,755.00

Transitions to New Technologies

Arnulf Grubler, Acting Program Leader
gruebler@iiasa.ac.at

Research Objectives

The strategic goal of the TNT Program is to further the understanding of the patterns, drivers, constraints, and impacts of technological change, particularly in the areas that are key for framing global sustainability conditions (such as climate change) and to disseminate policy-relevant research findings through high-level global forums and participation in major international scientific assessments.

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 fundamentally redefine products, services, and even entire markets. TNT's strategic research goal consequently focuses on the systemic aspects of technological change and draws on empirical case studies, associated "meta" analysis, novel modeling approaches, as well as scenario studies and robustness analysis to inform technology policy choices from a systemic perspective.

TNT's research aims for an improved empirical understanding that feeds into new modeling approaches of technological change with an emphasis on the treatment of technological uncertainty, spatial and actor heterogeneity, and assessments of the potential economic and societal impacts that could result from pervasive diffusion and adoption of new technologies. Priority is given to those technology areas that maximize synergies and cooperation with other IIASA research programs in particular in the energy and climate areas, complemented by exploratory analysis in key policy-relevant areas, such as the digital divide. A final objective of TNT is to maximize the visibility of its small research staff through participation in a few, key international assessments and collaborative activities, most notably the IPCC and GEA, including software development for scientific data documentation and dissemination.

Alignment with Strategic Plan

TNT research reflects IIASA's Strategic Plan in terms of investigating one of the major drivers of global transformations highlighted in the Strategic Plan: technological innovations and their diffusion. Technology research is also an integral component to address the three cross-cutting problem areas outlined by the Strategic Plan. TNT, as a leading research group on technology innovation systems has played and will continue to play a key role in IIASA's research in Energy and Climate Change, including long-term scenario development, technology portfolio analysis and modeling, as well as comparative innovation policy analysis. In collaboration with the Population Program (the second major driver highlighted by IIASA's Strategic Plan), TNT will continue to investigate the linkages between demographics, human capital, and technology diffusion, with special emphasis on the "digital divide" as a contribution to the Poverty and Equity theme. Contributions to the Food and Water theme are also planned.

Scientific Achievements in 2011

Highlights

As in previous years the thrust of TNT's research activities centered around the Global Energy Assessment (GEA, see also the ENE Progress Report). TNT researchers altogether served as convening and coordinating Lead Authors for four Knowledge Modules of the GEA. All chapters have been completed and submitted to the GEA and are scheduled for publication in 2012. An extensive dissemination of the findings from this major international assessment was also initiated. In addition to a series of journal articles, altogether three book volumes are planned as GEA spinoffs, with the first book manuscript having been submitted to the publisher in December 2011. TNT researchers have also presented first GEA findings in a large number of policy briefs and scientific presentations.

In-house research focused on three main areas: i) extending the work on historical technology scaling dynamics, ii) Further model development in the domain of technological complexity, and three external research contracts (MONITOR, WBGU, and ALPS).

Global Energy Assessment (GEA)

Within the context of the Global Energy Assessment, TNT researchers have received the distinction of coordinating four GEA Knowledge Modules (KMs being chapters of the final report). Arnulf Grubler serves as convening lead author (CLA), on KM18 on urbanization and KM24 on technology innovation policy as well as coordinator author of the GEA Energy Primer (KM1), for which a larger number of TNT and ENE scientists served as lead authors. Other TNT scientists serving as lead and contributing authors for KM18 and KM 24 include TNT research associates Shobhakar Dhakal and Charlie Wilson as well as Niels Schulz. TNT researcher and ENE Program leader Keywan Riahi serves as CLA on GEA's scenario chapter (KM17) which assumes a central synthesizing and coordinating role across the various topics addressed within the GEA. All TNT scientists have also actively contributed to this KM as well.

After completion of the chapters, GEA instituted a final round of peer review, which was successfully completed and the final revised manuscripts were submitted to GEA with publication scheduled for 2012. In parallel, a dissemination strategy of the findings from this major international assessment was developed for TNT. Key components are three commercial books, a series of high-level journal articles, high-level policy briefs, as well as development of educational materials.

The first book manuscript, *Energizing Sustainable Cities* (edited by Arnulf Grubler and David Fisk) and representing an extended version of KM18 was completed and submitted to the publisher (Earthscan) in December 2011 (*Figure 1*). A second

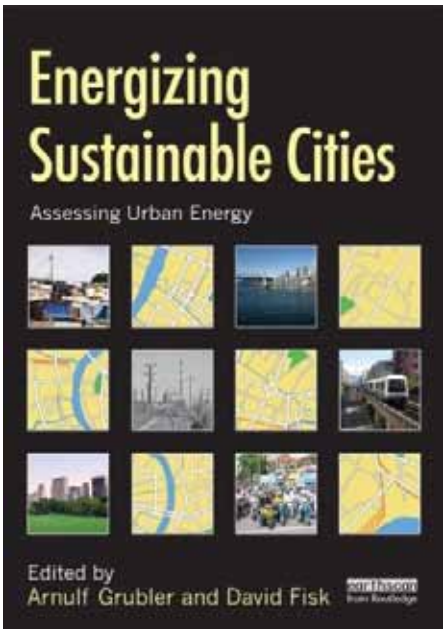

Figure 1. Book cover of first GEA spinoff book publication coordinated by TNT researchers.

book manuscript drawing on KM24's case studies is currently under preparation (edited by Arnulf Grubler and Charlie Wilson) and is planned to be submitted to Cambridge University Press in 2012. Lastly, TNT organized a writing session to extend the GEA Energy Primer and to develop an online textbook for use in university energy systems curricula with a first version planned to go online in Summer 2012. Two journal articles summarizing the main findings of the assessment of Energy Technology Innovation Systems (ETIS, see *Figure 2*) were also prepared and submitted to high-level journals, with additional journal articles being under preparation.

Lastly, pre-briefings of major GEA findings were presented on numerous occasions including invited keynote presentations at the UNFCC meeting in Durban, the IPCC Meeting on Human Settlements and the first IPCC Working Group III LA meeting (as input to AR5), to the Secretary General of the United Nations, at ICSU, UNIDO, the Global Environmental Facility (GEF), the World Bank, as well as in numerous universities and research organizations, including ETH Zurich, Harvard, Lund, MIT, NREL, RITE, Sao Paulo, TU Wien, Yale, among many others. These dissemination activities are spearheaded by Nebojsa Nakicenovic and Arnulf Grubler.

In-house Research

A number of research milestones were achieved in 2011.

Research into historical scaling dynamics continued to test the hypothesis of a negative correlation between market size and technology diffusion speed. This research is being performed by IIASA Postdoc Nuno Bento with contributions by Charlie Wilson and Arnulf Grubler. After further corroboration of the initial hypothesis by drawing on empirical case studies on the scaling of energy technologies in the 19th and 20th century, a comparison of the historical scaling dynamics with future projections in the climate mitigation literature was performed by Wilson and Peter Kolp in collaboration with Keywan Riahi and ENE researcher Volker Krey. An article summarizing the research findings was submitted to *Climatic Change*. Drawing on this research a new research collaboration also with ENE was initiated to endogenize technology diffusion dynamics into IAMs using

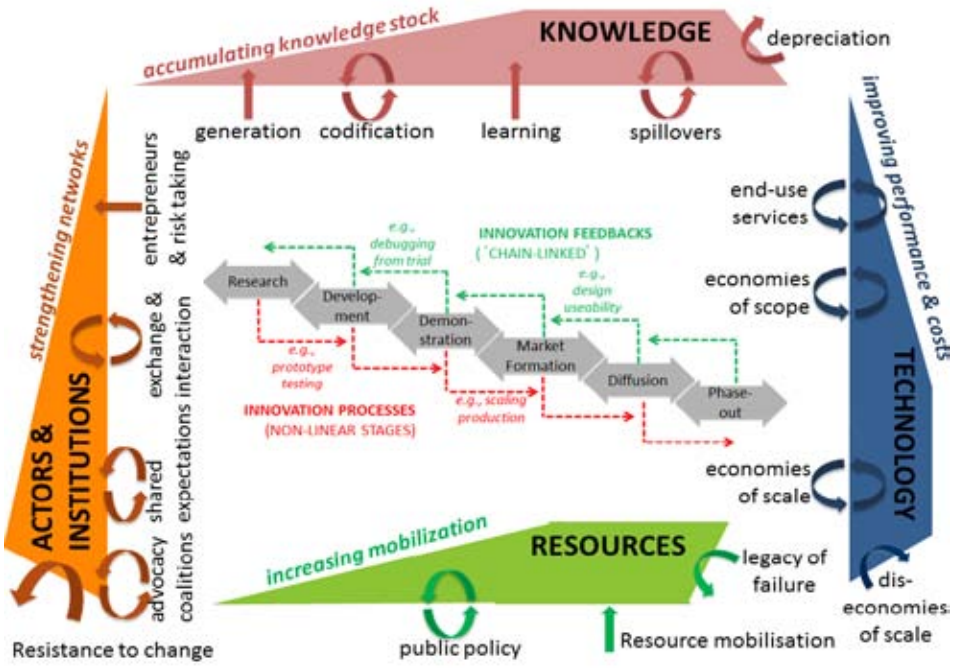

Figure 2. Conceptual framework of the Energy Technology Innovation System (ETIS) developed within GEA's assessment chapter of technology innovation policy (KM24).

IIASA's MESSAGE model as an example. This was funded via an external research grant from RITE in Japan (see also the discussion on the ALPS external contract below). A prototype model implementation was developed and tested, and a continuation of this research is planned for 2012.

TNT researcher Tieju Ma continued further model development of the agent-based model of technological complexity. This project aims to extend the original model developed by Ma and Grubler in collaboration with Nakicenovic and Brian Arthur by explicitly considering technology components as building blocks of the evolution of technological complexity. The empirical calibration of this model proved challenging due to the large number of technology components models (a few hundreds); however, it was possible to complete the prototype model implementation and to perform a large number of model simulations. Due to the specific nature of this agent-based model which combines stochastic innovation uncertainty with an evolving evolutionary selection environment, hundreds of "technology histories" need to be generated and then sampled statistically for robust evolutionary traits and patterns. Preliminary findings suggest that the evolution of technological complexity is quite scale-invariant with respect to the unit size of the technologies or technology components modeled. However, more work will be required before these preliminary findings can be further corroborated and the results submitted to a journal (planned for 2012).

New Initiatives

IPCC AR5

IPCC's Fifth Assessment Report (AR5) is well underway with first Lead Author Meetings being held in 2011. TNT researchers continue to be key contributors to the IPCC. Nebojsa Nakicenovic serves as Lead Author (LA) in the Working Group III chapter on Drivers, Trends, and Mitigation; Keywan Riahi is LA of the chapter on Energy Systems, and TNT research associate Shobhakar Dhakal serves as Co-Convening Lead Author on the chapter on Human Settlements. Arnulf Grubler has been appointed as IPCC Review Editor for Chapter 1.

Austrian Climate Assessment

Nebojsa Nakicenovic has been a key actor in the formation of a network of research institutions (which also includes IIASA) with the objective of performing an "Austrian IPCC" assessment. In 2011 the Austrian Panel on Climate Change (APCC) and a Climate Change Center Austria (CCCA) were created. Nakicenovic serves on the steering committees of these initiatives and as liaison to IIASA, and Keywan Riahi serves as coordinator for the entire APCC review process.

ICSU

The International Council of Science (ICSU) is the global umbrella organization for all Academies of Science and other learned societies and hence is a key player in steering international research cooperation and agenda setting, particularly in the domains germane to IIASA's research mission.

Nebojsa Nakicenovic has been appointed to its Committee on Scientific Planning and Review (CSPR) which as its first activity conducted a (Science and Technology) Foresight workshop in France.

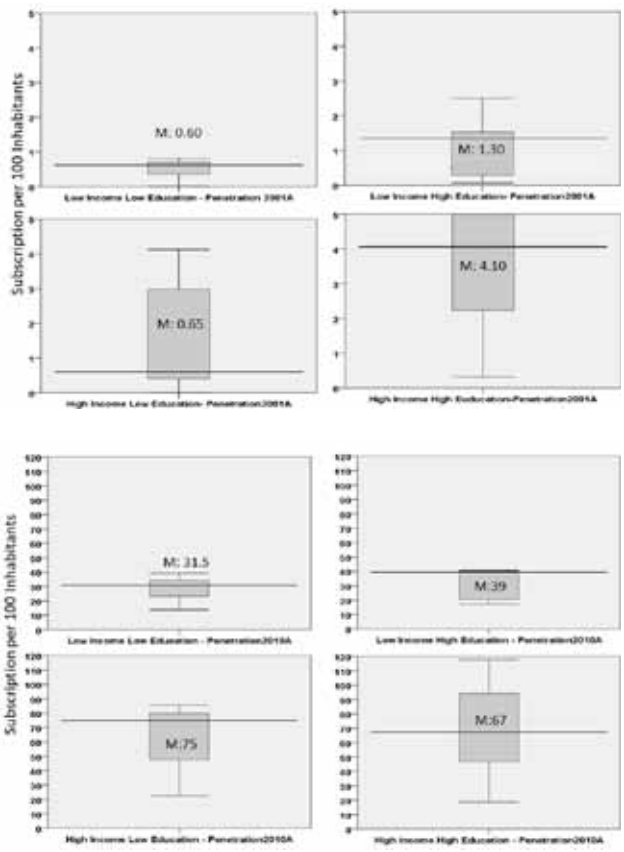

Figure 3. Diffusion of mobile communication (phones per 100 inhabitants, means and percentiles per subpopulation) as a function of income (Low/High) and human capital (Low/High educational attainment) for different subpopulations in Sub-Saharan Africa in 2001 (top) and 2010 (bottom). Note in particular the important influence of education on the early adoption rates of cell-phones (2001) and its diminishing impact for late, pervasive adoption (2010). In 2010 the poorest and least educated population of Sub-Saharan Africa had a subscription rate of 0.3 per capita, i.e. at least one subscription per household on average, compared to 0.006 (some 50 times lower) only 10 years earlier. This illustrates the powers of modern communication technologies in bridging the "digital divide."

Technological Change and Human Capital

As part of the 2011 YSSP research program, a pre-feasibility study on the influence of human capital on the adoption rate of new technologies was initiated. A case study on mobile telephone communication in sub-Saharan Africa was performed by TNT YSSP participant Mokter Hossain (co-supervised by Grubler and ENE's Shonali Pachauri). The study, drawing on methods proposed by researchers in IIASA's POP Program, identified human capital, as represented in different degrees of educational attainment, as an important determinant of the early adoption of mobile communication in Africa. However, the influence of this variable (along with income effects) diminishes with in-

creasing market penetration and near-universal access to the technology (*Figure 3*). Depending on (external) funding sources, it is planned to enlarge the research field of the influence of social heterogeneity on technology adoption in the future TNT research portfolio.

External Contracts

Three external research contracts were performed by TNT in 2011. One (MONITOR) was completed in 2011, one continued (WBGU), and a new contract (ALPS) was received.

MONITOR

This EU-funded research aimed at identifying and surveying (monitoring) a range of important determinant trends and drivers (macro-economic, technologic, regulatory) of relevance to air transport in Europe and globally. TNT's contribution focused primarily on a survey of recent scenario trends and macro-indicators. A final report was submitted to the German aerospace center (DLR) that coordinated this project.

WBGU

The successful collaboration with the German Advisory Committee on Global Change (WBGU) was also continued in 2011, with Nebojsa Nakicenovic serving as Committee member and Arnulf Grubler providing input on the lessons from historical technology transitions for a major WBGU study on Transformations, completed in 2011. The study "World in Transition – A Social Contract for Sustainability" represents a pioneering report in which traditional conceptualizations of transitions that have focused on the economic and technological dimensions is complemented by social and institutional perspectives. Its high-level policy impact can perhaps be best discerned by the fact that the visions postulated were submitted to the German parliament. Nakicenovic also reported on the study main findings to a number of high-level forums including COP17 in Durban, South Africa.

ALPS

TNT together with ENE received a new research contract from RITE in Japan on the topic of endogenizing technology diffusion dynamics in IAM (Integrated Assessment Models). The issue of how to represent the dynamics of technology and ensuing market penetration is of critical importance particularly for assessing feasibility, timing, and costs of climate stabilization efforts.

TNT researcher Arnulf Grubler developed a conceptual model and illustrative parametrizations on the determinants of diffusion rates as a function of systemic, economic, and technological attributes of innovations. ENE researcher Volker Krey developed a new modeling framework with a prototype implementation into the MESSAGE model that endogenizes traditional market penetration constraints into the modeling framework. It is planned to continue this line of research, also integrating the findings from TNT's technology scaling research work in 2012. The scope and extent of this research will depend also on the external funding sources available.

Policy Impact in 2011

Major policy impacts in 2011 included the WBGU Transformation study, co-authored by Nebojsa Nakicenovic, discussed above, and TNT's input to UN DESA's World Economic and Social Survey (WESS) 2011. WESS drew to a large extent on the findings from the GEA chapter on technological innovation (KM24) as well as a background paper written by Wilson and Grubler on Lessons from the History of Technological Change for Clean Energy Scenarios and Policies. Lastly, Grubler was also one of two external experts invited to comment on the new Russian In-

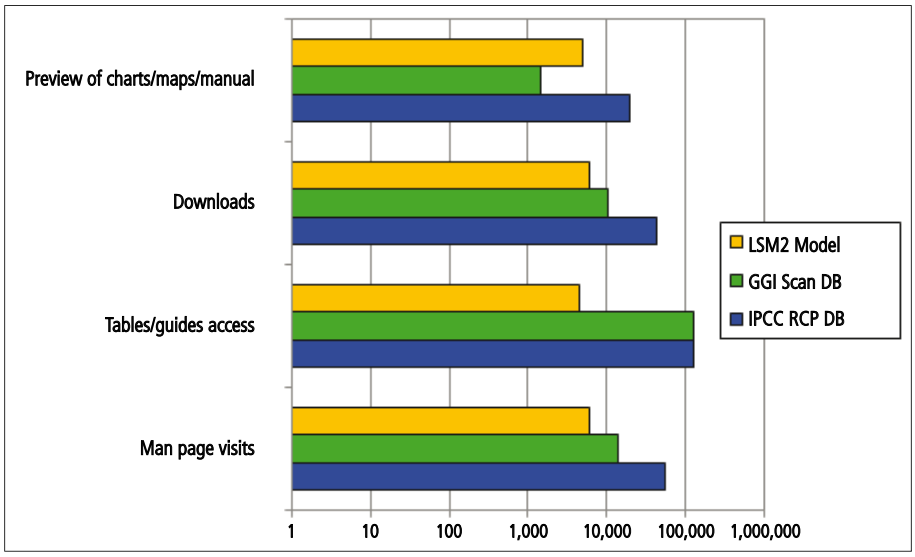

Figure 4. 2011 (year totals) access statistics to Web tools developed by TNT and ENE and offered as a service to the wider scientific community. Note in particular the logarithmic scale of access statistics. Next to the IPCC RCP scenario data base (see also discussion on TNT Dissemination), the tools offered include also the scenario database of IIASA's former Greenhouse Gas Initiative (GGI) as well as TNT's LSM2 model which allows formal analysis of technological growth, diffusion, and substitution processes.

novation Strategy 2020, discussed at a ministerial-level meeting in Moscow in February 2011.

Dissemination of TNT Research

In addition to publications in the form of scientific articles, assessment reports and policy briefs, Web-based research tools, models, and data bases have become an integral part of TNT's dissemination strategy. The scientific Web tools developed by TNT's Peter Kolp in collaboration with ENE for the display and dissemination of complex scientific information is receiving ever-increasing recognition and customer demand (*Figure 4*). Demand was particularly strong on the data base developed for the IPCC Reference Concentration Pathways scenarios (RCPs) following the publication of the RCP scenarios (see ENE Progress report and to which TNT has made important contributions) . There have been well over 100,000 accesses and close to 50,000 downloads, illustrating both the value added to the wider scientific community as well as a dissemination reach unparalleled by traditional media such as journal articles or other forms of paper publications.

Summary Activities 2011

TNT's in-house research effort in 2011 amounted to 42 person-months of scientific and professional staff. Program researchers taught classes at altogether six universities in Austria, China, Portugal, and the USA, delivered some 65 lectures and attended additional 53 professional, advisory, or steering committee meetings. 2011 publications included: one special journal issue (Energy Economics, edited by Nebojsa Nakicenovic and Bill Nordhaus), 25 peer-reviewed journal articles and book chapters, and an additional 11 working and other professional papers.

Activities for 2012

The main thrust of activities in 2012 will center around the completion of the numerous spin-off publications from dissemination of the GEA findings. In terms of in-house research effort the focus will be tripartite: modeling of technological complexity, technology scaling and endogenous models of technology diffusion dynamics, and (depending on available funding) analyses and models of the impact of social and product heterogeneity on technology diffusion.

Personnel Resources

Scientific Staff

Arnulf Grubler (Austria), Program Leader (acting) (76% p-t)
Adriaan Dangerman (Netherlands)*
Shobhakar Dhakal (Nepal) (10% p-t)*
Jessica Jewell (USA)
Tieju Ma (China) (17% p-t)
Nebojsa Nakicenovic (Austria) (60% p-t)
Keywan Riahi (Austria)
Charles Wilson (United Kingdom) (35% p-t)

Scientific Support

Peter Kolp (Austria) (90% p-t)

Postdoctoral Scholar

Nuno Da Costa Bento (Portugal)

YSSP

Mokter Hossain (Bangladesh)

Administrative Support

Elizabeth Lewis (United Kingdom)
Patricia Wagner (USA)

p-t = part time; *Guest Research Scholar

Scientific Recognition

TNT researchers Grubler, Ma, Nakicenovic, and Riahi have been appointed to altogether 28 external advisory boards and steering committees and serve on the editorial boards of 10 scientific journals reflecting their wide peer-recognition.

Publications [1]

Journal Articles

*Granier C, Bessagnet B, Bond T, Klimont Z & Riahi K (et al.) (2011). Evolution of anthropogenic and biomass burning emissions of air pollutants at global and regional scales during the 1980-2010 period. *Climatic Change*, 109(1-2):163-190 (November 2011) (Published online 9 August 2011). [ENE, MAG]

*Lamarque J-F, Kyle GP, Meinshausen M, Riahi K, Smith SJ, van Vuuren DP, Conley AJ & Vitt F (2011). Global and regional evolution of short-lived radiatively-active gases and aerosols in the Representative Concentration Pathways. *Climatic Change*, 109(1-2):191-212 (November 2011) (Published online 5 August 2011). [ENE]

*McCollum DL, Krey V & Riahi K (2011). An integrated approach to energy sustainability. *Nature Climate Change*, 1(9):428-429 (December 2011) (Published online 13 November 2011). [ENE]

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

*Meinshausen M, Smith SJ, Calvin K, Daniel JS, Kainuma MLT, Lamarque J-F, Matsumoto K, Montzka SA, Raper SCB, Riahi K, Thomson A, Velders GJM & van Vuuren DPP (2011). The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. *Climatic Change*, 109(1-2):213-241 (November 2011) (Published online 9 August 2011). [ENE]

*Nakicenovic N & Nordhaus W (eds) (2011). The Economics of Technologies to Combat Global Warming. *Energy Economics*, 33(4):565-708 (July 2011) (Special Issue).

*Nakicenovic N & Nordhaus W (2011). Editors' introduction: The economics of technologies to combat global warming. *Energy Economics*, 33(4):565-571 (July 2011) (Published online 4 February 2011).

*Riahi K, Rao S, Krey V, Cho C, Chirkov V, Fischer G, Kindermann G, Nakicenovic N & Rafaj P (2011). RCP 8.5 - A scenario of comparatively high greenhouse gas emissions. *Climatic Change*, 109(1-2):33-57 (November 2011) (Published online 13 August 2011). [ENE, ESM, MAG]

*Rogelj J, Hare W, Lowe J, van Vuuren DP, Riahi K, Matthews B, Hanaoka T, Jiang K & Meinhausen M (2011). Emission pathways consistent with a 2°C global temperature limit (Letter). *Nature Climate Change*, 1:413-418 (November 2011) (Published online 23 October 2011). [ENE]

*van Vuuren DP, Edmonds J, Kainuma M, Riahi K, Thomson A, Hibbard K, Hurtt GC, Kram T, Krey V, Lamarque J-F, Masui T, Meinhausen M, Nakicenovic N, Smith SJ & Rose SK (2011). The representative concentration pathways: An overview. *Climatic Change*, 109(1-2):5-31 (November 2011) (Published online 5 August 2011). [ENE]

*van Vuuren DP, Edmonds JA, Kainuma M, Riahi K & Weyant J (2011). A special issue on the RCPs. *Climatic Change*, 109 (1-2):1-4 (November 2011) (Published online 5 August 2011). [ENE]

*van Vuuren DP, Edmonds JA, Kainuma M, Riahi K, Weyant J (Guest Editors) (2011). Special Issue: The Representative Concentration Pathways in Climatic Change. Climatic Change, 109(1-2) (November 2011) (Published online 5 August 2011). [ENE]

*van Vuuren DP & Riahi K (2011). The relationship between short-term emissions and long-term concentration targets: A letter. *Climatic Change*, 104(3-4):793-801 (February 2011) (Published online 15 December 2010). [ENE]

*Wilson C & Grubler A (2011). Lessons from the history of technological change for clean energy scenarios and policies. *Natural Resources Forum*, 35(3):165-184 (August 2011) (Published online 21 June 2011).

Book Chapters

*Keirstead SAJ, Dhakal S, Mitchell J, Colley M, Connell R, Gonzales R, Herve-Mignucci M, Parshall L, Schulz NB & Hyams M (2011). Climate change and urban energy systems. In: Rosenzweig C, Solecki WD, Hammer SA & Mehrotra S (eds), *Climate Change and Cities*. Cambridge University Press, Cambridge, UK.

*Riahi K, Rose S, Urge-Vorsatz D & van Vuuren DP et al. (Contributing Authors) (2011). How to bridge the gap - What the scenarios and studies say. In: *Bridging the Emissions Gap: A UNEP Synthesis Report*. United Nations Environment Programme, Nairobi, Kenya (November 2011). [ENE]

Books

*Arent D, Bogner J, Chen C, Riahi K & Wagner F et al. (Contributing Authors) (2011). *Bridging the Emissions Gap: A UNEP Synthesis Report*. UNEP, Nairobi, Kenya (November 2011). [ENE, MAG]

*Nakicenovic N & Schulz NB (Contributors) (2011). *World in Transition: A Social Contract for Sustainability*. WBGU Secretariat, Berlin, Germany.

Other Publications

IIASA (2011). Food & water. *Options* (IIASA, Laxenburg, Austria), Summer 2011. [DIR, ENE]

Nakicenovic N (2011). Achieving universal energy access: Energy perspectives to achieve sustainability and climate change. *bridges*, 31 (24 October 2011). [ENE]

Nakicenovic N (2011). Clicking into GEA-r. *Public Service Review: International Development*, 19:38-39 (30 September 2011). [ENE]

Nakicenovic N (Contributor) (2011). A social contract for sustainability. Factsheet No. 1/2011, WBGU (German Advisory Council on Global Change), Berlin, Germany (September 2011).

*Nakicenovic N & Schulz NB (Contributors) (2011). World in Transition: A Social Contract for Sustainability. Summary for Policymakers. WBGU Secretariat, Berlin, Germany.

Interim Reports

Wilson C & Grubler A (2011). A Comparative Analysis of Annual Market Investments in Energy Supply and End-use Technologies. IIASA Interim Report IR-11-032.

Wilson C & Grubler A (2011). Lessons from the history of technology and global change for the emerging clean technology cluster. IIASA Interim Report IR-11-001.

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"MONITOR Monitoring System on the Development of Global Air Transport"	European Commisson DG Research	01.06.2009	27.08.2011	73,379.00	1,158.00
"ALPS2 (together with ENE) Alternative Pathways toward Sustainable Development and climate Stabilization"	Research Institute of Innovative Technology for the Earth (RITE)	01.06.2011	31.01.2012	91,890.00	69,793.00
Contribution toward participation in WBGU Advisory Board meeting during the period 1.1.11 to 31.12.11	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung	01.01.2011	31.12.2011	31,078.00	31,078.00

World Population

Wolfgang Lutz, Program Leader
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Research Objectives

From its earliest days in the 1970s, IIASA's World Population Program (POP) has worked at the cutting edge of formal and mathematical demography, with many of today's most prominent approaches and techniques developed or extended here. In the last decade, the research has broadened to include important applications of these tools to societal challenges in Europe and the developing countries.

In 2011 a strong program focus on global change with respect to the quantitative aspects of human populations has emerged, including a new and quickly productive collaboration with IIASA's Energy Program. This focus on global change is evidenced both in a continuing succession of articles in leading scientific journals and in our provision of science-based policy advice at high levels to the European Commission, national governments, and UN agencies.

Through formal agreements and growing informal staff collaborations, the POP Program has in 2011 forged a strong strategic alliance with the Vienna Institute of Demography of the Austrian Academy of Sciences and the Vienna University of Economics and Business to form the Wittgenstein Centre for Demography and Global Human Capital. The Wittgenstein Centre emphasizes modeling of the dynamics of human capital formation, including reconstruction of historical data and projections to the coming decades for most of the world's countries. These new data and associated research have included analysis of the economic, social, health, and democratization returns to investments in education. This work also includes analysis of societies' future adaptive capacities to deal with climate change. POP's extensive global network of collaborating regional population centers and associated scientists and policymakers assures research relevance to regional conditions and provides platforms for active institution building.

Alignment with Strategic Plan

Population growth and other demographic changes are major drivers of the transformations taking place in our world. Thus, understanding their implications for human, societal, and environmental wellbeing are crucial considerations on the road to sustainable development.

Studies by POP have a bearing on all three new research areas of IIASA Strategic Plan 2011-2020; however, it is worth highlighting the following key aspects:

- The enhanced methodology developed and used by POP helps governments, researchers, and the private sector take into account the uncertainty inherent in population forecasting and also helps fill the gaps in existing knowledge. This, in turn, enables more informed planning on the part of governments as they address the challenges of the future.
- The multi-state population projections conducted at IIASA relate level of education, especially that of women, to improved mortality, health and economic outcomes, and migration patterns. Policymakers are thus made aware of the double benefit of improving education levels, namely, increased economic prosperity and greater human well-being.
- POP, having been among the first to project societal aging, is looking in greater detail at the implications of aging on every aspect of our lives and at the differences across societies with respect to the need to cope and ways of coping with an aging population.

Scientific Achievements in 2011

Population estimates for small populations can be more accurately understood

POP staff continue the rich tradition of extending the mathematical and statistical tools of formal demography. A published study of bias, standard errors, and distributions of characteristics of life tables for small populations was one of this year's contributions (Scherbov and Ediev, 2011, "Significance of life table estimates for small populations: Simulation-based study of standard errors," *Demographic Research*, 8:22) Theoretical considerations and simulations show that the statistical efficiency of different methods is, above all, affected by the population size. Yet it is also significantly affected by the life table construction method and by a population's age composition. Study results are presented in the form of ready-to-use tables and relations, which may be useful in assessing the significance of estimates of life expectancy across time and space for territories with a small population size, when standard errors of life expectancy estimates may be high.

"Eight Billion" and other demographic milestones have uncertain timing

Bringing our estimates and forecasts to bear on events widely reported in the news, we presented new probabilistic forecasts of the timing of the world's population reaching 8 billion, the world's peak population, and the date at which one-third or more of the world's population would be 60+ years old. (Scherbov, Lutz, and Sanderson, 2011, "The uncertain timing of reaching 8 billion, peak world population, and other demographic milestones," *Population and Development Review*, 37:3). The timing of these milestones, as well as the timing of the Day of 7 Billion, is uncertain. We compute that the 60 percent prediction interval for the Day of 8 Billion is between 2024 and 2033. Our figures show that there is around a 60 percent chance that one-third of the world's population would be 60+ years old in 2100. In the UN 2010 medium variant, that proportion never reaches one-third. As in our past forecasts (Lutz et al. 2001, 2008), we find the chance that the world's population will peak in this century to be around 84 percent and the timing of that peak to be highly uncertain. Focal days, like the Day of 7 Billion, play a role

in raising public awareness of population issues, but they give a false sense of the certainty of our knowledge. The uncertainty of the timing of demographic milestones is not a constant of nature. Understanding the true extent of our demographic uncertainty can help motivate governments and other agencies to make the investments necessary to reduce it. This article and many associated interviews and side-articles by its authors brought the matter to public and policy prominence in many widely noted newspapers, news magazines, and radio and TV outlets.

Multi-state demography integrates the relationships of education to population growth and other societal outcomes

As part of our European Research Council-funded FutureSoc Project to systematically assess the returns to education across different outcomes, we published ongoing analysis in the special Population Issue of *Science*. (Lutz and Samir KC, 2011, "Global human capital: Integrating education and population," *Science*, 333:6042) Almost universally, women with higher levels of education have fewer children. Better education is also associated with lower mortality, better health, and different migration patterns. Hence, the global population outlook depends greatly on further progress in education, particularly of young women. By 2050, the highest and lowest education scenarios—assuming identical education-specific fertility rates—result in world population sizes of 8.9 and 10.0 billion, respectively. Better education also matters for human development, including health, economic growth, and democracy. Existing methods of multi-state demography can quantitatively integrate education into standard demographic analysis, thus adding the "quality" dimension.

International comparisons of cognitive functioning during aging imply countries' differential development potentials

Comparing the burden of aging across countries hinges on the availability of valid and comparable indicators. The Old Age Dependency Ratio allows only a limited assessment of the challenges of aging because it does not include information on any individual characteristics except age itself. Existing alternative indicators based on health or economic activity suffer from measurement and comparability problems. We proposed an indicator based on age variation in cognitive functioning. (Skirbekk, Loichinger, and Weber, 2011, "Variation in cognitive functioning as a refined approach to comparing aging across countries" *PNAS* 10:1073). This highly innovative study used newly released data from standardized tests of seniors' cognitive abilities for countries in different world regions. In the wake of long-term advances in countries' industrial composition and technologies, the ability to handle new job procedures is now of high and growing importance. Over time, this increases the importance of cognition for work performance. In several countries with older populations, we found better cognitive performance on the part of populations aged 50+ than in countries with chronologically younger populations. This variation in cognitive functioning levels may be explained by the fact that seniors in some regions of the world experienced better conditions during childhood and

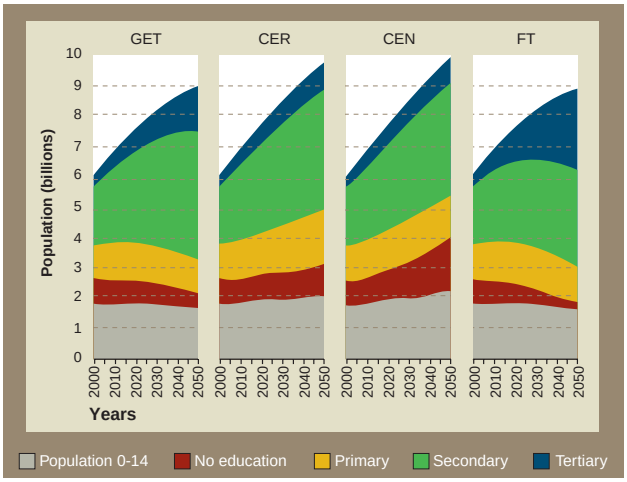

Figure 1. World population by level of educational attainment projected to 2050 on the basis of four different education scenarios: GET- Global Education Trend, CER- Constant Enrollment Rate, CEN = Constant Enrollment Number, FT = Fast Track.

adult life, including nutrition, duration and quality of schooling, lower exposure to disease, and physical and social activity patterns. Because of the slow process of cohort replacement, those countries whose seniors already have higher cognitive levels today are likely to continue to be at an advantage for several decades to come. This paper is one product of the ongoing Age and Cohort Change (ACC) project, which focuses on the following topics: human capital, skills, work performance, and beliefs and attitudes. Understanding age variation in productivity and how to improve senior workers' skills and capacities are paramount for aging countries. Aging and cohort change will also alter values and belief structures. A better understanding of these changes is necessary to improve the capacity to foresee and develop more targeted policies that relate to societal aging and other demographic change.

Progress with the new science-based IIASA-Oxford global population projections

This year saw a substantial advance in producing a new set of population projections by age, sex, level of educational attainment and labor force participation and health status, as part of the ERC Advanced Grant (€2.5 million) awarded to Wolfgang Lutz for a study on "Forecasting Societies' Adaptive Capacities to Climate Change" (FutureSoc, Grant Agreement Number 230195). The projections are being carried out by IIASA in collaboration with the James Martin School for 21st Century Studies at Oxford University. Unlike all previous population projections where the assumptions have been defined by small groups of experts, in this major new effort many alternative arguments about possible future trends in fertility, mortality, migration, and education were evaluated through a highly innovative Web survey instrument by more that 500 experts from around the world. The results were assessed by five small gatherings on three continents of global meta-experts in international migration, low- and high-fertility countries, and low- and high-mortality

countries. Work now proceeds on constructing socioeconomic-political scenarios from these expert assessments and applying our multi-state projections methodology to the production of consistent projections of fertility, mortality, migration, and education level for the world's countries.

Alongside this, we are producing a new set of country-level probabilistic population projections. Together, these two projection sets are already being recognized by important research and policy institutions such as UN agencies, as potentially the best available forecasts for policy planning purposes.

Introducing population considerations into the UN Rio+20 Conference on Sustainable Development

POP is engaged in two activities, along with associated consultations, to promote the integration of population considerations into deliberations and statements at this important conference. In late September with UNFPA financial support, we assembled a global panel of experts to consolidate the evidence linking population factors to green growth and sustainable development. A result was the Laxenburg Declaration on Population and Sustainable Development, subsequently introduced by UNFPA into widespread deliberative processes leading up to the Conference. The other activity is active collaboration, with IIASA funding support, between POP and ENERGY on the production of the population and education components of the new SSPs (Shared Socioeconomic Pathways) that will be used by the global Integrated Assessment Community over the coming years to address the socioeconomic challenges to mitigation and adaptation. POP has calculated five scenarios for populations by age, sex, and level of education for all countries to 2100. From the economic growth component scenarios have also been derived based on the estimated relationship between human capital and growth since 1970.

Establishment of a new centre on global demographic and human capital research

The Wittgenstein Centre for Demography and Global Human Capital formally opened in September 2011 at a symposium in the Austrian Parliament Building, presided over by the President of the Parliament and attended by Austrian and global scientists and policymakers. Funded by the Wittgenstein Prize to Wolfgang Lutz and formalized in a memorandum of understanding among the three foundation organizations including IIASA, this new Centre focuses more than 50 researchers on demographic analyses of human capital formation and its impact on society, the economy, and the environment. The Centre is advised by an International Scientific Advisory Committee of scientists and policy experts from around the world.

Policy Impact in 2011

Wolfgang Lutz gave the main speech on the "Day of Seven Billion," talking to delegations from all countries about "Demographic Challenges for Sustainable Development"at the United Nations Headquarters in New York, 31 October 2011. He also gave the main introductory lecture on "Demographic Change and Social Security" (45 minutes) at the Summit Meeting of the Austrian Social Partners on pension reform in Bad Ischl , on 10 October 2011. After this, the Austrian Federal Chancellor, Vice Chancellor, Minister of Social Affairs, Minister of Economic Affairs and president of Trade Unions each gave a 10 minute response to the points made by Wolfgang Lutz.

Figure 2. The architecture of the Wittgenstein Centre.

Sergei Scherbov was invited by UNFPA as an expert to the expert group meeting "7 Billion: Balance, Rights, and Equity" to review and discuss countries' population policy responses to advance the ICPD agenda in the EECA region, Erevan, Armenia, 19-21 October 2011. He also gave a training course on the main issues of population analysis for senior civil servants at the Presidential Academy, Minsk, Belarus, on 13 October 2011.

Vegard Skirbekk was a member of the Hewlett Foundation/ Norwegian Research Council scientific research funding committee (ECONPOP), which delegated resources to medium-scale research projections. It was the first venture of this kind (international NGO combining resources with Norwegian Research Council).

Activities for 2012

POP will continue the production of new and improved basic methodologies in formal demography, as well as their application to societal challenges. Production of the new population projections will be the most important product. Our work with the IIASA Energy Program and with the UNFPA to prepare for the Rio+20 international conference will also be a major focus. In addition collaboration with the Vienna Institute of Demography (Austrian Academy of Sciences) and the Vienna University of Economics and Business will be intensified under the umbrella of the new Wittgenstein Centre for Demography and Global Human Capital.

The Age and Cohort Change project will concentrate on projects involving international comparisons, meta-analytical work, measurement harmonization and statistical analysis, causality analysis, synthesis of results across studies, and manuscript preparation.

Personnel Resources

Scientific Staff

Wolfgang Lutz (Austria), Program Leader (80% p-t)
Vegard Skirbekk (Norway), Project Leader
Guy Abel (United Kingdom) (20% p-t)
Bilal Barakat (Germany) (40% p-t)
Stuart Basten (United Kingdom) (90% p-t)
Valeria Bordone (Italy)*
William Butz (USA)
Jesus Crespo Cuaresma (Spain) (20% p-t)
Inga Freund (Germany) (50% p-t)
Regina Fuchs (Austria) (20% p-t)
Alessandra Garbero (Italy) (80% p-t)
Anne Goujon (France) (20% p-t)
Rowena Gray (Ireland)
Clarissa Guimaraes Rodrigues (Brazil) (20% p-t)
Erling Häggström Lundevaller (Sweden) (25% p-t)*
Samir K.C. (Nepal)
Harold Lentzner (USA)
Elke Loichinger (Germany) (20% p-t)
Raya Muttarak (Thailand) (50% p-t)
Andrew Noymer (USA)
Elsie Pamuk (USA)
Ndola Prata (USA)*
Nikola Sander (Germany) (20% p-t)*
Warren Sanderson (USA)
Serguei Scherbov (Netherlands) (33% p-t)
Jan Sendzimir (USA)
Jose Siri (USA)
Marcin Stonawski (Poland)
Erich Striessnig (Austria) (20% p-t)
Muhammad Wazir (Pakistan)*
Daniela Weber (Austria)

YSSP

Anastasia Emelyanova (Russia)
Yang Li (China)
Ethan Sharygin (USA)

Administrative Support

Marilyn Brandl (Austria)
Ekaterina Smirnova (Netherlands)
Suchitra Subramanian (India)

p-t = part time; *Guest Research Scholar

Publications[1]

Journal Articles

*Carreon D & Noymer A (2011). Health-related quality of life in older adults: Testing the double jeopardy hypothesis. *Journal of Aging Studies*, 25(4):371-379 (December 2011) (Published online 9 March 2011).

*Crespo Cuaresma J (2011). How different is Africa? A comment on Masanjala and Papageorgiou. *Journal of Applied Econometrics*, 26(6):1041-1047 (September/October 2011) (Published online 26 April 2010).

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

*Crespo Cuaresma J, Foster N & Stehrer R (2011). Determinants of regional economic growth by quantile. *Regional Studies*, 45(6):809-826 (June 2011) (Published online 5 July 2010).
*Crespo Cuaresma J & Mishra T (2011). Human capital, age structure and growth fluctuations. *Applied Economics*, 43(28):4311-4329 (2011) (Published online 2 Feb 2011).
*Crespo Cuaresma J & Mishra T (2011). The role of age-structured education data for economic growth forecasts. *Forecasting*, 30(2):249-267 (March 2011) (Published online 16 December 2009).
*Crespo Cuaresma J, Oberhofer H & Raschky PA (2011). Oil and the duration of dictatorships. *Public Choice*, 148(3-4):505-530 (September 2011) (Published online 29 June 2010).
*Kaufmann E, Goujon A & Skirbekk V (2011). The end of secularization in Europe?: A socio-demographic perspective. *Sociology of Religion*, 72(2) (Summer 2011) (Published online 8 August 2011).
*Lutz W (2011). Demographic challenges affecting business schools. *Journal of Management Development*, 30(5):463-473 (May 2011).
*Lutz W (2011). Female education: A solution for a crowded planet. *Solutions*, 2(3) (April 2011).
*Lutz W & KC S (2011). Global human capital: Integrating education and population. *Science*, 333(6042):587-592 (29 July 2011).
*Miettinen A, Basten S & Rotkirch A (2011). Gender equality and fertility intentions revisited: Evidence from Finland. *Demographic Research*, 24(Art.20):469-496 (18 March 2011).
*Noymer A (2011). The 1918 influenza pandemic hastened the decline of tuberculosis in the United States: An age, period, cohort analysis. *Vaccine*, 29(Supplement 2):B38-B41 (22 July 2011) (Published online 12 July 2011).
*Noymer A (2011). Population decline in post-conquest America: The role of disease. *Population and Development Review*, 37(1):178-183 (March 2011) (Published online 9 March 2011).
*Noymer A, Penner AM & Saperstein A (2011). Cause of death affects racial classification on death certificates. *PLoS ONE*, 6(1):e15812 (January 2011).
*Pamuk ER, Fuchs R & Lutz W (2011). Comparing relative effects of education and economic resources on infant mortality in developing countries. *Population and Development Review*, 37(4):637-664 (December 2011) (Published online 13 December 2011).
*Scherbov S & Ediev D (2011). Significance of life table estimates for small populations: Simulation-based study of estimation errors. *Demographic Research*, 24(Art.22):527-550 (31 March 2011).
*Scherbov S, Lutz W & Sanderson WC (2011). The uncertain timing of reaching 8 billion, peak world population, and other demographic milestones. *Population and Development Review*, 37(3):571-578 (September 2011) (Published online 2 September 2011).
*Sobotka T & Lutz W (2011). Misleading policy messages derived from the period TFR: Should we stop using it? *Comparative Population Studies - Zeitschrift fuer Bevoelkerungswissenschaft*, 35(3):637-664 (15 September 2011).
*Sobotka T, Skirbekk V & Philipov D (2011). Economic recession and fertility in the developed world. *Population and Development Review*, 37(2):267-306 (June 2011) (Published online 22 June 2011).

Book Chapters

*Baehr R, Klingholz R & Lutz W (2011). Foreword - When growth limits development. In: Sippel L, Kiziak T, Woellert F & Klingholz R (eds), *Africa's Demographic Challenges: How a Young Population Can Make Development Possible*. Berlin Institute for Population and Development, Germany (September 2011).
*Goujon A & Wazir A (2011). Human capital and population development: Pakistan and the "cannon or butter" dilemma. In: Hummel LJ & Wolfel RL (eds), *Understanding Pakistan through Human and Environmental Systems*. United States Military Academy, West Point, NY, USA.
*Luy M, Wegner C & Lutz W (2011). Adult mortality in Europe. In: Rogers RG & Crimmins EM (eds), *International Handbook of Adult Mortality*. Springer-Verlag, Dordrecht, Netherlands (February 2011).

Other Publications

IIASA (2011). Education: Key to climate change adaptation? *Options* (IIASA, Laxenburg, Austria), Winter 2011/2012.
IIASA (2011). Education spells hope for world wellbeing. *Options* (IIASA, Laxenburg, Austria), Winter 2011/2012.
IIASA (2011). Gender attitudes linked to larger families. *Options* (IIASA, Laxenburg, Austria), Winter 2011/2012.
IIASA (2011). Stereotyping underlies statistics. *Options* (IIASA, Laxenburg, Austria), Summer 2011.
IIASA (2011). Pakistan faces choice: Education or unrest. *Options* (IIASA, Laxenburg, Austria), Winter 2011/2012.
IIASA (2011). Recession hits U.S. fertility. *Options* (IIASA, Laxenburg, Austria), Winter 2011/2012.
Lutz W (2011). Global demography: Population inflation. The World Today; 67(5):24-26 (May 2011).
Lutz W (2011). The new Wittgenstein Centre for Demography and Global Human Capital: A hub for demographic analyses in Vienna. *Bridges*; 29 (April 2011).

Skirbekk V, Stonawski M & Goujon A (Contributing Authors) (2011). Global Christianity: A report on the size and distribution of the world's Christian population. The Pew Forum on Religion & Public Life, Pew Research Center, Washington, DC, USA (December 2011).

Interim Reports

Goujon A, Lutz W & Wazir A (2011). Alternative Population and Education Trajectories for Pakistan. IIASA Interim Report IR-11-029.

Sanderson WC, Skirbekk V & Stonawski M (2011). Young Adult Failure to Thrive Syndrome. IIASA Interim Report IR-11-003.

Scherbov S, Lutz W & Sanderson WC (2011). The Uncertain Timing of Reaching 7 Billion and Peak Population. IIASA Interim Report IR-11-002.

Striessnig E & Lutz W (2011). Optimal Fertility. IIASA Interim Report IR-11-031.

Wamsler C (2011). Climate Change, Adaptation and Formal Education: The Role of Schooling for Increasing Societies' Adaptive Capacities. IIASA Interim Report IR-11-024.

Scientific Recognition

Through scientific articles in leading journals, interviews in prominent news and opinion outlets, and active participation in journal reviewing, professional meeting attendance, and other professional activities, POP staff have in 2011 extended the tools of formal demography, demonstrated their applicability to societal challenges in Europe and globally, and laid the groundwork for producing in 2012 a new set of evidence-based population projections that will be the best available for scientific and policy uses.

Selected Invited Lectures

POP staff were invited to give lectures and papers at many international and local scientific meetings throughout the year. Here is a selection of the most noteworthy.

William Butz

- Invited lecture "The Intellectual Discovery of Human Capital" at the Vienna Institute of Demography (VID), Vienna, June 30, 2011
- Invited lecture "How to Write a Loosing Proposal" at the VID, Vienna, September 14, 2011 and Max Planck Institute of Demographic Research, Rostock, October 17, 2011
- Keynote speech "Demography and Policy" at the Demo-Doc summer workshop at the Max Planck Institute of Demographic Research, Rostock, October 17, 2011
- Invited lecture "Population and Sustainable Development" at the dinner event organized by United Nations Population Fund (UNFPA) in preparation for RIO+20, New York, December 14, 2011

Wolfgang Lutz

- Invited lecture "Population and Human Capital as Factors in Poverty Reduction" at South African National Research Foundation, Capetown, January 27, 2011
- Invited lecture "The Future of World Population and Human Capital" at the Oxford Martin School for 21st Century Studies, February 17, 2011
- Invited lecture "Asian Human Capital Accumulation: Challenges for Sustainable Development in Aging Societies" at Chulalongkorn University, Bangkok, March 15, 2011
- Invited lecture "Managing the Future Through Global Education: New Scientific Insights" at the Symposium on Ageing Societies - Mature People, the Festive Plenary Assembly of the Austrian Academy of Sciences, Vienna, May 11, 2011
- Invited lecture "Global Population Challenges in the Context of Climate Change and Sustainable Development" at the Royal Society, London, June 3, 2011
- Opening keynote "Die Zukunft des Alterns in Oesterreich und der Welt" [The future of ageing in Austria and the world] at the Bundesministerium fuer Verkehr, Innovation und Technologie (bmvit) [Ministry for Traffic, Innovation and Technology], Sektion III/Abteilung 12, Vienna, June 20, 2011
- Invited lecture "Options for Representing Demographic and Economic Assumptions to Span the Range of Future Developments over the 21st Century" at a side workshop of the WGIII IPCC AR5 meeting of the Intergovernmental Panel on Climate Change (IPCC), Changwon City, Korea, July 17, 2011
- Invited lecture "The Linkages Between Population Dynamics and Sustainable Development" at the Joint Executive Board of UNFPA, UNDP and UNOPS, New York, September 7, 2011

- Invited lecture "Oesterreich 2050-was sagt die Demographie dazu?" [Austria 2050-what does demography say?] at the Oesterreichischer Wissenschaftstag 2011, Semmering, Austria, October 27, 2011

Sergei Scherbov

- Keynote "Aging in Europe: A New Look Into an Old Problem" at the symposium Impact of Demographic Change in Thailand organized by National Economic and Social Development Board (NESDB) of the Royal Thai government and the United Nations Population Fund (UNFPA), Bangkok, April 25, 2011
- Invited lecture "Rethinking Age and Ageing" at the Symposium on Ageing Societies - Mature People, the Festive Plenary Assembly of the Austrian Academy of Sciences, Vienna, May 11, 2011
- Invited lecture "Population Dynamics, Labor Force and Pension Age" at the CIS Inter-Parliamentarian Assembly, St. Petersburg, June 23, 2011
- Invited lecture "Rethinking Aging" at the British Society of Population Studies (BSPS) Conference 2011, York, September 7, 2011
- Invited lecture „Projecting Future Aging: A New Approach" at International Seminar on Population Estimates & Projections organized by Latin American Population Association (ALAP), Rio de Janeiro, November 9, 2011

Vegard Skirbekk

- Invited lecture "Productivity Potential by Age and Cohort: Examples from Different World Regions" at the Annual Meeting of Population Association of America (PAA), Washington DC, March 31, 2011
- Invited lecture "An Investigation into Gender Differences in Productivity Potential for those aged 50 and above" at the at the Conference on Personalized Aging organized by Jacobs Center on Lifelong Learning and Institutional Development, Bremen, 26 May, 2011
- Invited lecture "Cognitive Function in Normal- Weight, Overweight, and Obese Elderly: A Cross-Country Analysis" at the British Society of Population Studies (BSPS) Conference 2011, York, September 7, 2011
- Invited lecture "Cognitive and Non-cognitive Skills over the Life Cycle" at Human Capital and Aging Conference organized by ROA / Netspar, University of Maastricht, Mastricht, October 14, 2011
- Invited lecture "Employability and Productivity Over the Life Course" organized by German Federal Ministry for Family Affairs, Senior Citizens, Women and Youth, Berlin , 12 December, 2011

Anne Goujon gave a lecture "Towards a Catholic North America? Projections of Religious Denominations in Canada and the US up to 2060" at the Vienna Institute of Demography (VID), Vienna, Austria, April 21, 2011 and a presentation by video conference "Multistate Population Projections by Levels of Education: the Case of Pakistan" at training course on long-term demand forecasting and projection techniques at Pakistan institute of Engineering and applied sciences (PIEAS), Islamabad, November 22, 2011.

Erich Striessnig gave a presentation "Optimal Fertility" at the Economic and Social Research Council (ESRC) seminar, University of Portsmouth, Portsmouth, July 21, 2011.

Advisory Boards and Editorships

William Butz

- Population Association of America (PAA) representative on section K (Statistics) of National Committee of the American Association for the Advancement of Science (AAAS).
- Member of Board of Reviewing Editors of *Science* Magazine, with principal responsibility for submissions in the social sciences and to the Policy Forum and Education Forum, plus consulatation on special issues.
- This year Principal External Editor for special issue on "Population".

Wolfgang Lutz

- Member of the Committee on Population, US National Academy of Sciences.
- Member, Board of Directors (Vorstand), Berlin Institute for Population and Development, Germany.
- Editor, *Vienna Yearbook of Population Research*.
- Editorial Board, *Population and Development Review*.
- Editorial Committee Member, *Asian Population Studies*, Routledge.
- Editorial Board Member, *Demographic Research*, an on-line journal of the Max Planck Institute for Demographic Research.
- Editorial Board Member, *European Population Studies*, the official journal of the European Association for Population Studies (EAPS).
- Editorial Board Member, *Journal of Population Ageing*, Oxford
- Editorial Board Member, *Canadian Studies in Population*, Population Research Laboratory, University of Alberta.

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"FutureSoc Forecasting Societies Adaptive Capacities to Climate Change"	European Commission, Research Executive Agency (REA)	01.03.2009	28.02.2014	2,438,404.00	567,581.00
"ACC The demography of skills and beliefs in Europe with a focus on cohort change"	European Commission, European Research Council Executive Agency	01.10.2009	30.09.2014	981,417.00	150,249.00
Collect demographic data and estimate the religious structure of population in select countries	Pew Research Center	01.05.2010	30.04.2012	275,627.00	101,262.00
"EM-UNFPA Knowledge base on emerging population issues at global level strengthened: Support to IIASA"	United Nations Population Fund (UNFPA)	01.08.2011	31.12.2011	88,601.00	88,601.00

Other Research

Extreme Events in Human Systems

Leena Ilmola-Sheppard, Coordinator
ilmola@iiasa.ac.at

Objectives

Researchers from IIASA's Extreme Events Program in Human Systems are investigating the implications of seven different shocks on Finnish society with the aim of creating a portfolio of actions that could increase national resilience in responding to the shocks. The outcomes will be used to better prepare countries to be more resilient in the face of shocks or disturbances that strike a system from the outside, the effects and consequences of which could be either negative or positive.

Alignment with the IIASA strategy

The 7 Shocks and Finland project has had a very strong applied focus. A concrete tool (the Resilience Portfolio method) has been produced as a result of it, and it has introduced resilience criteria into the decision making of the Finnish Government.

The project was financed partly by Finnish government agencies and partly by the Finnish private sector.

The project partners were the Academy of Finland, Association of Finnish Local and Regional Authorities, Federation of Finnish Commerce, Federation of Finnish Financial Services, Federation of Technology Industries, FIMECC Oy – Finnish Metals and Engineering Competence Cluster, FortumOyj, Ministry of Defense, Ministry of Education, Ministry of Employment and the Economy, Ministry of Finance, Ministry of the Interior, National Emergency Management Supply Agency, Prime Minister's Office, Research and Innovation Council of Finland, Sitra – Finnish Innovation Fund, Tekes – The Finnish Funding Agency for Technology and Innovation, TeollisuudenVoima, TietoOyj, Yle – National Broadcasting Company.

The Program had two projects running in 2011:

- 7 Shocks and Finland
- SMI project

7 Shocks and Finland

Objectives

The 7 Shocks and Finland project sought to raise understanding of long-term national resilience requirements against a background of increasing uncertainties in the global physical and social environments. The project studied the impact of seven hypothetical shocks:

1. EMU collapse.
2. Internet crashes becoming common and unpredictable.
3. Nokia headquarters moving from Finland.
4. "Once-in-a-100-years" droughts and flash floods devastating Europe.
5. China collapsing due to internal disruption.
6. Finnish pulp and paper industry leaving the country
7. Price of energy dropping by 90%.

Partners asked for results to be produced quickly. The project started in June 2011 and was completed by mid-December 2011.

Scientific Achievements in 2011

The project was able to validate the Resilience Portfolio method, originally developed in the Game Changers project, and to include a third dimension to the resilience concept defined in the strategic management literature.

Two scientific papers are in work.

Activities for 2012 (outline of areas to be covered in 2012)

The methods will be developed further in the similar project with South Korea (Korean Institute of Science and Technology Policy (STEPI). The results of these two projects will be compared. The work will be part of the Advanced Systems Analysis Program.

SMI-pilot project

The Xevents initiative also focused on development of the social dynamics follow-up and anticipation system. The pilot developed a measurement concept that integrates both quantitative and qualitative methods. The details of the project, funded by the Ministry of Defence of Finland, is confidential.

Based on the pilot results, the Ministry of Defence and Ministry of Interior of Finland have made a decision to implement the methods developed in the pilot project. The Implementation project will be completed by the end of October 2012 within the Advanced Systems Analysis Program.

The report, among other things, looks at what would happen if Finland lost its pulp and paper industry

Personnel Resources

Scientific Staff

Thomas Brudermann (Austria) (75% p-t)
John Casti (USA) (75% p-t)
David Horlacher (USA)
Leena Ilmola-Sheppard (Finland) (75% p-t)
Matthias Jonas (Germany)
Peter Klimek (Austria) (50% p-t)
Victor Kremenyuk (Russia) (25% p-t)*
Chin-Min Lee (Korea, Republic of) (40% p-t)
Olli Lehtonen (Finland)*
Manfred Lex (Austria) (50% p-t)
Juuso Liesiö (Finland)*
Forrest MacKellar (USA) (50% p-t)
Cesare Marchetti (Italy) (25% p-t)*
Isolde Prommer (Austria)*
Niels Schulz (Germany)
Jose Siri (USA)
Martin Spielauer (Austria)*

Scientific Support

Julia Heilig (Austria)*

YSSP

Qianlai Luo (China)
Prestige Makanga (Zimbabwe)

Administrative Support

Suchitra Subramanian (India)
Deirdre Zeller (Ireland)

p-t = part time; *Guest Research Scholar

Publications[1]

Journal Articles

*Boon J-P, Casti J & Taylor RP (2011). Artistic forms and complexity. *Nonlinear Dynamics, Psychology, and Life Sciences*, 15(2):265-283 (April 2011).

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

Scientific Recognition

Policy Impact in 2011 includes lists of policy briefings given (written or at meetings), membership of policy-relevant committees)

The main objective of the 7 Shocks and Finland project was to establish a decision-making community that would introduce resilience as one of the criteria of decision making. The project established a group of 20 organizations (approx.40 decision makers) which have now taken up the challenge.

The Finnish Government has decided that the theme will be covered in the next Government's Futures Review, which will be used as a basis for the next Government Program and the strategic ministerial planning. The results of the project will also be used in two major documents currently being written, namely, the Governmental Resolution on Emergency Management and the Governmental Resolution on Internal Security.

Finland meetings

- Two project workshops, a ½-day meeting in September, and a 2-day analytical workshop in IIASA in November. We had 25 decision makers at each of the workshops.
- 17 partner specific meetings in Helsinki.
- A presentation to the Finnish Parliament's Futures Committee, 14 February 2012.

Public presentations:

- Tulevaisuusseminaari Miten metsä näkyy suurten haasteiden ratkaisuissa? 25.5.2011 Helsinki (120 participants).
- World Wildlife Foundation 50-year theme seminar: Pulp and Paper Industry Seminar, 5 May 2011 Helsinki (200 participants).
- Summer Conference of the Finnish Futures Society, 18-19 August 2011, Otava (30 participants)
- Uncertainty and Foresight Seminar by Finnish Futures Society, 20 September, Helsinki (70 participants).
- 7 Shocks breakfast seminar, arranged by the partners of the project, 1 February 2011 (170 participants).
- 7 Shocks and Finland Seminar, arranged by the Academy of Finland and the Finnish IIASA Committee, 28 February 2011 (180 participants).

European Union Meetings

- COST Strategic Workshop "Foresight on Future Demand for Forest-based Products and Services: Scenario Building" 22-23February 2011 in Barcelona, Spain
- EFP –Foresight in Public Research Organisations, 7-8 June 2011 Vienna, Austria
- COST Final Conference, "Foresight on Future Demand for Forest-based Products and Services" 13 September 2011 in Sekocin Stary, Poland
- NRC FLIS annual meeting, 16-17February 2012 in Ljubljana, Slovenia

Other meetings

- 7 Shocks Seminar (full day) arranged by Korean Science and Technology Institute, 6 February 2012, Seoul, South Korea (40 participants).
- 7 Shocks Seminar arranged by Korean Institute for Policy and Administration, 7 February 2012, Seoul, South Korea (20 participants).

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"KoreanTrustFund (funds to be used for research collaboration, travel, etc.)"	Korea Science and Engineering Foundation (KOSEF)	01.07.2008	31.12.2012	96,278.00	10,000.00
"TEKES Game Changers and Finland: Sub-consultancy Agreement between ETLA and IIASA (in respect of the Game Changers and Finland project between ETLA and Tekes)"	Elinkeinoelämän Tutkimuslaitos (ETLA)	01.06.2010	31.03.2011	71,482.00	21,444.00
"Xevents_Scots Research Project Agreement for Game Changers and Scotland"	Scottish Government	01.11.2010	31.03.2011	60,000.00	36,000.00
"Xevents_Sanoma IIASA Xevents Project to participate in the Finnish Xevents Research Consortium"	Sanoma Corporation	01.12.2010	31.03.2011	15,000.00	11,250.00
"7 Shocks The Seven Shocks and Finland"	Numerous	22.06.2011	31.12.2011	95,000.00	95,000.00
Contribution toward participation in WBGU Advisory Board meeting during the period 1.1.11 to 31.12.11	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung	01.01.2011	31.12.2011	20,275.00	20,275.00
"SMI Suomi Mood Indicator"	Ministry of Defense of Finland	30.06.2011	31.12.2011	22,000.00	23,468.00

Other Publications

Publications[1]

Directorate (DIR)

Journal Articles

*Bakir NO & von Winterfeldt D (2011). Is better nuclear weapon detection capability justified? *Journal of Homeland Security and Emergency Management*, 8(1):1-18 (29 March 2011).

*Keeney RL & von Winterfeldt D (2011). A value model for evaluating homeland security decisions. *Risk Analysis*, 31(9):1470-1487 (September 2011) (Published online 9 March 2011).

*Prager F, Beeler Asay GR, Lee B & von Winterfeldt D (2011). Exploring reductions in London Underground passenger journeys following the July 2005 bombings. *Risk Analysis*, 31(5):773-786 (May 2011) (Published online 13 January 2011).

Other Publications

IIASA (2011). Food & water. *Options* (IIASA, Laxenburg, Austria), Summer 2011. [ENE, TNT]

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

Capacity Building

Young Scientists Summer Program

Tanja Huber, Coordinator
huber@iiasa.ac.at

In 2011 the Young Scientists Summer Program welcomed 56 advanced graduate students from 28 countries to work on their research projects within IIASA's programs, and to be part of one of the Institute's most acclaimed programs.

Since the beginning of the YSSP in 1977, some 1,620 participants have benefited from the opportunity of collaborating with IIASA scholars and enhancing their own perspectives and career opportunities. Many have achieved high positions in science, business, and government, while others have returned to IIASA as research scholars or continued to work as close collaborators in the Institute's research network.

For the first time this year the Program welcomed two **Annual Fund** recipients: Prestige Makanga from Zimbabwe, and Shariar Rahman from Bangladesh. Anastiasia Emelyanova from Russia was supported through the **Petr Aven scholarship**.

The 2011 scientific program was designed to highlight ongoing research at IIASA. A list of nine seminars presented by IIASA staff was offered. The seminars were held every Wednesday morning and were followed by group discussions with YSSPers and IIASA staff.

- **Dynamics at the Interface of Ecology and Evolution**: from Individuals to Ecosystems: EEP Program Leader Ulf Dieckmann gave an overview on adaptive evolution as "ecology in action."
- **Transitions to new Technologies**: TNT Acting Program leader Arnulf Grübler introduced a few key concepts along with ongoing empirical and modeling research examples to explain the dynamics and speed of technological change.
- **Global Energy Perspectives**: IIASA Deputy Director Nebojsa Nakicenovic presented energy perspectives (based on the work at IIASA and Global Energy Assessment) that addressed the paradigm-changing, multiple energy challenges toward more sustainable futures.

- **Policy Scenarios for Improving Household Access to Electricity and Clean Cooking in Developing Countries**: ENE research scholar Shonali Pachauri presented results of an analysis to model how household energy transition can be accelerated through the use of alternative policy levers.
- **World Population, Female Education, and Sustainable Development**: POP Program Leader Wolfgang Lutz talked about how a better educated and hence smaller global population would be a key to reducing poverty, improving health, and raising adaptive capacity to unavoidable climate change.
- **Optimal Forest Management: An Approach to Tying together Economic Benefits and Ecological Costs**: ASA Research Scholar Elena Rovenskaya looked at a study based on a size-structured version of the Gurtin-MacCamy model for a managed forest with biological reproduction.
- **Application of Integrated Assessment Models in the Policy Process**: MAG Research Scholars Klimont Zbigniew and Fabian Wagner discussed examples of applying IIASA's GAINS model in regional environmental policy.
- **Applying Systems Analysis for Climate Governance**: RPV Research Scholar Tony Patt identified the key attributes of a successful policy strategy and how these could appear in future climate governance.
- **Food, Feed, and Fuel: Prospects for China Based on Simulations of the Chinagro Model through 2030**: ESM Research Scholar Laixian Sun (on behalf of the CATSEI Team) assessed prospects and challenges for the Chinese agriculture until 2030 under different scenarios.

External speaker invited to IIASA:

Pablo Suarez, Associate Director of Programs, Red Cross/Red Crescent Climate Center organized an interactive workshop on "A Game of Farmers, Food, and Financial Aid: Experience the Interplay of Droughts, Dialog, and Development."

Other extracurricular activities on offer:

- Coping with Uncertainty: Concept of Robust Solutions
- Workshop on Introduction to GIS (Geographic Information Systems)
- Media and Presentation Skills Coaching
- Concept of Robust Solutions: Practical Applications for Policy Decision Support
- Climate Change and Negotiation Simulation
- Economic Growth Seminar – Optimization of Investments in Capital and Labor Efficiency
- Dream Valley (DV) Project
- German Course
- Various social events (national festivities at IIASA, trips to Salzburg and Vienna) helped creating a social network and building friendships.

Supervision and research

Throughout the summer, YSSPers were in constant exchange with their IIASA supervisors and encouraged to give regular presentations on ongoing research, eventually coming to a close at the mandatory "Late Summer" workshop. After returning to their home countries, they submitted a paper summarizing the results of research done during the summer. Thirteen of these papers were nominated by supervisors for an IIASA scholarship award, of which three were selected.

YSSP Peccei and Mikhalevich awards

Honglin Zhong, of the Department of Geography at East China Normal University, and **Anna Timonina**, of the Department of Statistics and Decisions Support Systems at the University of Vienna, won IIASA's scholarship awards for their work during the 2011 Program. An exceptional third award was given to **Joeri Rogelj** of the Institute for Atmospheric and Climate Sciences in Zurich, Switzerland. Honglin's paper "Spatial Upscaling of Site-specific Crop Dynamic Models: Method and Application to Wheat Production in China" and Joeri's work on "Global Emissions in 2020 consistent with a 2°C Temperature Limit" won the Peccei Award, while Anna's study on "Optimal Strategies for Risk Management of CAT-Events" earned her the Mikhalevich Award. The awards provide financial support enabling the successful YSSPers to return to IIASA for three additional months of research.

YSSPers 2011

Borgar Aamaas (Norway)
Mariya Absar (Pakistan)
Javaria Ashraf (Pakistan)
Inbal Becker Reshef (USA)
Mario Cammarano (Italy)
Jing Dai (China)
Danielle Davidian (USA)
Taufeeq Dhansay (South Africa)
Marcela Doubkova (Czech Republic, Austria)
Anastasia Emelyanova (Russia)
Gustavo Burin Ferreira (Brazil)
Oleksiy Frayer (Russia)
Victoria Gass (Austria)
Hans Christian Gils (Germany)
Mokter Hossain (Bangladesh)
LeeAnn King (USA)
Matthew Labrum (USA)
Matthew Lampert (USA)
Mun Su Lee (South Korea)
Yang Li (China)
Huayi Lin (China)
Fei Liu (China)
Qianlai Luo (China)
Brijesh Mainali (Nepal)
Prestige Makanga (South Africa)
Pallavi Marrapu (India)
Julian Matzenberger (Austria)
Ahmed Harb Rabia (Egypt)
Misuhiro Nakamura (Japan)
Kapil Narula (India)
Tuyen van Nguyen (Vietnam)
Anna Olsson (Sweden)
Architesh Panda (India)
Xilei Pang (China)
Alena Puchkova (Russia)
Weronika Radziszewska (Poland)
Shahriar Rahman (Bangladesh)
Thiagu Ranganathan (India)
Anna Repo (Finland)
Joeri Rogelj (Belgium)
Lucia Seebach (Germany)
Ehan Sharygin (USA)
Tatyana Shutkina (Russia)
Ellen Slegers (The Netherlands)
Anna Timonina (Russia)
Natallia Tratsiakova (Belarus, Austria)
Renats Trubins (Latvia, Sweden)
Abonesh Tulu (Ethiopia)
Rafal Ulanczyk (Poland)
Maryana Vakolyuk (Ukraine)
Ziquiang Wu (China)
Fang Yan (China, USA)
Aika Yano (Japan, USA)
Chuanfu Zang (China)
Honglin Zhong (China)

External Research Contracts above €10,000

Title	Funder	Date from	Date to	Total (€)	2011 (€)
"Petr Aven Fellowship Funding for YSSPers (1 per year for 10 years)"	Alfa-Bank	01.04.2011	31.03.2021	50,000.00	5,000.00

Postdoctoral Program

Tanja Huber, Coordinator
huber@iiasa.ac.at

Every year a number of postdoctoral scholarships are available from different funding sources on topics for research related to IIASA's scientific agenda. These sources are: the IIASA Postdoctoral Program and the Kempe Foundation, Sweden.

The two IIASA-funded postdoctoral positions for 2011 were given to Narasimha D. Rao and Christina Kaiser.

Narasimha D Rao holds a PhD in Environment and Resources (2011) from Stanford University, USA. He is hosted by the Energy (ENE) program where he is researching the relationship between electricity access, livelihoods, and carbon dioxide emissions in India. His methods include economic simulation models of the electricity sector and social welfare, input-output analysis, and carbon accounting.

Christina Kaiser joined the Ecology and Evolution (EEP) Program in December 2011. She is working on a joint project of the EEP and the Ecosystem Services and Management (ESM) Program focusing on a soil carbon and nitrogen cycling model based on competitive and synergistic interactions between soil microbes belonging to different microbial functional groups in a spatially structured system.

Xiaojie Chen (EEP) and Nuno Bento (TNT), who received the IIASA-funded postdoctoral positions in 2010 continued their postdoctoral research in 2011.

Xiaojie Chen joined the Evolution and Ecology (EEP) Program in February 2011. His research focuses on evolutionary dynamics in biological and social systems, especially the emergence and stability of cooperation in social networks, using evolutionary game theory and adaptive dynamics. He received his PhD in 2011 in Dynamics and Control of Complex Systems from Peking University, China.

Nuno Bento is a Postdoctoral Research Scholar with the Transitions to New Technologies (TNT) program. His main areas of interest include sustainable development, energy economics, innovation and technological change, and transportation and hydrogen economics. He is currently investigating historical growth patterns in transport and new ones indicating greater structural change in response to rising urbanization and environmental issues.

Tobias Eriksson (ESM) and **Eva-Maria Nordström** (ESM) who are funded by the Kempe foundation in Sweden started their Postdoc fellowship at IIASA in October and November 2011. They continue to further develop their research at IIASA on scenario analysis for the forest sector (Nordström) and on the development of carbon balance models for boreal peatlands (Eriksson).

Postdocs at IIASA 2011

Nuno Bento (Portugal)
Xiaojie Chen (China)
Tobias Eriksson (Sweden)
Hiroshi Ito (Japan)
Christina Kaiser (Austria)
Eva-Maria Nordström (Sweden)
Narasimha Rao (India)
Tatsuya Sasaki (Japan)
Anna Scolobig (Italy)
Upasna Sharma (India)
Jose Siri (USA)

Publications[1]

Journal Articles

*Franklin O, Hall EK, Kaiser C, Battin TJ & Richter A (2011). Optimization of biomass composition explains microbial growth-stoichiometry relationships. *The American Naturalist*, 177(2):E29-E42 (Published online 12 January 2011).

*Kuhlicke C, Scolobig A, Tapsell S, Steinfuehrer A & De Marchi B (2011). Contextualizing social vulnerability: Findings from case studies across Europe. *Natural Hazards*, 58(2):789-810 (August 2011) (Published online 2 March 2011).

*Liu Y, Chen X, Wang L, Li B, Zhang W & Wang H (2011). Aspiration-based learning promotes cooperation in spatial Prisoner's Dilemma games. *EPL (Europhysics Letters)*, 92(6):(No.60002) (June 2011) (Published online 8 June 2011).

*Sasaki T & Unemi T (2011). Replicator dynamics in public goods games with reward funds. *Journal of Theoretical Biology*, 287:109-114 (21 October 2011) (Published online 3 August 2011).

Other Publications

Bianchizza C, Scolobig A, Pellizzoni L & Del Bianco D (2011). 2nd CapHaz-Net Regional Hazard Workshop: Social capacity building for Alpine hazards. CapHaz-Net WP8 Report, Institute of International Sociology, Gorizia, Italy (August, 2011).

1 *Peer Reviewed
Dark brown entries: in collaboration with other IIASA Programs, identified in brackets.

Pelling M, Bye L, Zehra Zaidi R, Scolobig A, Sharma U, Mafttei R, Tudor E, Mihai V, Porumbescu C & Angignard M (2011). The cultures of landslide risk management in Europe and India. Deliverable 5.5, SafeLand Project - Living with landslide risk in Europe, WP 5.1 (December 2011).

Scolobig A, Bayer J, Cascini L & Ferlisi S (2011). Design and testing: a risk communication strategy and a deliberative process for choosing a set of mitigation and prevention measures. Deliverable 5.7, SafeLand Project - Living with landslide risk in Europe (WP 5.1.).

Appendices

Models and Projects by Research Area

Energy and Climate Change Research Area

Energy & Climate Change research confronts two seemingly contradictory problems:

- The lack of access to energy prevents billions of people from participating meaningfully in modern society.
- The increasing use of fossil fuels by industrialized societies threatens to irreversibly alter the Earth's climate.

To address these problems, research is focused on five themes:

- Transformation of the global energy system to achieve a low-carbon world;
- Reframing the greenhouse gas debate;
- Investing in energy R&D;
- Consumer choice and technological efficiency in energy consumption; and
- Adaptation to climate change.

Programs

Although Energy and Climate Change-related research takes place throughout IIASA, work mainly centers in three programs:

1. Energy Program;
2. Mitigation of Air Pollution & Greenhouse Gases Program; and
3. Transitions to New Technologies Program.

Models, Tools, & Data

The major models, research tools, and databases produced by IIASA within the Energy and Climate Change area and further developed in 2011 include:

Energy Multi-Criteria Analysis Tool

An interactive Web-based scenario analysis tool which allows the concurrent assessment of multiple energy objectives.

GAINS

A model to analyze the simultaneous management of air pollution and greenhouse gases.

MESSAGE

A model to analyze energy systems and to evaluate climate, air pollution, energy access, and energy security policies (see p. 40).

MESSAGE Access Model

A model to assess future transitions in household energy use and the costs of alternative policies, and thereby accelerate universal transition to modern energy sources and technologies.

Representative Concentration Pathways Database

A database with scenarios from the integrated assessment community to expedite climate change assessments.

Projects

A wide range of research projects from across IIASA contributed to the Energy and Climate Change research area in 2011 and these include:

ALPS

The Alternative Pathways toward Sustainable Development and Climate Stabilization project develops alternative scenarios with realistic assumptions that nations, as actors in the global community, have multiple objectives with different priorities.

Assessment of Climate Change Mitigation Pathways (AMPERE)

AMPERE researchers are using state-of-the art models to develop long-term strategies and scenarios to find economically feasible ways to lessen the global impact of climate change.

Austrian Panel on Climate Change (APCC)

An in-depth assessment of the effects of climate change on Austria is underway and should support mitigation and adaptation strategies for the future.

Extreme Weather Impacts on Carbon Sinks (CARBO-Extreme)

European ecosystems help stabilize the atmosphere by soaking up significant amounts of the carbon in fossil fuel emissions, but researchers are concerned that the effectiveness of these carbon sinks might be diminished by expected increases in extreme weather.

CIAM-2010; CIAM-2011

These are ongoing assessment modeling projects for the Centre for Integrated Assessment Modeling. Scenarios are analyzed for cost-effective reductions of acidification, eutrophication, tropospheric ozone, and related phenomena, especially fine particulate matter pollution.

Cityzen

The effects of megacities and emission hot spots on their local, regional, and global environment, with respect to both air pollution and climate change.

ClimateCost

Advancing knowledge on long-term targets and mitigation policies, the costs of inaction, and the costs and benefits of mitigation of climate change.

Decarbonizing Energy through Pricing Policies (Climate Governance)

Examining the potential of energy pricing at national and regional scales to decarbonize the world's energy supply (RPV).

Development, Climate Change and Clumsiness

Research into how clumsy rather than elegant solutions can help solve policy disputes related to climate change (RPV).

Assessing European Climate Change Policies (EC4MACS)

EC4MACS project provides scientific and economic analyses of policies in support of Europe's Thematic Strategy on Air Pollution and the European Climate Change Programme in order to better understand how to further reduce greenhouse gas emissions.

ECLAIRE

Assessment of the effects of climate change on air pollution impacts and response strategies for European ecosystems.

Impacts of Short-Lived Air Pollutants (ECLIPSE)

ECLIPSE is conducting research to increase knowledge about emissions of ozone and aerosols, which act as short-lived climate forcers, and identify concrete, cost-effective abatement measures (see p. 71).

Energy Use Impacts on the Environment (EnerGEO)

EnerGEO is a four-year project to assess the current and future impact of energy use on the environment by linking environmental observation systems with the processes involved in exploiting energy resources.

EUCLIMIT

Development and application of EU economy-wide climate change mitigation modeling capacity (all greenhouse gas emission and removals).

Future Impacts of Climate Change (FutureSoc)

FutureSoc is an effort to define the consequences of climate change on future human societies and examine the ability of those societies to cope with the coming changes.

Understanding Air Pollution in China (GAINS-City)

By interfacing tools developed by Chinese researchers with IIASA's GAINS model, the project will connect data about urban air pollution and greenhouse gas emissions to allow Chinese officials to develop better clean air policies (MAG).

Reducing GHG Emissions Uncertainties (GESAPU)

Research in the more than ten years since the Kyoto Protocol has shown that the methods used to measure and inventory greenhouse gas emissions have significant uncertainties and gaps. GESAPU is intended to reduce the uncertainties of GHG emissions in Poland and Ukraine.

Sources and Sinks for Greenhouse Gases (GHG-Europe)

GHG-Europe is analyzing European agricultural and forestry lands to determine both the sources and sinks for three major greenhouse gases and determine what percentage of those gases is anthropogenic.

Management of Heterogeneous Dynamical Systems

The project's goal is to understand the heterogeneous interactions of the parts of large socioeconomic systems that function across many sectors and are driven by multiple agents.

Restructuring Systems to Limit Climate Change (LIMITS)

LIMITS is examining how to fundamentally restructure energy systems and land-use management practices on a global scale in order to limit warming from climate change to two degrees Celsius.

Evaluating Black Carbon Cuts in Finland (MACEB)

IIASA researchers are using the GAINS model in a partnership with Finnish scientists to develop a tool by which the climate effects of reducing black carbon emissions from different economic sectors can be evaluated.

Cutting Greenhouse Gases in Europe (MAG-Climate Package)

IIASA researchers are using the GAINS climate model to support the European Commission's effort to reduce greenhouse gases by 20 percent and significantly increase renewable energy use in Europe by 2020 (MAG).

Clean Air Strategies for Europe (MAG-EU)

IIASA's Mitigation of Air Pollution & Greenhouse Gases Program (MAG) is using its modeling tools to identify strategies to assist in meeting European Union's clean air goals (MAG).

Developing Clean Air Modeling Tools (MAG-UNECE)

The Mitigation of Air Pollution & Greenhouse Gases Program develops modeling tools that identify strategies for the United Nations and European Union efforts to control greenhouse gases and air pollution (MAG).

Creating Policy Tools for Climate Change Adaptation (MEDIATION)

MEDIATION is a project using case studies to provide European policymakers with the scientific information and technical tools they need to effectively develop policies to adapt to climate change.

Monitor

The project conducts monitoring and assessment of sectorial implementation actions (notably related to transport, energy, and agriculture) as part of the EC's Thematic Strategy on Air Pollution and its related legal instruments.

NitroEurope

Study of the nitrogen cycle and its influence on the European greenhouse gas balance.

Envisioning Paradigm Shifts in Society (PASHMINA)

The PASHMINA project uses complex modeling to create scenarios that envision changes in the use of energy, transportation, land, and the environment 20 to 40 years into the future.

Atmospheric Chemistry and Climate Change (PEGASOS)

The goal of PEGASOS is to enhance our understanding of the interactions of climate and atmospheric chemistry in the past, present and future.

PostCopUncertainty

ACRP3 - Uncertainty in an Emissions Constrained World: The Case of Austria.

PURELEC

Assessing investment in renewable electricity under policy uncertainty (ESM).

Accelerating Cuts in Greenhouse Gases (RESPONSES)

RESPONSES is a project to develop strategies that will enable European Union countries to accelerate cuts in greenhouse gas emissions and better adapt to environmental, social, and economic disruptions caused by climate change.

Activities for 2012

For future activities of the Energy and Climate Change Research Area please see the 'Activity for 2012' section of the research program pages, in particular the Energy Program, the Mitigation of Air Pollution & Greenhouse Gases Program and the Transitions to New Technologies Program.

Food and Water Research Area

IIASA's Food & Water research area aims to create analytical and diagnostic frameworks to ensure that food and water are available to a population projected to reach nine billion by 2050. The research, which explores new technologies, investment strategies, policies, and institutional innovations related to food and water focuses on four themes:

- Food security;
- Integrated water resource management;
- Managing multiple ecosystems;
- Safeguarding sustainable seafood and aquatic ecosystems.

Programs

Although Food and Water-related research takes place throughout IIASA, work mainly centers in two programs:

1. Ecosystems Services and Management Program, and
2. Evolution and Ecology Program.

Models, Tools, & Data

The major models, research tools, and databases produced by IIASA within the Food and Water area and further developed in 2011 include:

BeWhere

A model that optimizes the size, location, and technology of bioenergy production plants from the regional to the European level.

G4M

A model to assess forest management decisions concerning afforestation and deforestation.

GAEZ

GIS-based modeling framework combining land evaluation methods and crop modeling to evaluate alternative use options of land and water resources. The model generates comprehensive spatial information for rational land use planning and decision making for food security and agricultural development.

Geo-Wiki

The global land cover validation tool.

GLOBIOM

A global model to assess competition for land use between agriculture, bioenergy, and forestry.

Harmonized World Soil Database

A global database of harmonized soil information.

LANDFLOW

This model quantifies commodity flows and associated resource use as agents of environmental change and thus contributes important insights required for policies aiming at sustainable consumption and resource use.

WFS - World Food System

The World Food System model provides a framework to simulate alternative development scenarios of the world food and agriculture system and evaluate the impacts of policy options.

Projects

A wide range of research projects from across IIASA contributed to the Food and Water research area in 2011 and these include:

ACM

Agriculture and Carbon Markets.

ADAPTFISH

Adaptive Dynamics and Management of Coupled Social-Ecological Recreational Fisheries.

Agro-ecological assessment for the transition of the agricultural sector in the Ukraine

Assessment of Ukraine's land resources for current and future climatic conditions to provide a basis for elaboration of integrated strategies and policies towards sustainable management of natural resources and the environment while improving international economic competitiveness.

AndesPlus

Developing and reviewing methods that are feasible for producing scientific bases for climate change adaptation projects in mountain regions, for instance, adaptation to rapid glacier retreat in the Tropical Andes.

Animal Change

Creates scenarios that project 20 and 40 years into the future to allow policymakers to see what impact climate change is likely to have on livestock production in Europe, Northern and sub-Saharan Africa, and Latin Americ.

Assessing the Impact of Climate Change and Intensive Human Activities on China's Agro-Ecosystem and its Supply Potentials

Joint NSFC-IIASA project including five work blocks on: climate modeling; AEZ and DSSAT model fusion; land use change and multi-cropping index; demography, urbanization and labor force trends; and economic modeling of food demand and climate change impacts.

Assessing the Market for Commercial use of Biomass for Heat and Power Generation in Bulgaria, Romania, Ukraine, Belarus and Turkey

Provide an assessment of the market potential of biomass fuels for heat and power generation in Bulgaria, Romania, Ukraine, Belarus and Turkey to the European Bank for Reconstruction and Development (EBRD). The agriculture-based bioenergy potential includes crop residues, livestock manure, and dedicated energy crops grown on available surplus land.

Assessment of Brazil´s residual land potentials

Spatial estimation of Brazil's residual land biomass potential for biofuels assessed under strict sustainability criteria.

Balkan GEO Network

Towards Inclusion of Balkan Countries into Global Earth Observation Initiatives.

BIOFUELS

Provision of supporting activities for the development of baseline data and methodology for reporting requirements for biofuels.

Biofuels Baseline 2008

Provide support to the European Commission, by compiling baseline information on biofuel production, consumption, origin of feedstock and dynamics of international trade. Backcasting scenario simulations for period 2000-2008 with the World Food System model to assess the sustainability impacts of the use of biofuels in the EU.

BioSpaceOpt

Regional integrative spatial assessment of bioenergy utilization paths: modeling approach and case study. A transferable and scientifically profound model framework for the assessment and optimization of regional biomass utilization paths.

Climate, Land, Energy and Water Strategies (CLEWS): an AEZ Assessment of Mauritius

Case study of Mauritius to demonstrate the complex climate-land-water-energy nexus in which the WEAP water model, the LEAP energy model and the AEZ land production planning model were applied in an integrated fashion in the face of climate change and trends of decreasing annual rainfall.

Extreme Weather Impacts on Carbon Sinks (CARBO-Extreme)

Research into whether the effectiveness of these carbon sinks in European ecosystems might be diminished by expected increases in extreme weather (ESM).

Re-engineering Cities for Good (CFG)

The project examines how a city's infrastructure can be re-engineered to restore the natural ecosystem services that existed on the land before the city was built (RPV).

DECC emissions

Provision of Forestry business as usual emissions projections and abatement cost data to the UK Department of Energy and Climate Change.

Eco-evolutionary dynamics of living systems

To better understand human-induced biosphere impacts, this project will improve models for assessing the ecological and evolutionary dynamics of living systems.

Eco-evolutionary Vegetation Modeling and Management

The development of eco-evolutionary models will allow scientists to better understand how plants around the world respond to climate change and disturbances such as fires and grazing.

Improving Earth Observation Methodology (EGIDA)

EGIDA is a technical project to create a standard methodology to support GEOSS, the Global Earth Observations System of Systems, through development of evaluation processes, assessment indexes, and databases.

Energy Use Impacts on the Environment (EnerGEO)

EnerGEO is a four-year project to assess the current and future impact of energy use on the environment by linking environmental observation systems with the processes involved in exploiting energy resources.

EuroGEOSS — A European Approach to GEOSS

EuroGEOSS contributes to the international effort to create the Global Earth Observation System of Systems (GEOSS) by making existing systems that gather data on forestry, drought, and biodiversity interoperable and easier to use.

Evolutionarily sustainable consumption

The evolutionary consequences of fishing affect a host of heritable traits in fish populations, and IIASA researchers are developing a toolkit to allow scientists to assess these impacts.

Modeling the Structure of Forests (Forest Structure)

The Forest Structure project is creating a model that, by encompassing a broad scale that runs from individual trees up to entire forests, will allow researchers to better understand the impact of climate change, major disturbances, and succession on forests (ESM).

GAEZ Technology transfer workshops project

Provision of a series of AEZ technology transfer workshops of the GAEZv3.0 modeling framework and supporting climate, soil, terrain and land cover databases for on-site use at FAO HQ, focusing on applications at national level, including agricultural production impacts of climate variability and climate change and an assessment of apparent yield gaps of major food crops.

GEOCARBON

Operational Global Carbon Observing System.

Sources and Sinks for Greenhouse Gases (GHG-Europe)

GHG-Europe is analyzing European agricultural and forestry lands to determine both the sources and sinks for three major greenhouse gases and determine what percentage of those gases is anthropogenic.

Global IQ

Assessing the impacts of global changes and the costing of adaptation to them.

IGERT

The IGERT program will teach fellows about real-world policy applications in the natural resources arena and enable the transfer of knowledge in a way that is useful to policymakers in responding to the challenges created by demands for diminishing resources, and the need to maintain and build resilience in stressed watersheds.

IMPACT2C

Quantifying projected impacts under 2°C global warming.

Impact of EU food and non-food imports on deforestation

Provide to the EU DG-Environment guidance on policies for reducing EU consumption impacts based on LANDFLOW model analysis quantifying the impacts of EU consumption – primary products as well as processed or manufactured goods - on past deforestation (period 1990-2008).

Integrated Assessment of Fisheries

This project is developing tools that integrate the biological, social, and economic aspects of fishery systems to help create management systems that promote sustainable fisheries.

Integrated modeling of food, energy and water security for sustainable social, economic and environmental development in Ukraine

Collaboration project between IIASA and Ukrainian NMO Institutes undertaking model-based scenario analysis towards sustainable agriculture intensification pathways in Ukraine under globalization, trade liberalization, and reform of agricultural land ownership.

Integration of Mainstream Economic Indicators with Sustainable Development Objectives (INSTREAM)

This EU FP7 research project was successfully completed in 2011. Research Results were presented and discussed in a conference attended by European Environment Agency, the European Commission, the OECD, UNEP and the Global Footprint Network.

Climate Change and Agricultural Productivity (ISAC)

High-frequency, high-resolution imaging from new satellites is providing detailed agricultural information that will allow scientists to better monitor the impacts of drought and climate change on crops and model future agricultural productivity under different climate change scenarios.

LandSpotting

Aiming to improve the quality of land cover information by vastly increasing the amount of in situ validation data available for calibration and validation of satellite-derived land cover via social games.

Life Cycle Impacts of Goods, Services, Activities (LC-IMPACT)

The LC-IMPACT project is developing methods to assess the environmental life cycle impact of a vast number of goods, services and activities. The assessments examine the environmental costs of such things as erosion caused by land use and threats from toxic substances used in production processes.

Restructuring Systems to Limit Climate Change (LIMITS)

LIMITS is examining how to fundamentally restructure energy systems and land-use management practices on a global scale in order to limit warming from climate change to two degrees Celsius.

LULUCF II

Long-term analyses of LULUCF options at EU level.

Packard/ Nicholas Institute (Duke University) Report

The Net Global Effects of Alternative U.S. Biofuel Mandates Fossil Fuel Displacement, Indirect Land Use Change, and the Role of Agricultural Productivity Growth.

Envisioning Paradigm Shifts in Society (PASHMINA)

The PASHMINA project uses complex modeling to create scenarios that envision changes in the use of energy, transportation, land, and the environment 20 to 40 years into the future.

Impacts of Glacial Retreat in the Andes (PRAA)

PRAA uses pilot projects in three Tropical Andes countries to help local ecosystems and economies better adapt to the many impacts of the rapid glacier retreat underway throughout the region.

Impact of Technological Change in Europe (PROSUITE)

PROSUITE is a collaboration to develop the tools needed to predict the impact technological changes will have on Europe's environment, economies, and social institutions over the next several decades.

RAMCUB

Regional assessment of the market for commercial use of biomass for heat and power generation in Bulgaria, Romania, Ukraine, Belarus and Turkey.

Rational Adaptation in the Financial Arena

This exploratory project brings the anthropological theory of risk to bear on the financial arena and examines how "clumsy" solutions might lead to better responses to an ever-shifting risk environment (RPV).

SCENES

An integrated project aiming to develop a set of comprehensive scenarios of Europe's freshwater futures up to 2025, covering all of "Greater" Europe.

Systemic Risk and Network Dynamics

This project will deepen the understanding of cascading failure in networks and develop ways to lessen the risks of collapse and improve recovery.

ZAPAS

Assessment and Monitoring of Forest resources in the Framework of the EU-Russia Space Dialog.

Activities for 2012

For future activities of the Food and Water Research Area please see the 'Activity for 2012' section of the research program pages, in particular the Ecosystems Services and Management Program and the Evolution and Ecology Program. In addition, the following activities involving researchers from the Land Use Systems (LUS) group are also planned:

- In the context of GAEZ technology transfer to FAO HQ, LUS researchers will work with FAO experts toward standardizing and extending the AEZ modeling framework and databases for application at national/sub-national level. Undertake illustrative case study of Tanzania with focus on yield gap identification, climate change impacts and food-water linkages.
- Extend land use and food modeling system with an explicit water resources modeling component to further enhance its capability for integrated land-water assessments. Expand the GAEZ model system with a water routing scheme at the cropping zone/watershed level for spatially assessing water productivity and water competition issues.
- To complete and implement a systematic global assessment of semi-arid areas, quantifying crop yield and land productivity impacts, resulting from large scale application of soil moisture conservation techniques. A preliminary AEZ study conducted for ICRISAT has shown remarkable increases of yield potentials through efficient use of renewable water resources with soil moisture conservation.
- Expand GAEZ data portal with a wide range of results mapped and tabulated at watershed level.
- Quantified global scenarios of land use change and agricultural production and water demand will be developed as part of the World Water Scenarios Project being jointly led by UN-Water's World Water Assessment Program and IIASA. In association with stakeholders, the Scenarios Project is developing a water vision for 2050 and new, inter-sectoral, integrated water scenarios at multiple scales. It will also establish the linkage between sustainable water availability and food security toward 2050.
- Based on the findings of the impact analysis undertaken in 2011, the EU commissioned project **The impact of EU consumption of food and non-food imports on deforestation** is identifying policy options to reduce the impacts of EU imports and consumption on deforestation. IIASA's policy contribution in 2012 is focusing on agriculture.
- The Harmonized World Soil Database (HWSD), which originated from work begun at IIASA to improve the agro-edaphic element of GAEZ v3.0, has now been adopted officially by the Global Soil Partnership as the definitive soil database at present. In 2012 IIASA has updated the HWSD to Version 1.21, adding new data for Tunisia and additional bulk density information globally, and addressing minor inconsistencies from previous releases. A process is in place to further enhance the HWSD in countries and regions where it still relies on the Digital Soil Map of the World, beginning with the submission of soils data within the next year for the United States of America by the USDA and Australia by CSIRO, data which will be incorporated into the HWSD at IIASA.

Two collaboration projects with the Indian NMO are scheduled to begin in 2012:

- Following a IIASA-TIFAC workshop held in February 2012 in India, the first project investigates **Climate Change Adaptation Approaches for Sustainable Livelihoods** involving several collaborating partners in India led by Institute of Rural Management Anand (IRMA). The study seeks to develop the knowledge, strategies, approaches, measures and processes that enable vulnerable communities in Gujarat plains and hills agro-climatic region to cope with and adapt to the impending impacts of climate change in ways which are effective and responsive to the specific environmental and resources context but also widely applicable, replicable and up-scalable. Since little knowledge and validated field level experiences exist for climate change adaptation, the proposed study will apply a multi-scale approach to identify, model and evaluate suitable adaptation options of rural livelihoods in response to climate change. Gujarat

encompasses a wide range of climatic and agro-ecological conditions that has resulted in a rich diversity of rural livelihoods being exposed to a variety of possible future climate change impacts.

- The second is a project with the Centre for Water Resources Development & Management (CWRDM), Kozhikode, Kerala on the **Evaluation of soil nutrient budgets at field, farm and regional level in humid tropics of Kerala and development of a model for management of soil health**. The project will develop a decision support system to sustain soil fertility and will provide soil information for a potential update of the HWSD in India.

Poverty and Equity Research Area

IIASA's Poverty & Equity research area explores the drivers of the social, economic, environmental, and political factors that create the deep inequities that exist in human societies and on the policies needed to deal with them. It aims to unravel the interrelated influences that determine levels of human development and wellbeing.

There are currently three research themes:

- Integrated multi-dimensional modeling of poverty;
- Wellbeing, development, and equity;
- Poverty traps.

Programs

Although Poverty and Equity-related research takes place throughout IIASA, work mainly centers in two programs:

1. Risk, Policy, and Vulnerability Program (see p. 73); and
2. World Population Program.

Models, Tools, & Data

The major models, research tools, and databases produced by IIASA within the Poverty and Equity area and further developed in 2011 include:

CATSIM

A modeling approach to improve financial disaster risk management.

MESSAGE-ACCESS model

Population Projections

IIASA's probabilistic world population projections.

Projects

A wide range of research projects from across IIASA contributed to the Poverty and Equity research area in 2011 and these include:

Age and Cohort Change (ACC)

The ACC project is a broad-based study to understand the influence of aging and cultural values on the productivity of older workers.

Analyzing the Energy Dimensions of Poverty

IIASA's energy experts are analyzing how improving access to modern energy carriers and technologies in developing countries can potentially improve human health.

CHANGES

Changing Hydro-Meteorological Risks,as Analyzed by A New Generation of European Scientists.

Equitable Governance of Common Goods

A project to improve the regulation of open resources by translating successful small-scale, bottom-up regulations to large-scale, top-down regulations (EEP).

Future Impacts of Climate Change (FutureSoc)

FutureSoc is an effort to define the consequences of climate change on future human societies and examine the ability of those societies to cope with the coming changes.

Linking Disasters for Risk Reduction (MATRIX)

Natural disasters are typically treated as individual incidents, but scientists are developing methods to link events such as earthquakes and landslides to enable policy makers to take more effective risk reduction measures.

Creating Policy Tools for Climate Change Adaptation (MEDIATION)

MEDIATION is a project using case studies to provide European policymakers with the scientific information and technical tools they need to effectively develop policies to adapt to climate change.

Poverty Traps

To escape from poverty traps that are caused by natural disasters, low-income households need assistance from public and private partnerships that are informed by risk analysis and based on local needs.

Improving Landslide Risk Responses (SafeLand)

SafeLand is a response to the growing risk of landslides in mountainous regions of Europe due to climate change-related increases in overall rainfall, concentrated rains over short periods, more extreme weather, and increased snowmelts in Alpine regions.

Activities for 2012

For future activities of the Poverty and Equity Research Area please see the 'Activity for 2012' section of the research program pages, in particular the Risk, Policy and Vulnerability Program and the World Population Program.

Models and Projects by Cross-cutting Research

Drivers of Global Transformation

The main drivers of transformations and their interactions are:

- People (population growth, education, migration);
- Technologies (new technologies, rate of diffusion, technological change; and
- Economic growth

The human population and the conditions under which people live are the ultimate objects of development, bringing about many of the environmental, economic, and social changes that continually challenge the sustainability of our current development paths. Whether development is sustainable is judged on three criteria: long-term human survival, health, and well-being.

Population studies at IIASA are premised on developing and using advanced techniques to more accurately project future levels of population and their distribution which, by their very nature, are prone to uncertainty. The focus in 2011 was to put human beings at the center of sustainable development, with a continuing emphasis on education, human capital building, and the impacts of migration.

Research into technology at IIASA aims to better understand of the patterns, drivers, constraints, and impacts of technological change, particularly with respect to global sustainability conditions (such as climate change). Our research focuses on the systemic aspects of technological change and draws on empirical case studies, associated "meta" analysis, novel modeling approaches, as well as scenario studies and robustness analysis to inform technology policy choices from a systems perspective.

IIASA has significant research skills that are contributing to studying sustainable economic development. One important area is the study of the co-benefits of pollution control in terms of health and climate change. Another interesting area is the exploration of new technologies for environmentally compatible economic growth, like carbon capture and storage, renewable energy, or nuclear technologies. Yet another area is the study of energy paths that lead to a sustainable high-efficiency, low-carbon energy economy. An overarching question is whether advancing green technologies can improve a country's economic competitiveness and spur additional growth and employment.

Programs

Although relevant research on these three aspects is being conducted throughout IIASA, the work is mainly centered in three programs:

1. World Population Program,
2. Transitions to New Technologies. and
3. Advanced Systems Analysis

Models, Tools & Data

The major models, research tools, and databases produced by IIASA within the Drivers of Global Transformation activities and further developed in 2011 include:

Energy Carbon Database

Energy and Carbon Dioxide Emissions Data Uncertainties.

LSM2

A software tool to estimate the parameters of technological growth and substitution processes.

Population Projections

POP is continuing to develop the mathematical and statistical tools of formal demography, inter alia, to help fill gaps in existing knowledge and add value to statistics by relating level of education, especially of women to projections and looking at the implications of societal aging.

Scaling Dynamics of Energy Technologies

Meta-analysis of unit and industry level scaling dynamics in energy technologies and climate change mitigation scenarios.

Projects

A wide range of research projects from across IIASA contributed to the Drivers of Global Transformation activities in 2011 and these include:

Age and Cohort Change

The demography of skills and beliefs in Europe with a focus on cohort change

ALPS2

Alternative Pathways toward Sustainable development and Climate Stabilization

Drivers of Extreme Events

The goal of this project is to understand mechanisms leading to extreme events in complex dynamic, with special attention paid to the risk of cascading failure in networks.

EM-UNFPA

Knowledge base on emerging population issues at global level strengthened: Support to IIASA United Nations Population Fund (UNFPA)

FutureSoc

Forecasting Societies' Adaptive Capacities to Climate Change

Global Economic Growth and Optimization

Using systems analysis tools to examine the drivers of economic growth, this project is developing economic scenarios to determine how best to achieve sustainable development (ASA)

Impact of Technological Change in Europe (PROSUITE)

PROSUITE is a collaboration to develop the tools needed to predict the impact technological changes will have on Europe's environment, economies, and social institutions over the next several decades.

MONITOR

Monitoring System on the Development of Global Air Transport

Pew Centre Research

Collecting demographic data and estimate the religious structure of population in select countries

Advanced Systems Analysis

Systems analysis is a problem-solving process that addresses large-scale social and technical problems of great complexity and urgency, for example, the many aspects of climate, energy, agriculture, and food and water systems. Advances in systems analysis take place across the Institute through the development of models and tools, and can be read in the individual program reports. However, cross-cutting research into systems analysis is centered in the Advanced Systems Analysis (ASA) Program. ASA's overall objective is to achieve a cutting edge in systems analysis and to provide a substantial basis for tying together systems methods and applied research on global change.

Models

The ASA Program assists other IIASA programs in creating new models to meet research needs and integrating or adapting existing models. In 2011 its work has centered on:

- Optimal growth modeling for POP
- Adaptive forest modeling for analysis of long-term policy in forest management for ESM
- Long-term farmland model for NMO, Finland
- Random signal model for recognizing early warning signals in a time series preceding a collapse observed in the past for work on drivers of extreme events
- Robust stochastic models for supporting policymaking in the areas of food, water, and energy security were constructed
- Dynamic stochastic optimization strategic planning model for the project EnRiMa
- Testing to find a threshold separating mutually compatible and incompatible models in terms of model integration
- Development of a multi-agent stochastic reduction model for emission trading under asymmetric information in collaboration with ESM and MAG
- Development of a Web-enabled interactive multiple-criteria analysis tool for simultaneous exploration of relations between three key energy sustainability objectives—energy security, climate change mitigation, and the reduction of air pollution and its human health impact, was developed in collaboration with ENE.
- An exploratory project, Dream Valley, a goal of which is to develop a cross-disciplinary modeling and assessment framework for simulation of complex dynamical systems and testing methods for forecasting their future behaviors.

Projects

A wide range of research projects from across IIASA contributed to the Advanced Systems Analysis activities in 2011 and these include:

Energy Efficiency and Risk Management in Public Buildings (EnRiMa)

Within the framework of the EU-funded EnRiMa project (), a requirement analysis for supporting decisions on robust energy-efficient and cost-effective energy use in public buildings is being developed.

Dream Valley

Pilot version of an agent-based Dream Valley model describing the dynamics of a regional socioeconomic-environmental system was constructed. The model simulates the states of the individuals who inhabit a certain geographic area and work at a factory located there. A factory produces goods, sells them on market, pays taxes to the government, and invests part of its income in capital accumulation. The production process pollutes the environment, which in turn harms people's health. The government uses the tax to support public health.

Achieving Low Carbon Economies (Attainability)

By identifying which barriers to achieving deep reductions in greenhouse gas emissions can be removed by changing policies and economic incentives, the Attainability Project is pinpointing the best short- and long-term responses available to policymakers.

Interactions in Economic Sectors (Game Dynamics)

The goal of the Game Dynamics Project is to better understand the highly complex dynamics of interactions between players acting in different sectors with no set behavior patterns.

Global Economic Growth and Optimization

Using systems analysis tools to examine the drivers of economic growth, this project is developing economic scenarios to determine how best to achieve sustainable development.

Creating Synthetic Knowledge for Complex Systems (Model Integration)

The Model Integration Project will overcome the limitations of current integrated models in studying complex systems and develop simpler models that can create synthetic knowledge and describe complex systems from different perspectives.

Seven Shocks and Finland

The project is investigating the implications of seven different shocks on Finnish society, and will create a portfolio of actions that could increase the resilience in responding to the shocks.

Drivers of Extreme Events

The goal of this project is to understand mechanisms leading to extreme events in complex dynamic, with special attention paid to the risk of cascading failure in networks.

Policy and Governance

A Policy Impact section is included in each Research Program report.

Communications

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Objectives

IIASA's Communications (COM) Department aims to help position IIASA as a leading global organization engaged in research into environmental, economic, technological, and social change by:

1. Raising awareness of IIASA's objectives and impact, and building positive perceptions of IIASA among external target audiences;
1. Supporting the development of new and existing partnerships (funders, researchers, policymakers); and
2. Supporting the communication activities of IIASA scientists.

Much of COM's activities can be categorized as related to science communication and publishing plus other ancillary services (reproduction and audio support for events).

Science Communication

COM manages the following major communication channels by developing content and ensuring the channel delivers the information in a timely and professional manner:

- **Media**: Coverage increased to over 2200 articles in 2011 (up from approx 1170 in 2010) and was generated by 15 press releases and 2 media alerts, targeted media interviews and productive collaborations with communication teams of IIASA's research partners.
- **Web site**: Unique visitors to IIASA's site numbered 47,499 in 2011. Major preparation for the launch of new IIASA Web site in spring 2012 took place in 2011. Designed, launched and maintained mini Web site for IIASA Conference 2012.
- **Options Magazine**: The 2011 issues focused on two of IIASA's three new research areas and each issue has a circulation of approx. 7,500.

- **E-newsletter**: Published three times a year with approx 2,600 subscribers.
- **Annual Report**: A yearly overview of the achievements of IIASA's research sent to approx 3,100 subscribers.
- **NMO Country Profiles**: Summaries of the relationship between IIASA and 17 of its NMOs are available.
- **Marketing Materials**: Flyers (IIASA, YSSP, Postdoc), folders and packages of branded materials for YSSP (Brochure, Folder, Calendar, Abstract book, Certificates) and for Endowment Fund (Donation cards and flyers and envelopes)
- **New Media**: IIASA Facebook (353 likes), IIASAVienna Twitter (119 followers), IIASA Live You Tube (746 video views). Statistics as of 7 Feb 2012.
- **Exhibitions**: IIASA exhibit and communication support for UN Climate Change Conference in Durban and Vienna Energy Forum, which increased awareness of IIASA among the events' delegates.
- **Media Training**: An introduction to the media and delivering key research messages for YSSPers. Feedback was highly positive.

In addition COM provided strategic and tactical communication advice to a wide range of IIASA staff ranging from speech writing and presentation preparation for IIASA Director to fundraising campaign by Development Office.

Publishing

COM provides a range of publishing related activities typical of a small, international, scientific institute:

- **Language Editing**: COM offered a new editing service for journal articles in 2011. Demand exceeded expectations, with over 25 articles edited. Feedback was highly positive.
- **Graphics**: Design and lay out for IIASA corporate publications and marketing materials, range of advertising materials

for Conference 2012 and launch of Wittgenstein Centre, and various graphic support for IIASA programs ranging from covers for publications to figures for Science and Nature articles.

- **Translation**: Provided official translations for five items from German to English and vice versa.
- **Scientific Publishing**: COM provides a range of editing, typesetting, and graphic support for publishing books, research reports, journal articles and newsletters aimed at academic community. In 2011 work covered two books Elements of Adaptive Dynamics [EEP], Fisheries Induced Genetic Change [EEP], a forthcoming IIASA research report on suicide in eastern Europe, an issue of the POPNET newsletter sent to approx 2,600 demographers, plus COM provided advice on wide range of publishing contracts and copyright transfer forms.
- **Permissions and Requests**: Granted approx 15 permissions to use IIASA copyrighted material in 2011 and requested approx 25 permissions with external publishers on behalf of IIASA staff.
- **Publications Catalog**: COM maintains the record of all publications by IIASA affiliated researchers making them publicly available when copyright allows. Currently just under 10,000 entries with 300+ added in 2011.

Reproduction

COM provides a small in-house printing service, in 2011 this included:

- Copying on request (approx 100,000 copies), printing 14 Interim Reports, printing numerous IIASA business cards, official invitations, door labels, name stands, and Christmas Cards.

Audio Support

COM provided audio support for over 70 events on IIASA's premises in 2011 and introduced a new wireless microphone system for the Wodak room to facilitate communication during large meetings such as Council meetings.

Resources

- COM delivered the above to budget and deadline despite maintaining costs at €70,000 below 2009 levels through continuing to observe the agreed measures taken in 2010 as part of IIASA's policy to cut costs across the Institute.

Fundraising

In 2011, IIASA's Annual Fund was able to support young scientists from developing countries participate in the Young Scientists Summer Program (YSSP), which was only made possible thanks to our generous donors. IIASA Endowment Fund is continually developing to support the creative exploration of new frontiers in systems analysis research at IIASA.

IIASA is very grateful to the individuals listed here and 17 anonymous donors for their contributions and for their belief in the goals and mission of this Institute.

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In honor of Professor Manfred Grauer, who asked for donations to IIASA on his retirement from the University of Siegen, Germany:

Access E.V.
DHI-WASY GmbH
Dieter B. Pressmar
Dr. Merten + Steinke Holding GmbH
Gedia Gebrüder Dingerkus GmbH
Gerhard Knolmayer
Harald Boden
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Michael Gail
Nancy Roggenkamp
Zentrum für Informations und Medientechnologie (ZIMT), Universität Siegen

2011 Scientific Meetings, Sponsored or Co-sponsored by IIASA

GAINS-City for Chinese Cities Kick-off Meeting
10-11 January
Mitigation of Air Pollution and Greenhouse Gases

Global Energy Assessment (GEA) Retreat
17-18 January
Global Energy Assessment

4th Meeting of the Toyota Ozone Project
18-19 January
Mitigation of Air Pollution and Greenhouse Gases

Workshop on Education and Research in Innovation and Economic Development
18 January
Ecosystems Services and Management

Workshop on Systems Analysis Approaches to Poverty and Equity Research
25-28 January (held in Cape Town, South Africa)
Directorate

Specialists Workshop for Remote Sensing and Landspotting in Land-use Change
28 January
Ecosystems Services and Management

Global Energy Assessment Executive Committee
31 January- 2 February
Global Energy Assessment

Global Energy Assessment (GEA) Internal Writing Meeting
17-20 February
Global Energy Assessment

Asian Regional Planning Meeting for the New Set of Global Population and Education Projections
28 February-12 March (held in Bangkok, Thailand)
World Population

Global Energy Assessment (GEA) Internal Writing Meeting of the Co-Chairs and Director
4-7 March
Global Energy Assessment

International Workshop on Urban Energy and Carbon Modeling in Rapidly Urbanizing World
10-11 March
Transitions to New Technologies

Meeting of the Network for National Integrated Assessment Modelling (NIAM)
21-22 March
Mitigation of Air Pollution and Greenhouse Gases

LIFE III - EC4MACS Project Meeting
22-23 March
Mitigation of Air Pollution and Greenhouse Gases

The Game Changers Conclusion Seminar
23-25 March (held in Edinburgh, United Kingdom)
Exploratory and Special Projects

Workshop on Diffusion of New Energy Technology in China
25-26 March (held in Shanghai, China)
Transitions to New Technologies

Director Search Committee Meeting and Candidate Interviews
4-6 April
Council and External Relations

Matrix Project Progress Meeting
4-5 April
Risk Policy and Vulnerability

WWF/WBCSD/IIASA Workshop
14 April
Ecosystems Services and Management

Safeland Stakeholder Meeting 1
14 April (held in Nocera Inferiore, Italy)
Risk Policy and Vulnerability

Mediation Project Task 4.3 Meeting
18-19 April
Risk Policy and Vulnerability

TCM: Terrestrial Ecosystem Carbon Sink Management Decision-Support System Workshop
28 April
Ecosystems Services and Management
Joint Russia and IIASA-ESM Round-table on Forest Inventory
06 May
Ecosystems Services and Management

Safeland Stakeholder Meeting 2
11 May (held in Nocera Inferiore, Italy)
Risk Policy and Vulnerability

Austrian NMO Meeting
13 May
Directorate

Safeland Stakeholder Meeting 3
18 May (held in Nocera Inferiore, Italy)
Risk Policy and Vulnerability

Safeland Stakeholder Meeting 4
25 May (held in Nocera Inferiore, Italy)
Risk Policy and Vulnerability

Council Meeting
6-7 June
Directorate
US NMO Committee Meeting
08 June
Directorate

Security in the Age of Systemic Risk: Strategies, Tactics and Options for Dealing with Femtorisks and Beyond. A Workshop to Define Evolving Challenges and Innovative Approaches
09-10 June
Directorate

Characterizing and Validating Global Agricultural Landcover
13-17 June
Ecosystems Services and Management

GOFC/CEOS WGCV Global Land Cover Validation Workshop
16-17 June
Ecosystems Services and Management

Global Energy Assessment (GEA) Council Meeting
20-24 June
Global Energy Assessment
GAINS Workshop Focusing on Key Measures for the Revision of the CLRTAP Gothenburg Protocol
20-21 June
Mitigation of Air Pollution and Greenhouse Gases

Vienna Energy Conference 2011: Energy for All – Time for Action
21-23 June (held in Vienna, Austria)
Global Energy Assessment

Expert Group Meeting on SD21 Sustainable Development Scenarios for the Rio+20 Summit
27-29 June
Energy

FuturICT Austria
1 July
Advanced Systems Analysis

Expert Workshop on Community -based Environmental Monitoring
19 July
Ecosystems Services and Management

Internal Writing Team Retreat
10-12 August (St. Peter am Ottersbach, Austria)
Transitions to New Technologies

FroSpects Workshop on Niche Theory and Speciation
29-31 August (Keszthely,Hungary)
Evolution and Ecology

EnRiMa Project Technical Meeting
7-8 September
Advanced Systems Analysis

Dynamics, Economic Growth, and International Trade, DEGIT-XVI
08-09 September (held in St. Petersburg, Russia)
Advanced Systems Analysis

IIASA - Japan Collaboration Meeting
16 September
Directorate

CCTAME Final Project Meeting
19-20 September
Ecosystems Services and Management

Austria Boku – IGERT
26 September -21 October
Risk Policy and Vulnerability

Austria IIASA - IGERT Students
26 September - 16 December
Risk Policy and Vulnerability

Hungary IIASA - IGERT Students
26 September - 16 December
Risk Policy and Vulnerability

IGERT – Poland
26 September - 21 October (held in Wroclaw, Poland)
Risk Policy and Vulnerability

Expert meeting "How Population Factors Promote or Impede Sustainable Development"
30 September - 01 October (held at IIASA and Vienna, Austria)
World Population

Assessment of Climate Change Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates (AMPERE) 2nd Project Meeting
03-05 October
Energy

Workshop on the Likely Future Trajectories of International Migration
03-05 October (held in Boulder, USA)
World Population

GAINS-CITY workshop
03-07 October
Mitigation of Air Pollution and Greenhouse Gases

Integrated Assessment Modeling Consortium (IAMC) Meeting
06-07 October (held in Vienna, Austria)
Energy
Science Advisory Committee (SAC) Meeting
17-18 October
Directorate

Global Energy Assessment (GEA) Council Meeting
19 October
Global Energy Assessment

IEA-IIASA BECCS Experts Workshop
03-04 November
Ecosystems Services and Management

Workshop on the Likely Future Trajectory of Fertility
07-09 November (held in Dhulikhel, Nepal)
World Population

Council Meeting
07-08 November
Directorate

Mid-term Workshop of NSFC-IIASA. "Assessing the Impact of Climate Change and Intensive Human Activities on China's Agro-Ecosystem and its Supply Potentials
08- 09 November
Ecosystems Services and Management

IIASA – NRF Consultation Meeting 2011
09 November
Directorate

Seven Shocks and Finland, Analysis Session
24-25 November
Exploratory and Special Projects
IGERT – Spain
26 November – 1 December (held in Madrid, Spain)
Risk Policy and Vulnerability

Conference of the Parties (COP 17) Climate talks
28 November- 09 December (held in Durban, South Africa)
Directorate
Geo-wiki/Eurogeoss Integration Meeting
29 November -01 December
Ecosystems Services and Management

International Conference Education and the Global Fertility Transition
30 November-01 December (held in Vienna, Austria)
World Population

Workshop on the likely future developments of fertility in low-fertility countries
01- 02 December (held in Vienna, Austria)
World Population

Green Growth and Sustainable Development Symposium
09- 10 December
Advanced Systems Analysis

2011 IIASA Guest Lectures

- 25-NOV-11, **Prof. Manfred Grauer**, Director, Information Systems Institute, University of Siegen, "About Complex Event Processing (CEP) and Advanced Systems Analysis (ASA)"
- 2-NOV-11, **Prof. Clemens Atzberger**, Head, Surveying, Remote Sensing & Land Information (IVFL), University of Natural Resources and Life Sciences, Vienna (BOKU), "Coarse resolution time series analysis at IVFL: from pre-processing to selected applications"
- 25-OCT-11, **Dr. Michael Raupach**, CSIRO Marine and Atmospheric Research, CSIRO Fellow , "Global Carbon Cycle Research - Recent Trends and Insights to Constraining Cumulative Emissions"
- 27-SEPT-11, **Dr. Paul Gauché**, Stellenbosch University, "Solar Thermal Energy"
- 16-AUG-11, **Hans Liljenström**, Systems Analysis Group, Dept of Energy & Technology, SLU, Sweden, "Man and Nature - Coping with Internal and External Complexity"
- 8-AUG-11, **Nikita Strelkovsky**, Lomonosov Moscow State University, "Agent-based approach: from essentials to comprehensive tools for socio-environmental modeling and simulation"
- 4-AUG-11, **Dr. Edmar Teixeira**, The New Zealand Institute of Plant & Food Research, "Modeling crop production at global and local scales"
- 4-AUG-11, **Alexander Tarasyev**, IIASA and Inst. of Mathematics and Mechanics, Ekaterinburg, "Optimization of Investments in Capital and Labor Efficiency"
- 1-AUG-11, **Warren Sanderson**, IIASA and Stony Brook University, NY State, Alexander Tarasyev, IIASA and Inst. of Mathematics and Mechanics, Ekaterinburg, Anastasy Usova, Inst. of Mathematics and Mechanics, Ekaterinburg, "Optimization of Investments in Capital and Labor Efficiency"
- 26-JUL-11, **Prof. Sir Chris Llewellyn Smith**, Director of Energy Research, Oxford University, and President of the Council of SESAME, "International Scientific Collaboration: Benefits, Challenges and Opportunities"
- 14-JUL-11, **Dr. Pablo Suarez**, Red Cross / Red Crescent Climate Centre, "A Game of Farmers, Food, and Financial Aid: Experience the Interplay of Droughts, Dialog, and Development"
- 14-JUL-11, **Dr. Mahshid Sotoudeh**, Austrian Academy of Sciences, "Participative foresight as a mediation instrument between science and society"
- 12-Jul-11, **Pietro Landi**, Department of Electronics and Information, Politecnico di Milano, "Can we predict branching scenarios?"
- 12-JUL-11, **Dr. Dipak Gyawali**, ISET-Nepal, Michael Thompson, IIASA, "The end of the age of aid and how to make the most of it"
- 14-JUN-11, **Prof. Doyne Farmer**, Santa Fe Institute, "Predicting Technological Progress"
- 30-MAY-11, **Jesus Crespo-Cuaresma**, IIASA and WU Vienna, "Spatial Filtering, Model Uncertainty and the Speed of Income Convergence in Europe"
- 25-MAY-11, **Prof. Leen Hordijk**, Director of the JRC Institute for Environment and Sustainability, "JRC's new 2010-2020 strategy: more economics, modelling and scenario analysis"
- 17-MAY-11, **Dr. Rupert Seidl**, BOKU, Institut für Waldbau , scientist, "Disturbed models: the why and how of integrated vegetation – disturbance modeling"
- 10-May-11, **Peter Fleissner**, Technical University Vienna (TUW), "Reconstructing the Economy by Means of Input-Output Methods"
- 21-APR-11, **Armon Rezai**, Dept. of Socio-Economics - Vienna Univ. of Economics and IIASA, Lance Taylor, Dept. of Economics - New School for Social Research, Reinhard Mechler, IIASA and Dept. of Socio-Economics - Vienna Univ. of Economics, "Ecological Climate Economics. Real Climate Policy and Economic Growth"
- 18-APR-11, **Dr. Florian Hartig**, Helmholtz Centre for Environmental Research (UFZ), "Dynamic versus evolutionary stability under relative nonlinearity of competition"
- 31-MAR-11, **Warren Sanderson**, IIASA and Stony Brook University, NY State, Erich Striessnig, IIASA, Wolfgang Schöpp, IIASA, "The Costs and Benefits of Reducing PM2.5 in South Asia"
- 15-MAR-11, **Doug Arent**, Executive Director of the Joint Institute for Strategic Energy Analysis at NREL "The Joint Institute for Strategic Energy Analysis"
- 14-MAR-11, **Jesse H. Ausubel**, The Rockefeller University, "The Census of Marine Life: Some Major Findings"
- 9-MAR-11, **Dr. Kenneth Karlsson**, Ris DTU, "Global and regional modelling of renewable energy systems"
- 02-MAR-11, **Matt Lampert**, Research Fellow of the Socionomics Institute, doctoral student in the Department of Sociology University of Cambridge - UK, "Improving Path Dependence: A Socionomic Perspective on Anticipating Social Change and Extreme Events"
- 25-FEB-11, **Dr. Volodymyr Riaboshlyk**, "Numerical Forecasting of Output and Employment Declines along with Forecasting of Growth"
- 17-Feb-11, **Prof. Tim Bedford**, University of Strathclyde, "Dynamic Systemic Risk Model Application"
- 09-FEB-11, **Dr. Aaron Tovish**, Mayors for Peace, "The Need to Revisit Nuclear Winter; New Science, New Politics"
- 31-JAN-11, **Thomas Brudermann**, WU-Vienna, "Mass Psychology and Agent-based Modeling"

ABOUT IIASA

IIASA is an international, independent, interdisciplinary research institution with 40 years' experience in researching global change.

IIASA is sponsored by its National Member Organizations. On 1 January 2012 these were:

AUSTRIA The Austrian Academy of Sciences
BRAZIL Center for Strategic Studies and Management in Science, Technology and Innovation (CGEE)
CHINA The National Natural Science Foundation of China
EGYPT The Academy of Scientific Research and Technology (ASRT)
FINLAND The Finnish Committee for IIASA
GERMANY The Association for the Advancement of IIASA
INDIA The Technology Information, Forecasting and Assessment Council (TIFAC)
JAPAN The Japan Committee for IIASA
MALAYSIA Academy of Sciences Malaysia
NETHERLANDS The Netherlands Organization for Scientific Research (NWO)
NORWAY The Research Council of Norway
PAKISTAN The Pakistan Academy of Sciences
REPUBLIC OF KOREA National Research Foundation of Korea (NRF)
RUSSIA The Russian Academy of Sciences
SOUTH AFRICA The National Research Foundation
SWEDEN The Swedish Research Council for Environment,Agricultural Sciences and Spatial Planning (FORMAS)
UKRAINE The Ukrainian Academy of Sciences
UNITED STATES OF AMERICA The National Academy of Sciences

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