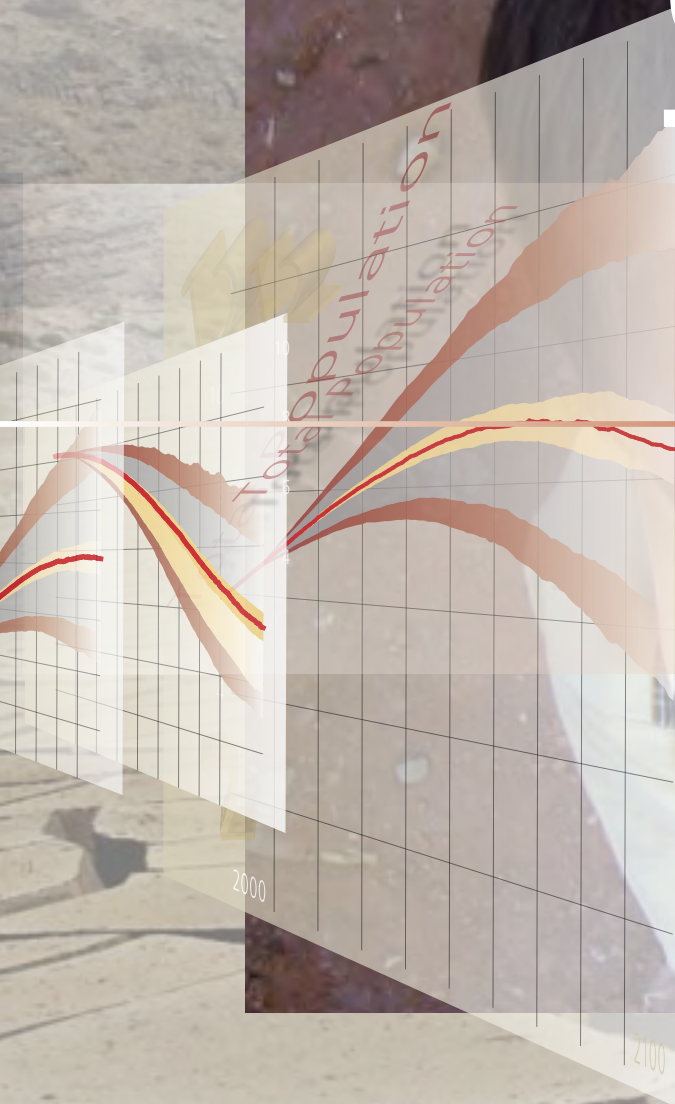


Global development Challenges for science



Population change

Pages 10-13

Insurance and climate change

Pages 16-17

The economy and the environment

Pages 18-19

Energy inequality

Pages 24-25

In today already walks tomorrow



Leen Hordijk
Director, IIASA

The IIASA Conference, which will take place from 14–15 November in the Hofburg Imperial Palace in Vienna, is a requirement under the Institute's Charter. Its purpose is: to provide scientific and technical advice to the Council and Director; to encourage links among Institute programs and between IIASA and other research institutions; and to foster understanding of the work of the Institute. Thus, if one had to choose a single word to encapsulate the rationale for holding an IIASA Conference, it would—in my opinion—be communication.

The Conference will give everyone, both IIASA staff and Conference participants, a chance to communicate: to display the Institute's progress to date and to determine the future directions our work might take. In fact, I believe that we will all come away from the Conference with a far sharper vision of our priorities and a renewed enthusiasm for tackling them, perhaps in hitherto unthought-of ways and with input from fresh sources.

IIASA has come a long way, both practically and philosophically, in the 35 years since its foundation at the height of the Cold War. The theme of IIASA Conference '07, *Global Development: Science and Policies for the Future*, will bring the work we are doing to the attention of a much wider public via the traditional and the new media, including the Internet. The phenomenal success of our podcasts has convinced me that there is a much greater audience for our work than we realized. The worldwide success of *An Inconvenient Truth*—former US Vice President Al Gore's documentary film—is indicative of public interest in these matters.

Policymakers in industry, government, and international organizations the world over are now extremely sensitive to their constituencies' concerns over global change and its implications for development. Our Conference will, I am sure, be closely watched by the policy community and its ideas taken further and acted upon.

2007 is also the centenary of the birth of Rachel Carson, a quiet and unassuming biologist, who is widely credited with launching the global environmental movement in 1962 with her book *Silent Spring*. In a speech in the same year, she said prophetically:

Your generation must come to terms with the environment. Your generation must face realities instead of taking refuge in ignorance and evasion of truth. Yours is a grave and a sobering responsibility, but it is also a shining opportunity. You go out into a world where mankind is challenged, as it has never been challenged before, to prove its maturity and its mastery—not of nature, but of itself. Therein lies our hope and our destiny. In today already walks tomorrow.

That *sobering responsibility*, that *shining opportunity* are challenges that IIASA faces every day on an international and interdisciplinary front, and we are making extraordinary headway in areas which earlier observers and researchers could only have dreamed of.

If that concept can be communicated on 14–15 November to delegates and to the wider public, then our Conference will be a resounding success.

About IIASA

IIASA is an international scientific institute that conducts policy-orientated research into problems that are too large or complex to be solved by a single country or academic discipline.

IIASA's scientists research

- energy and technology;
- environment and natural resources; and
- population and society.

IIASA produces

- data, models, and research tools;
- refereed scientific literature; and
- policy-relevant information.

IIASA helps

- countries make better-informed policy;
- develop international research networks; and
- support the next generation of scientists.

IIASA is funded and supported by scientific institutions and organizations in the following countries:

Austria, China, Czech Republic, Egypt, Estonia, Finland, Germany, Hungary, India, Japan, Netherlands, Norway, Pakistan, Poland, Russian Federation, South Africa, Sweden, Ukraine, United States of America.

International Institute for Applied Systems Analysis

A-2361 Laxenburg, Austria

Phone +43 2236 807 0

Fax +43 2236 71313

E-mail inf@iiasa.ac.at

Web www.iiasa.ac.at



About Options

Options magazine features the activities of the International Institute for Applied Systems Analysis (IIASA), located in Austria.

Editor Iain Stewart

Writer Kathryn Platzler

Contributors Markus Amann, W. Brian Arthur, M. Bruce Beck, Paul Crutzen, Günther Fischer, Stefan Hochrainer, Leen Hordijk, Joanne Linnerooth-Bayer, Wolfgang Lutz, Reinhard Mechler, Shonali Pachauri, Warren Sanderson, Sergei Scherbov, Gunnar Sjöstedt, Pablo Suarez, Michael Thompson

Prepared by the IIASA Publications Department
Printed by Remaprint, Vienna

Options is sent to over 6,500 policy makers, diplomats, and scientists. If you would like a free subscription, please send your name, address, and profession to publications@iiasa.ac.at.

Copyright © 2007

International Institute for Applied Systems Analysis
ZVR: 524808900

Sections of *Options* may be reproduced with acknowledgment to IIASA. Please send a copy of any reproduced material to the editor.

The views and opinions expressed herein do not necessarily represent the positions of IIASA or its supporting organizations.

2 editorial

In today already walks tomorrow

4 research highlights

IIASA in print ■ Disturbance stimulates biodiversity ■ Optimal economic growth problems ■ Limitations to climate change consensus ■ Learning from seasonal climate forecasts ■ Russian forestry CD

6 research in the pipeline

MICDIF models microbes ■ Plurel prefers pop ■ Adaptation to climate risks ■ Chinese agricultural transition

7 iiasa news

IIASA turns 35 ■ And South Africa makes 19...

8 work in progress

Grand challenges for engineering
Turning cities into forces for good in the environment

9 getting research into practice

Cleaning Europe's air without burdening economic development
IIASA scientific model guides successful multilateral treaty to protect environment

28 iiasa alumni

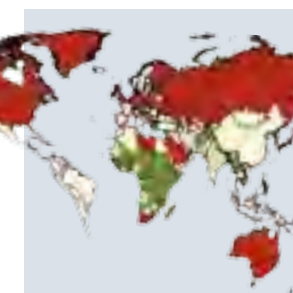
Jesse Ausubel ■ Petr Aven ■ Kirit Parikh
■ Thomas Schelling ■ Harry Swain

29 day in the life

IIASA's driving force
Erich Kreamsner loves his job—and it's not just because of the Mercedes



Cover photo
by Vipin Babu



10 feature articles

- 10 **The growing divergence in population trends and concerns**
We may soon be living in a world with rapid population decline in some areas and explosive growth in others.
- 14 **What is systems analysis?**
One thing systems analysis is not, Leen Hordijk explains, is "Jabberwocky."
- 16 **A favorable climate for insurance**
Climate change is set to make many of Africa's problems worse. By 2020, yields from rain-fed agriculture could decrease by half in some African countries.
- 18 **Green light for sustainability measures**
Contrary to widely held popular belief, environmental policies do not need to raise costs.
- 20 **From QWERTY to Microsoft**
If you've ever wondered why your keyboard looks the way it does, IIASA can explain.
- 22 **Negotiating the environment: Why such complexity?**
Part of the complexity of environmental issues is that they usually affect more than one country to different degrees and in different ways.
- 24 **Global development and energy inequality**
The Millennium Development Goals did not address energy for the poor. Yet security of energy supply is vital to move the development process forward.
- 26 **Global Development: Science and Policies for the Future**
A preview of IIASA speakers and the issues being addressed on 14 and 15 November at the IIASA Conference '07 on the occasion of IIASA's Thirty-Fifth Anniversary.

POPULATION AND DEVELOPMENT

IIASA in print

The September issue of *Population and Development Review*, a leading journal in the demography field featured four papers from different IIASA authors.

In "Pandemic Influenza: A Review," Landis MacKellar of IIASA's Health and Global Change (HGC) Project, reviews the current state of knowledge regarding a potentially deadly influenza outbreak and the state of policy responses to it. While pandemics will occur, Dr. Mackellar warns against crisis-mentality preparedness planning which will likely lead, he says, "to a boom-bust policy cycle."

In "Contesting the Cause and Severity of the Black Death: A Review Essay," Andrew Noymer, also of HGC, reviews the most



The Dance of Death by Hans Holbein the Younger reflects the grim reality of life during the Black Death

demographically oriented of all the recent histories of the Black Death, *The Black Death*, 1346–1353, by Ole Benedictow of the University of Oslo—"a useful compendium of the demography of the most calamitous epidemic in documented history."

In "Impacts of Demographic Trends on US Household Size and Structure" Leiwen Jiang and Brian O'Neill develop a set of projections of future living arrangements in the USA. "Anticipating changes in the number, size, and composition of households is important," say the authors for many issues of social concern, for example, consumption patterns, biodiversity, the needs of the elderly, and the environment.

According to "A Near Electoral Majority of Pensioners: Prospects and Policies," by Warren C. Sanderson and Sergei Scherbov of the World Population Program, the proportion of voting age populations 65 years or older will roughly double from 2000–2050 in many of today's richer countries. They will represent a near majority in the electorates of these countries, creating unprecedented changes in the political landscapes. The article shows that those pensioners will have long time horizons, suggesting that they will favor policies designed to keep pension systems sustainable.

Reprints of these articles may be ordered through IIASA's online Publication Catalog. ■

www.iiasa.ac.at/Publications

ECOAGRICULTURE

Disturbance stimulates biodiversity

Jan Sendzimir, a researcher with IIASA's Risk and Vulnerability Program, has co-authored a chapter in the recently published *Farming with Nature*, edited by Sara J. Scherr and Jeffrey A. McNeely. The book offers a synthesis of the state of knowledge of key topics in ecoagriculture.

Diverse types of "ecoagricultural" landscapes are being developed by innovative farmers and scientists, and indigenous land managers to generate co-benefits for production, biodiversity, and local residents.

"Strategies to Exploit Ecological Disturbance," the chapter co-authored by Dr. Sendzimir and Ms. Zsuzsa Flachner of the Hungarian Academy of Sciences is subtitled "River floodplain polyculture—exploiting flooding as an engine of biodiversity in the Tisza River Basin."

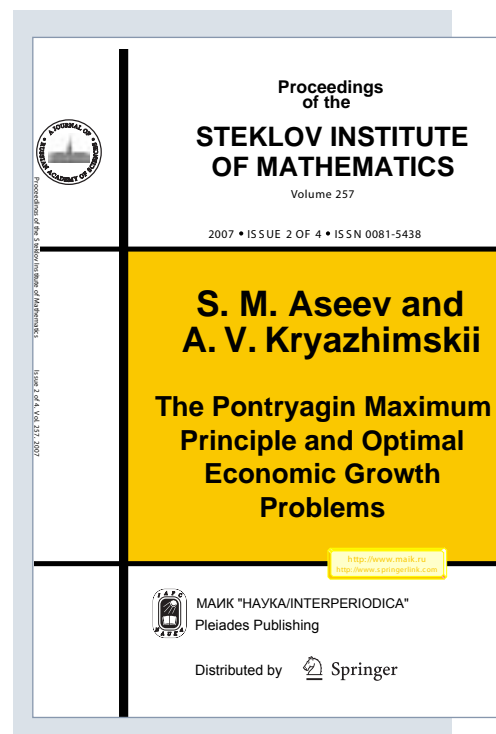
Say the authors: "While it may be counter-intuitive to any society that has used technology to minimize disturbance, some socio-ecosystems did exist [in the Tisza River Basin] where appreciable biodiversity levels were maintained by disturbance." Sophisticated cultures could integrate economic and ecological processes to exploit disturbance, riding it like a wave. ■

IIASA's Risk & Vulnerability Program
www.iiasa.ac.at/Research/RAV

MATHEMATICS

Optimal economic growth problems

Arkady Kryazhimskii, the leader of IIASA's Dynamic Systems Program, co-authored an article with S.M. Aseev, also of IIASA and the Russian Academy of Sciences, that appeared in the *Proceedings of the Steklov Institute of Mathematics* in July this year. The article, on the Pontryagin maximum principle and optimal economic growth problems, is devoted to the theory of the Pontryagin maximum principle as applied to a special class of optimal control problems that arise in economics when studying economic growth processes.



The approach proposed is applied to the analysis of the problem of optimal economic growth of a technological follower, a country that absorbs, in its technological sector, part of the knowledge produced by a technological leader. By optimizing its growth performance, the technological follower dynamically redistributes available labor resources between the manufacturing and research and development sectors of the economy. This problem is of independent interest in endogenous economic growth theory. ■

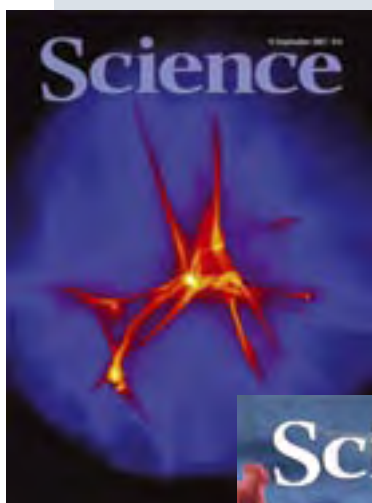
IIASA's Dynamic Systems Program
www.iiasa.ac.at/Research/DYN

SCIENCE ARTICLE

Limitations to climate change consensus

Brian O'Neill, leader of IIASA's Population and Climate Change (PCC) Program and co-leader of IIASA's Greenhouse Gas Initiative (GGI), together with three co-authors, Michael Oppenheimer, Mort Webster, and Shardul Agrawala, have criticized, in a recent *Science* article (14 September 2007), the emphasis on consensus in reports of the Intergovernmental Panel on Climate Change (IPCC). While agreeing that the accomplishments of the IPCC have been "singular," the authors believe that the reports focus too much on expected outcomes and "numerical estimates," excluding the more extreme possibilities that consensus may disregard or downplay. The search for consensus by the IPCC, say the authors, is no longer as crucial for governments as the full exploration of uncertainty arising from increasing and rapid dynamic processes in the environment. ■

IIASA's Population and Climate Change Program
www.iiasa.ac.at/Research/PCC



SUSTAINABILITY

Learning from seasonal climate forecasts

In Africa meteorologists and representatives from government ministries, non-governmental organizations, and businesses have negotiated seasonal climate forecasts for the last ten years. The aim is to provide an indication of rainfall 3 to 6 months in advance to benefit climate-sensitive sectors such as agriculture and water-resource management.

Anthony Patt, research scholar in IIASA's Risk and Vulnerability Program, has led an assessment of climate forecast applications in Africa, commissioned by the US National Oceanic and Atmospheric Administration. The key findings have appeared in a recent *Science* article (5 October 2007), co-authored by Laban Ogallo of Kenya and Molly Hellmuth of Columbia University, formerly of IIASA. They point to the successes and failures, and the institutional factors that have made the difference. ■

IIASA's Risk & Vulnerability Program
www.iiasa.ac.at/Research/RAV

FOREST PRODUCTIVITY & GROWTH

Russian forestry CD

Over 15 years of research on Russian forestry is now available on a CD-ROM, compiled and published by IIASA's Forestry Program.

It was in the mid-1990s that IIASA's Forestry Program first began to develop a modeling framework for the pan-Russian analysis of forest productivity and growth. At the same time, huge databases were assembled in Russia based on growth information collected from experimental plots, growth investigations of different kinds, and other important research.

Though the first Interim Reports on this activity were presented in 1996, the work has continued. During the last 10 years new models have been developed for individual species, and additional data have been collected with the goal of achieving a reliable basis for analyzing the growth and productivity of the main Russian forest species at the pan-Russian level. The significance of this work—a multi-person, multi-year effort on the part of the Forestry Program and its colleagues in Russia—has been heightened by the increasingly important context of global change.

The CD-ROM includes a selection of some of the very diverse information available on forests and forest management in



Russia, models, and tables. The Russian Federal Forest Service has provided a careful professional analysis of the materials and has recommended their practical use within Russian forestry and forest management. With this goal in mind, the Russian Federal Forest Service has published an 800-page book that includes models and tables from the CD. The book is in Russian, with an English summary and explanations so that it can also be used by English-speakers. Ten thousand copies of the book are being distributed to all Russian forest enterprises.

It is hoped that the CD-ROM, containing information that makes future analysis of one of the world's largest wood baskets possible, will also be of use to those in the international scientific community working on different aspects of research in Russian forestry and the forest sector. The CD-ROM's contents are available online. ■

www.iiasa.ac.at/Research/FOR/forest_cdrom

NEW IIASA RESEARCH AREA

MICDIF models microbes

This year IIASA's scope of research has been expanded to a new field of science. IIASA's Forestry Program is a driving force in MICDIF, a project linking microbial diversity and functions across scales and ecosystems. The project includes development of a new model for better predictions of decomposition of organic material and nitrogen mineralization in soil and water, which are processes crucial for ecosystem responses to climate change, as well as for agricultural production.

The aims will be reached by integration of experimental work and theoretical insight to understand microbial interactions. IIASA modelers will integrate and interpret the substantial experimental work performed by leading experts in microbial ecology, biology, and chemistry from 10 different research groups in Austria and Switzerland.

A recent meeting at IIASA focused on development of new modeling concepts, including optimal behavior and microbial biofilms and their impact in the coming experiments. Microbial biofilms, microbes building layers of protective polymeric substances, are well known in aquatic environments but not, until recently, recognized as also playing a role in soils. ■

MICDIF network: www.micdif.net

CLIMATE INSURANCE

Adaptation to climate risks

In September IIASA, Munich Re, and the German Agency for Technical Cooperation (GTZ) co-organized an expert workshop on Insurance Instruments for Adaptation to Climate Risks. The workshop, which took place at IIASA, was part of the activities of the Munich Climate Insurance Initiative (MCII) and was supported by the EU integrated project on Adaptation and Mitigation (ADAM).

Experts from the climate-change, development and donor communities, including the private sector shared ideas and experiences on supporting insurance-related instruments as a strategy for adapting to climate change. Among the issues addressed were: (1) the viability of public-private insurance systems serving the poor; (2) the role of international climate and development organizations, and the private sector in supporting insurance in developing countries; and (3) the potential for linking public and private-sector institutional agendas for raising capital.

It is envisaged that the discussions stemming from this workshop will contribute to developing options within and beyond the post-Kyoto regime. ■

IIASA's Risk and Vulnerability Program
www.iiasa.ac.at/Research/RAV

TRADE, SOCIETY, AND ENVIRONMENT

Chinese agricultural transition

IIASA's Land Use Change and Agriculture Program is working with five international partner institutes in a three-year EC-funded project launched in early 2007. The CATSEI (Chinese Agricultural Transition: Trade, Social and Environmental Impacts) project investigates the impact of China's current economic transition on its agricultural economy with special reference to the consequences of trade liberalization and of changing trade flows. The project will track impacts on social conditions and on the environment in China's rural areas, as well as on markets in the rest of the world, with particular emphasis on the EU. The research opts for a quantitative approach, supplemented by qualitative investigations, and focuses on three themes: trade, social conditions, and environment.



The trade component will consider China as an integral part of the world economy and study the impact of changes in China's trade volumes on the world markets, especially from the European Union point of view. A linkage will be established between three major models: the Chinagro welfare model, the GTAP-model of world trade, and FEA-27, a model of the European Union's agriculture for 27 member states.

The research on social conditions will link geo-referenced household surveys to a population census of China and a detailed geographical data set to trace impacts at the household level.

CATSEI's environmental component, led by IIASA, will further develop major environment-economy interlinkages along three separate lines: water, emissions/pollution, and climate change. All three are of critical importance to China's future and already seriously affect the well-being of the population. ■

IIASA's Land Use Change and Agriculture Program
www.iiasa.ac.at/Research/LUC

URBANIZATION

Plurel prefers pop

Together with 31 partner organizations from 14 European countries and China, IIASA's World Population Program (POP) is participating in PLUREL, a large research project on peri-urban land use relationships that will run from 2007 to 2010. The research is funded by the European Commission.

Urbanization is arguably the most significant process of land use change in Europe, with over 70 percent of Europe's population now living in urban areas, a growth of almost 80 percent in 50 years. The most obvious signs of this are the proliferation of built-up areas and the creation of large transport networks. Other visible markers are the establishment of recreational facilities, such as theme parks and golf courses, and the conversion of

farmsteads into residences and hobby farms in near-urban landscapes.

The PLUREL project will develop new generic strategies and planning and forecasting tools essential for developing sustainable rural-urban land use relationships. These will support the analysis of urbanization trends in the EU so that ways of both supporting this process and mitigating its negative impacts can be identified. The PLUREL tools will help improve the quality of life in cities and in peri-urban and rural surroundings. PLUREL will evaluate costs for the implementation of these strategies and help stakeholders to better understand, plan and forecast the interactions between urban, peri-urban, and rural areas. ■

PLUREL project: www.plurel.net

IIASA ANNIVERSARY

IIASA turns 35

In October 1972 representatives of the Soviet Union, United States, and 10 other countries from the Eastern and Western blocs met in London to sign the charter establishing IIASA. It was the culmination of six years' effort driven forward by both US President Lyndon Johnson and USSR Premier Alexey Kosygin. For IIASA it was the beginning of a remarkable project to use scientific cooperation to build bridges across the Cold War divide and to confront growing global problems on a truly international scale.

In October 2007 IIASA celebrated its thirty-fifth anniversary with a reception in its Schloss Restaurant. Over 200 guests, including IIASA alumni and local dignitaries, attended. ■



IIASA's 35th birthday celebration Leen Hordijk, director, cuts the cake for IIASA's alumni, friends, and staff.



NEW NATIONAL MEMBER ORGANIZATIONS

And South Africa makes 19...

Three new national member organizations (NMOs) have joined IIASA this year: on 1 January, India's Technology Information, Forecasting and Assessment Council (TIFAC) and the Pakistan Academy of Sciences (PAS); on 1 July, the National Research Foundation (NRF) of South Africa. This brings IIASA membership to 19.

A *New York Times* article (20 October 2003) on "India's Sizzling Economy" comments on the rapid and highly visible economic progress being made in India. However, India, which is the second most populous country in the world, also has numerous pressing problems, for example, significant overpopulation, environmental degradation, and widespread poverty. Membership of IIASA will bring a fresh impetus to efforts to alleviate these problems. And TIFAC—identified by industry, institutions, and policymakers as a huge storehouse of advanced information on almost all areas of technology—can only add to the Institute's reach, knowledge, and expertise.

One of the well-known disadvantages of globalization is the growing gap between developed and developing nations. All IIASA national member organizations share the latest technologies and know-how, and this brings valuable synergy in a global world where interdependence has become a byword. The new Pakistan NMO, the Pakistan Academy of Sciences (PAS), believes that political instability, population pressure, harsh climate, the import of manufactured goods, and huge national debts have widened the gap between East and West not only economically but also in terms of scientific and technological progress.

Pakistan inherited very few institutions capable of scientific development and technological research at independence in 1947. The last five decades have proved to be a successful catch-up exercise. PAS acts as a forum for advancing research and building human capital in new scientific and technological areas. Indeed, the Pakistani private sector is looking to harness the Academy's technological know-how to gain a competitive edge in international markets and thus start narrowing the economic gap.

The National Research Foundation (NRF) of South Africa, based in Pretoria, is the newest IIASA member. It specializes in astro/space/geo sciences, biodiversity and conservation, nuclear sciences (including particle beam technology and nuclear medicine), calling these fields its "business areas." The practical applications of science are therefore of exceptional importance to the NRF, and it places great emphasis on the building of human capital through lifelong learning in science-related fields as an investment in the country's future. Scientific progress is, according to the NRF, a way of improving the quality of life for all South Africans.

This is an important aim. Although apartheid ended almost 15 years ago, its legacy remains and millions of South Africans, mostly black, continue to live in poverty. South Africa's United Nations Human Development Index has also fallen dramatically in the last decade, much of this attributable to the AIDS pandemic in the country.

Forging strategic partnerships locally and internationally is part of the process of improving the quality of life, and in joining IIASA, NRF is extending the resources needed by researchers to foster and expand the country's research capabilities.

Globalization has posed many challenges to the international community. Problems are more diffuse, more complex. They can no longer be addressed by countries on an individual basis, and the solutions often lie in the realm in which IIASA excels. This is one reason why we have seen a resurgence of interest in joining IIASA and why we expect it to maintain its momentum in the coming years. ■

India's Technology Information, Forecasting and Assessment Council: www.tifac.org.in

Pakistan Academy of Sciences: www.paspk.org

National Research Foundation of South Africa: www.nrf.ac.za

CITIES

Grand challenges for engineering

Turning cities into forces for good in the environment

The world is becoming ever more populous and urbanized. Cities are inherently unmitigated environmental “evils”; with no extenuating circumstances; like bulls in china shops. Man’s burden on the environment—woe, that it is—will continue to be piled upon woe. So runs the popular mind-set.

Yet things do not have to be this way, no matter how hard it may be today to conceive of cities as forces for good in the environment. Far from infrastructures having to take on the burden of compensating for the ills of cities, the two should “act” deliberately to contribute positively to enhancement of the environment around them. That is our grand challenge for engineering; and this is how we might begin to think of responding to the challenge.



In introducing their concept of the “urban ecological footprint”—massive, of course, for cities such as Paris, New York, and so on—William Rees and Mathis Wackernagel invite us to conceive of the city as a “large animal grazing in its pasture.” We imagine that animal to be a bull. The “bull” of intense social and economic activity in the city is to be shod, we suggest, with the “padded athletic trainers” of re-engineered infrastructures and imbued with a technological deftness and intelligence sufficient for restoring the business of running the environmental “china shop” in which it charges about—indeed, profitably expanding the shop’s operations.

The city, continuing the large grazing animal analogy, takes in its daily grass and daily water, while we, for readily understandable but increasingly unsustainable reasons, have engineered the return of the residuals of this metabolism to the air, water, and land environments surrounding the city. In the Global North, a good deal of the city’s daily water is used to remove the residuals of its daily grass as wastewater so that citizens can lead healthy and productive lives. And much technological effort has been invested in treating that wastewater, not always to the better of the air, missing an opportunity to benefit the land, while not being a wholly unmitigated good for the water environment. In short, wastewater treatment in the Global North can end up shunting nitrogen into the atmosphere, to avoid fertilizing the aquatic environment, while we labor awfully energetically with the Haber-Bosch process to pull that nitrogen out of the atmosphere to produce industrial fertilizer.

How, then, can the built infrastructure be re-engineered to restore the natural capital and ecosystem services of the nature that inhabited the land before the city arrived there; how can it be re-engineered to enable the city to act as a force for good, to deliberately and positively compensate for the ills of the rest of man’s interventions in nature? And how can cities of the Global South avoid adopting the same technological trajectory? Can they, as it were, “leapfrog” the Global North by foregoing the entire human-waste-into-the-water-cycle phase, and thereby end up one step ahead?

More profoundly, how can the engineering of city infrastructure be deployed expressly so that those at the bottom of the pyramid of dignified human development may be brought to a level where they care to engage in a debate over such a grand challenge for the next century—of cities as forces for good—beyond their desperate needs of survival for just today and tomorrow? ■

Further information This essay is part of a project by the US National Academy of Engineering to determine the Grand Challenges for Engineering during the next 100 years: www.engineeringchallenges.org

Professor Paul Crutzen (Nobel Prize for Chemistry), **Professor M. Bruce Beck**, and **Dr. Michael Thompson** are all Institute Scholars at IIASA. They also research at the Max Planck Institute for Chemistry, University of Georgia, and University of Oxford, respectively.

AIR POLLUTION

Cleaning Europe's air without burdening economic development

IIASA scientific model guides successful multilateral treaty to protect environment

Twenty years ago acid rain ravaged Europe turning trees yellow and killing thousands of fish. Caused by air pollution, acid rain is now under control in Europe, thanks, in part, to the crucial role played by IIASA.

Today, air pollution remains harmful but its effects, such as causing respiratory diseases, are often less visible. Fortunately, plans now in place will clean Europe's air over the coming fifteen years adding, on average, three months to the lives of people living in Europe through improved health. Once again IIASA's research has played a vital role.

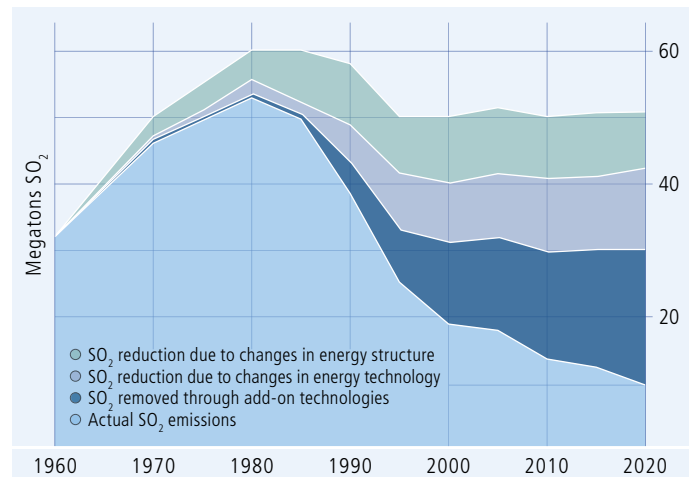
Cleaning up Europe's air is not easy. It requires an effective environmental policy to reduce air pollution in over thirty European countries. And making the policy requires resolving complex scientific and political issues.

An effective policy must consider all the numerous sources of air pollution, ranging from agriculture through industry to transport. Measures to tackle air pollution must be equally numerous. A successful policy must understand the range of air pollutants which, individually and in combination, have multiple effects on the environment. Air pollutants are blown across national boundaries meaning the many countries must agree on the same policy. But each country generates different amounts of air pollution and feels the effects of air pollution unequally.

Yet policymakers have overcome these difficulties with the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe. It is one of the oldest and most successful multilateral treaties protecting the environment, with targets that have led its Parties to slash their emissions of air pollutants drastically. For example, over the past 20 years sulfur dioxide emissions in Europe have plunged by more than 60 percent (see figure).

What was and is the secret of the Convention's success? The answer is the close collaboration that took place between scientists and policymakers who negotiated it. And guiding both groups along the way was a scientific tool, developed by IIASA, known as the Regional Acidification INformation and Simulation (RAINS) model. Indeed, RAINS was the first computer model to be at the center of major international environmental negotiations.

With a few hours of training, scientists, diplomats, politicians, and other non-technical users can pose any number of "what-if" questions to RAINS. How much would it cost to reduce ozone levels to a given standard for all of Europe? For the worst-affected



In 1994 the IIASA RAINS model underpinned the agreement of 33 European governments to reduce damaging sulfur dioxide (SO₂) emissions, when the Second Sulphur Protocol to the Convention on Long-range Transboundary Air Pollution was signed in Oslo. Also known as the Oslo Protocol, it contributed to the sharp decrease in SO₂ emissions during the 1990s.

areas only? What is the cheapest way to stop acidification of forest soils in Bohemia?

With answers to such questions, RAINS has helped European governments agree on increasingly sophisticated environmental policies. The model showed that if the goal is to protect the environment at the lowest cost, making the traditional uniform cuts in emissions across countries is neither efficient nor effective. RAINS helped governments find a more targeted approach leading to the Second Sulphur Protocol to the Convention and subsequent reductions in acid rain.

Such successes persuaded the Convention's Parties (33 European countries) to ask IIASA to further develop RAINS. They and IIASA scientists wanted to move away from artificially isolating air pollutants in separate agreements to making policies that address a complex range of related air pollutants and problems simultaneously.

The resulting Gothenburg Protocols further reduced Europe's problems of acid rain and ozone pollution both quickly and at the lowest cost. Today, RAINS is central in tackling health problems associated with air pollution in the European Commission's Thematic Strategy on Air Pollution for Europe.

RAINS has come a long way since IIASA began developing it in 1983. But without IIASA's approach of bringing together interdisciplinary and international researchers to work on problems that cross national borders, RAINS would not have been possible. ■

Further information Hordijk L & Amann M (2007). How Science and Policy Combined to Combat Air Pollution Problems. *Environment Policy and Law* 37/4: 336–340. Available as Reprint RP-07-002 in IIASA's online publication catalog at www.iiasa.ac.at/Publications.

Professor Leen Hordijk is the Director of IIASA and **Dr. Markus Amann** is the leader of IIASA's Atmospheric Pollution and Economic Development Program.

The growing divergence in population trends and concerns

New IIASA world population projections for the 21st century

Not surprisingly, the global demographic landscape is difficult for many people to comprehend. In some parts of the world, rapid population growth continues to be a major source of concern, with populations likely to triple in some places over the course of this century. In some areas—predominantly Eastern Europe—the population has actually started to decline, causing great concern among governments and the public there.



2001 PROJECTIONS “The End of World Population Growth,” the set of probabilistic world population projections published by IIASA’s World Population Program (POP) in *Nature* in 2001, was generally greeted as good news for the planet. According to POP’s research, the clearly unsustainable growth in human numbers in a finite environment would reach a benign end through voluntary family limitation rather than the often-predicted Malthusian check of increasing death rates. While the findings were cause for optimism at the global level, they were partly misinterpreted. In fact, some people believed that population concerns at the regional and national level were now no longer justified.

Nothing could be further from the truth. Indeed, for different reasons in different parts of the world, concern over population is rising. In Africa, there is mounting evidence that continuing “explosive” population growth is a key obstacle to the eradication of poverty and to improving education. At the same time, countries with rapidly aging and shrinking populations worry that their social security systems will be overburdened and that the welfare of their citizens is at risk. This bifurcation in terms of demographic trends and associated concerns has actually become more pronounced since 2001. ►

Reconstructing and projecting the population by level of educational attainment

IIASA's World Population Program has pioneered methods of multi-state population projections that it has recently applied to modeling the dynamics of growing human capital.

In this methodology, the population is structured by the level of educational attainment in addition to age and sex. The fact that people with different levels of education tend to have different levels of fertility and mortality is also taken into account. POP has finished a reconstruction of the populations of 120 countries for the period 1970–2000 for four educational attainment categories by 5-year age groups of men and women. This fully consistent and very detailed new dataset is, in several respects, superior to other datasets that have been used to estimate macro-level economic returns to education. Indeed, the first applications of global economic growth regressions to these new data have already shown the consistently positive and significant effects on rates of economic growth of improving the educational status of the working age population.

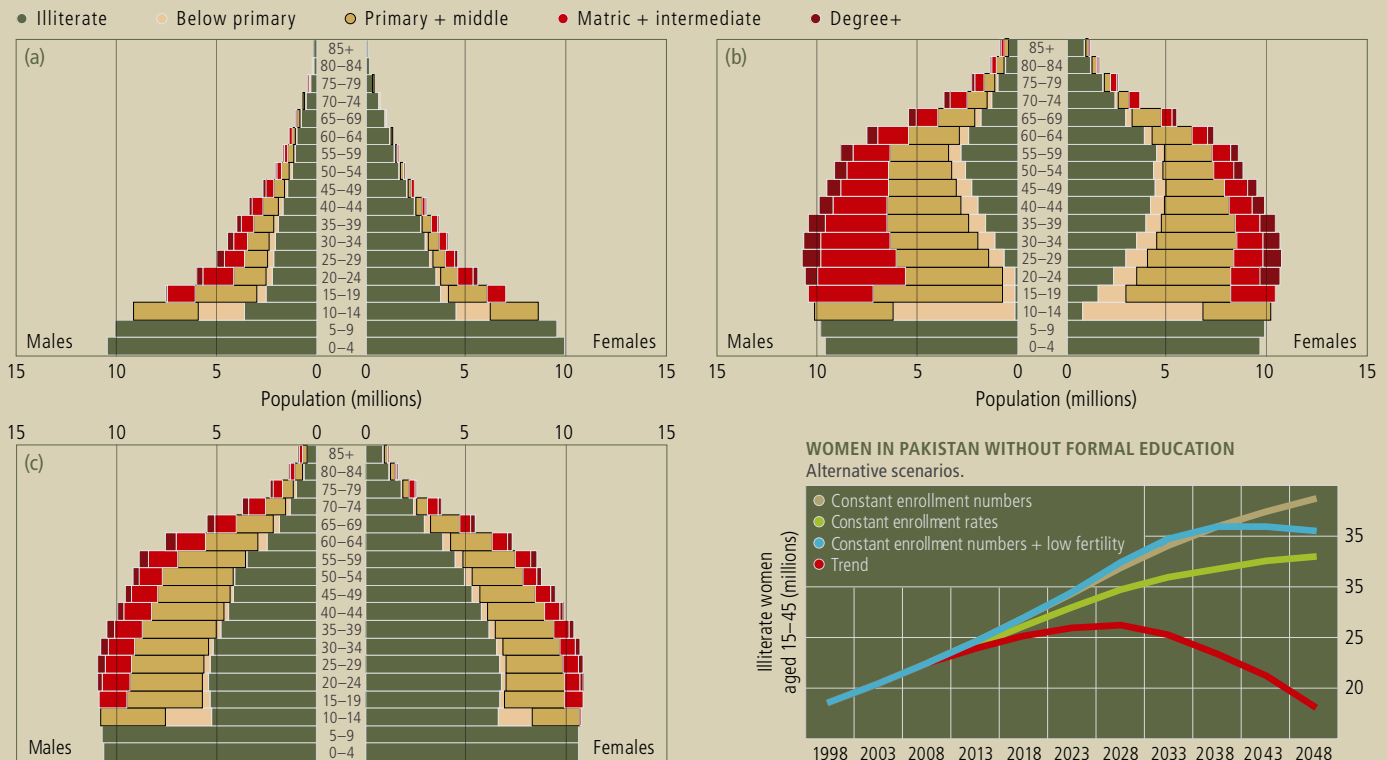
The methods are currently being applied to produce policy-relevant scenarios on future educational attainment distributions for all countries. The figures here illustrate one such application for IIASA's new member country, Pakistan.

Pyramid (a) shows the age pyramid by level of education for 1998, the year of the last census. This pyramid is a comprehensive reflection of recent demographic and

and take the place of the less educated elderly. Hence, the recent improvements in education among younger Pakistanis have laid the basis for a better educated future adult population, even if enrollment rates do not improve further. However, the human capital in Pakistan in 2048 looks much better if the trend of educational expansion continues, as is shown in the other pyramid.

A comparison of the pyramids of 1998 and 2048 also illustrates the massive population growth that Pakistan is likely to experience. Its population size is projected to increase from 136 million in 1998 to around 290 million in 2048, more than doubling. A comparison of Pyramids (b) and (c) also shows that the pyramid is somewhat broader at the bottom in the case of constant enrollment rates than in that of continued improvements in education. This is because less educated women have higher birth rates than more educated women, and this results in more children in the case of no further improvements. But the interaction goes both ways. High fertility also makes it more difficult for the education system to enroll the rapidly increasing number of children in school. Hence in Pakistan—as in many other countries, particularly in Africa—declines in fertility through improved reproductive health services will also make it easier to meet the national and international education targets. This is also illustrated in the chart, which gives the number of women without any formal education under alternative scenarios. In addition to the two scenarios described above

POPULATION PYRAMIDS FOR PAKISTAN (a) By age, sex, and level of education, 1998; (b) Continuation of improving trend scenario, 2048; (c) Constant enrollment scenario, 2048.



education trends in Pakistan. It shows a very young population age structure with children aged 0–4 being the largest age group because of continued high fertility. It also shows the education of the younger generations improving in quality, with the majority of the adult population lacking any formal schooling. This is particularly true of women and is due to a major gender gap in education.

Pyramids (b) and (c) show alternative scenarios for the year 2048. Pyramid (c) assumes that school enrollment rates remain constant at their current level, and Pyramid (b), which extrapolates from the recent improvement trend, assumes continued improvements in school enrollment. It is interesting to see that even the constant enrollment scenario results in a significantly better educated adult population over the coming decades. There is a great momentum in improvements in the educational structure where education is concentrated at young age, but it takes decades before the better educated young cohorts move up the age pyramid

they show two others in which the more pessimistic assumption is made that the education system can only keep the absolute number of students constant and will not even be able to absorb a constant proportion of the increasing number of children. The fourth scenario combines this with the assumption of an exogenous fertility decline. It shows that even under the pessimistic education assumption this fertility decline will contribute to improving the educational profile of the adult population in the longer term because a higher proportion of the fewer girls will have a place in school.

Demographic trends and improvements in educational composition are not only closely dependent on each other, but also follow the same laws of population dynamics. This is why IIASA's World Population Program for the period 2006–2010 has chosen a research focus on human capital. We will soon publish the world's first global education projections in addition to our probabilistic projections. ■

NEW PROJECTIONS In mid-2007 POP produced a new set of world population projections using the same long-term assumptions about the future levels of fertility, mortality, and migration as in the 2001 study, but incorporating all the new empirical evidence that has become available between 2001 and now.

Trajectories of population growth have a strong path dependence. Thus, an extra six years of empirical trends at the beginning of the century have the potential to greatly influence the range of likely outcomes by the end of it. The new results show that there are indeed significant changes in the outlook for certain regions, but as these go in opposing directions and partly offset each other, the aggregate results at the global level remain amazingly stable.

The probability that world population will peak during this century has increased marginally. The period during which the median of the projections reaches a peak (around 2070) and the level of this peak (around 9 billion people) remain virtually unchanged. As Figure 1 indicates, by the middle of the century, the 80 percent uncertainty range for world population is 7.8 to 9.9 billion. By 2100 it further broadens to 6.2–11.1 billion. In other words, there is a more than a 10 percent chance that the world population in 2100 will be

In the latter, two interesting recent developments have critically changed the earlier assumptions made by all international forecasting agencies. First of all, the fertility decline seems to have stalled in a number of important African countries. This coincides with an actual decline in the level of schooling of young adults and worsening health care and family planning services. Second, fewer people than anticipated are dying of AIDS. This has less to do with the rapid spread of anti-retroviral treatment in parts of the continent than with a significant downward correction of the estimates made by UNAIDS of the numbers of people infected with the virus. Put together, a higher starting level of fertility plus a lower level of mortality result in higher population growth, even when the long-term assumptions are left unchanged.

AFRICA'S POPULATION TO DOUBLE As Figure 2 shows, Africa's population will almost certainly more than double from its current level of around 740 million. Because of the great longer-term uncertainties surrounding the future speed of fertility decline and the possible new health crises under the very poor development conditions anticipated, the 95 percent range by the end of the century is very broad, from a low 1.1 billion to a very high 3.3 billion.

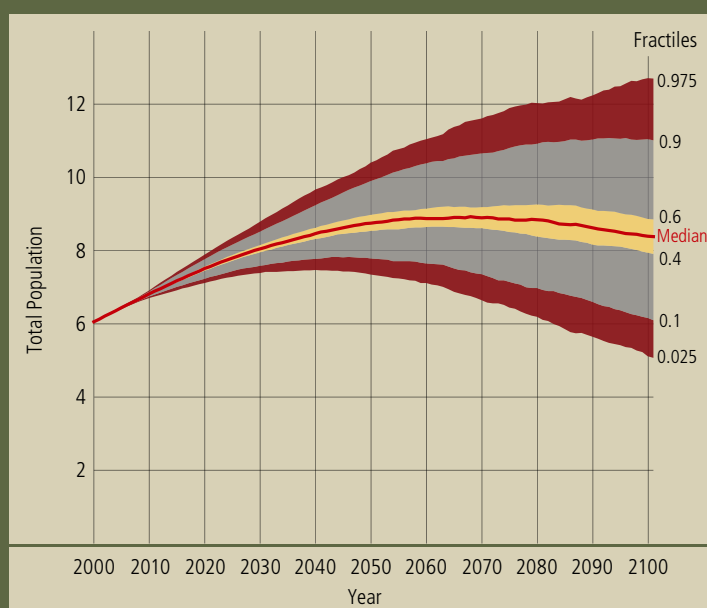


Figure 1. Total population of the world, in billions.

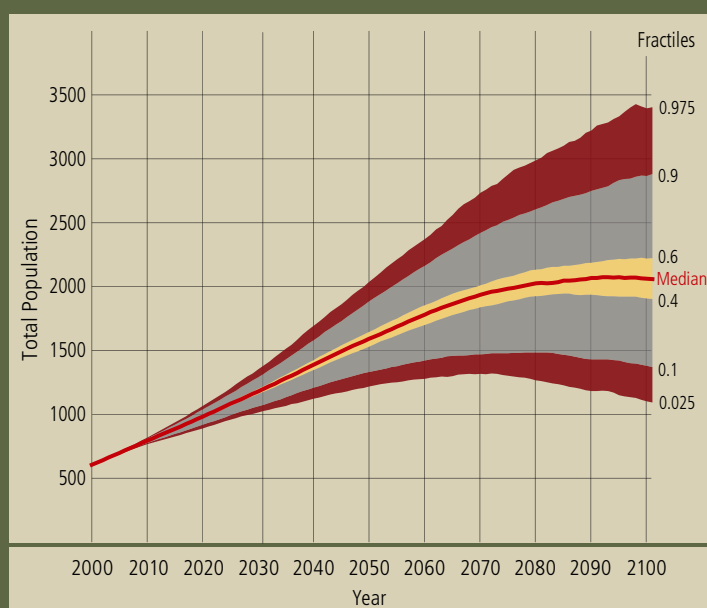


Figure 2. Sub-Saharan Africa population, in millions.

smaller than it is today and an equal chance it could be more than 11 billion. However, a further doubling of world population from currently 6.6 to 13.2 billion is seen as extremely unlikely (a less than 2 percent chance) from today's perspective.

REGIONAL SHIFTS This global picture, however, hides several important regional shifts. Because of continued very low fertility or further fertility declines in some regions that already had low fertility, Eastern Europe and the China region are now shown by the POP research as having lower population growth than was projected in 2001. This is offset at the global level by higher anticipated population growth in sub-Saharan Africa.

The central 20 percent range is 1.9–2.2 billion by 2100. Two factors will in all likelihood keep Africa at the bottom of world development unless some trends change radically in the near future: continued very rapid population growth together with stagnant or declining educational attainment levels (partly as a consequence of rapidly increasing numbers of children), and the additional environmental and agricultural problems likely to be caused by climate change.

EASTERN EUROPE'S POPULATION SHRINKING Eastern Europe and the European part of the former Soviet Union lie at the other extreme. The political changes that took place in 1990 triggered a precipitous fertility decline, together with some mortality increase,

particularly among men. However, these regions already had a fairly old age structure. In 2001 it was assumed that these extremely low levels of fertility (in some cases close to half the replacement level) were only a temporary distortion. Since then, there has been continued low fertility (together with significant out-migration in most of the countries). This has distorted the age structure to such an extent that even in the unlikely event of a return to replacement-level fertility, there would be a population decline because fewer and fewer women are entering reproductive age. In 2001 we were already projecting a significant shrinkage for these regions. However, as is evident from Figure 3, the shrinking is faster and more dramatic. A reduction over the coming decades is a near certainty, and the population size is likely to decline to less than half its current level by the end of the century.

CHINA: FIRST GROWTH THEN SHRINKAGE Finally, China as a region is a very interesting case. It combines near certain population growth in the next decades with almost certain population decline in the longer run. As shown in Figure 4, the history of quite high fertility followed by a very steep fertility decline has resulted in an age

to include not only uncertain future paths but also uncertain starting conditions above the range just indicated. But as the median of this range is still 0.4 children lower than the earlier assumptions, the new outlook for China shows more rapid population aging and shrinkage than just a few years ago, again under the same long-term assumptions. As Figure 4 shows, after an initial increase China's population is likely to be back down to its 2000 level during the 2040s and then, by the end of the century, possibly almost down to half the 2000 level.

Population projections have traditionally assumed that all countries of the world, after passing through the demographic transition, will converge demographically. This has been most obvious in the long-held United Nations assumptions that all countries would converge to replacement-level fertility and eventually even to the same level of life expectancy; moreover, as a result, demographic differentials around the world would disappear.

But on a global level the demographic trends have seen little convergence over the past decades. In fact, over the past few years there has been outright divergence. Regions with already low fertility have seen further declines, and regions with high fertility have shown lower than expected declines. The high level of path

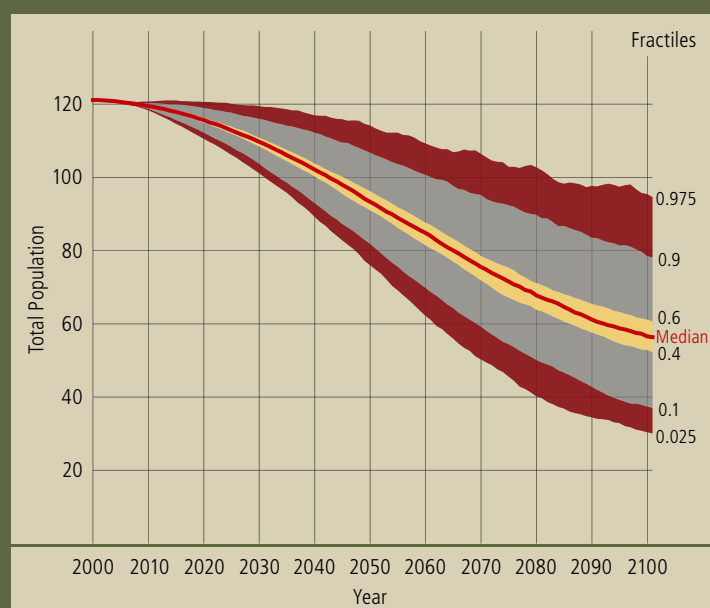


Figure 3. Eastern European population, in millions.

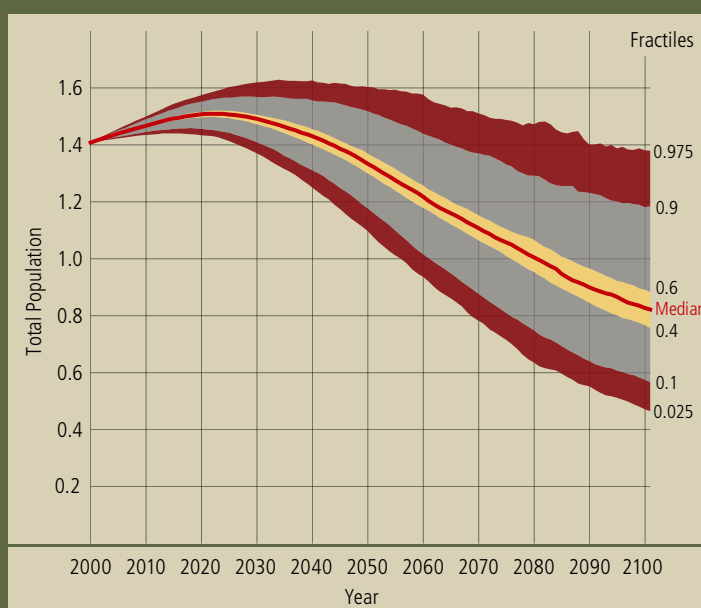


Figure 4. Population of China and Cambodia, Hong Kong, Laos, Mongolia, North Korea, Taiwan, Vietnam, in billions.

structure where age groups of people of reproductive age are still increasing. Currently, this implies some further population growth to around 1.5 billion in the 2020s before a lasting population decline will begin.

The population outlook for China is made more uncertain because there is no consensus among experts as to what the current level of fertility is. In 2001 the general agreement was that the total fertility rate was around 1.9. Since then, there has been mounting evidence that even at the time of the 2000 census it was already much lower—somewhere in the 1.2 to 1.8 range, with the best guess at around 1.5.

To cope with this uncertainty regarding the world's most populous country, POP chose to expand the probabilistic approach

dependency inherent in population growth has already produced a more heterogeneous demographic picture for the twenty-first century. Based on these trends one may also have to rethink, among other things, some of the longer term socio-economic scenarios used for the analysis of climate change. A world where there is little international cooperation may not necessarily be a world with a higher population; it may be a world with rapid population shrinkages in some areas and explosive growth in others. ■

Further information IIASA's World Population Program at www.iiasa.ac.at/Research/POP

Professor Wolfgang Lutz is the leader of IIASA's World Population Program. **Professor Warren Sanderson** and **Dr. Sergei Scherbov** are senior research scholars in IIASA's World Population Program.

The art and craft of systems analysis

Dr. Roger Levien, IIASA's second director, was asked so frequently what systems analysis was that he had a quotation from *Through the Looking-Glass* by Lewis Carroll framed and put up in his office.

It read:

"When I use a word," Humpty Dumpty said, in a rather scornful tone, "it means just what I choose it to mean—neither more nor less."

One should not, I believe, see the framing of these words as a tongue-in-cheek reaction on Roger Levien's part. At the time (the mid-1970s), IIASA was sponsoring a series of books on the state of the art of applied systems analysis, plus a handbook for practitioners, managers, scientists, teachers, and students that would be co-edited by two of the "grand old men" in the field, Edward S. Quade and Hugh J. Miser. In preparation for this research, IIASA circulated a questionnaire on the foundations, arts, techniques, and applications of systems analysis to its member organizations and analysts outside the Institute. There were many responses, but they only served to confirm what everyone knew: there was no common agreement about what systems analysis was. In fact, the answers showed that the conceptual basis of the discipline needed to be enriched and strengthened. The Humpty Dumpty anecdote shows quite clearly, in my view, that IIASA was determined to put its own stamp on the theory and practice of systems analysis at the earliest possible stage.

Systems analysis sounds as if it should be rocket science, but at Wageningen University in the Netherlands I taught it as a first-year course to my students. To explain what systems analysis is all about, I usually took a page out of the Quade and Miser handbook and began by saying what it is not. It is not synonymous with modeling. It does not only involve classifying systems or discovering properties common to categories of system. It is not something used to discover the nature of social or environmental ills. It is not just a branch of applied mathematics. It is also not a science, although science and technology are its cornerstone.



HUMPTY DUMPTY sat on a wall in the classic *Through the Looking-Glass* by Lewis Carroll—English logician, mathematician, and novelist. Illustration by John Tenniel, 1871.



Systems analysis at IIASA is, in fact, a problem-solving process in which many people take part: scientists of relevant disciplines, stakeholders, and decision makers. These are not just problems per se, but problems along with all the attendant factors and concepts they encompass. To quote Quade and Miser, these factors include: "the knowledge and methods of modern science and technology, in combination with concepts of social goals and equities, elements of judgment and taste, and appropriate consideration of the larger contexts and uncertainties that inevitably attend such systems." It can thus be said that systems analysis has both a quantitative and a qualitative side.

The central purpose of systems analysis is to help private decision makers and public policymakers resolve the problems that they face in the short, medium, and long term. The problems we address at IIASA are large-scale socio-technical problems—problems affecting the future of the human race, the planet on which we live, the energy we use to cook our food and to run our industry, human health, air quality, changes in the biosphere—problems of such immensity, complexity, and urgency that to neglect a single aspect could be very costly, and not just in monetary terms.

Perhaps part of what led to the confusion faced by visitors to Roger Levien's office in the 1970s is that the form of systems analysis is constantly transforming as it adapts

to diverse problems and differing contexts. It is not static. However, to those who ask: "What does IIASA do?" or "How does IIASA work?" I believe it is possible to "explain" systems analysis using a nine-step framework.

First, we marshal all the information and scientific knowledge available on the problem in question; if necessary, we gather new evidence and develop new knowledge. Second, we determine what the goals of the stakeholders are, both of the people and the institutions. Third, we explore different alternative ways of achieving those goals, and we design or invent new options, where appropriate. Fourth, we reconsider the problem in light of the knowledge accumulated. Fifth, we estimate the impacts of the various possible courses of action, taking into account the uncertain future and the organizational structures that are required to implement our proposals. Sixth, we compare the alternatives by making a detailed assessment of possible impacts and consequences. Seventh, we present the results of the study in a framework that facilitates choice by the stakeholders. Eighth, we provide follow-up assistance. Ninth, we evaluate the results. Please note that computer modeling is a useful device in helping obtain answers at any of the above stages.

Systems analysis has been the most helpful in addressing issues dominated by science and engineering, for industrial or military applications. It also works well with budgetary decisions where it points to the most cost-effective courses of action. It is more problematical where political, organizational, and social factors predominate and where goals may be obscure and authority diffuse and overlapping. As well as being used to craft good solutions, systems analysis can also be an art in terms of achieving an often delicate balance that satisfies multiple stakeholders.

While systems analysis like any other human endeavor has its limitations and there are other means available to assist the decision maker, it does have a number of virtues. It introduces a certain objectivity into the subjective process of decision making and thus can help with acceptance and implementation of decisions; it can take uncertainty explicitly into account; it determines interactions and side effects; it may reveal unexpected consequences of policies and actions; it may provide insight into issues and suggest better alternatives.

As will have been noted, systems analysis is itself inherently multi- and interdisciplinary. IIASA, as a specialist in systems analysis, is structured to reflect this way of thinking and researching.

Finally, to return to *Through the Looking-Glass*, where this article began. Humpty Dumpty, as we all know, eventually fell off his famous wall. Before doing so, however, he explained a word to Alice that she had not been able to understand. That word, of course, was "Jabberwocky."

Systems analysis at IIASA is making an important—even essential—contribution to solving some of the world's most complex problems, as will be seen in the other pages of *Options* and at our Conference. I hope that this short piece will prove helpful to those readers who automatically think "Jabberwocky" when the term "systems analysis" is mentioned! ■

Further information Miser HJ & Quade ES eds. (1985). *Handbook of Systems Analysis*, Volume 1. New York: John Wiley & Sons.

Professor Leen Hordijk is the Director of IIASA.

A favorable climate for insurance

An evaluation of a weather-related insurance program in Malawi offers lessons for reducing farmers' vulnerability to drought and other climate-related risks in highly exposed regions of the world

Africa is already particularly vulnerable to climate variability. In the last year alone, some 25 million people in sub-Saharan Africa faced weather-related food crises. And in Southern Africa drought and adverse weather caused much of the recent hunger experienced there (Table 1).

But climate change is set to make many of Africa's problems worse. Faced with climate change impacts ranging from droughts and heat waves to windstorms and other weather extremes, scientists argue that many of Africa's dry areas will become drier and its wet areas wetter. It is forecast that by 2020 between 75 and 250 million Africans will suffer from too much or too little water. In some African countries, yields from rain-fed agriculture could fall by half by 2020.

In the short term, the recent introduction of weather-related insurance programs in Africa, including an index-based insurance pilot program in Malawi, is offering smallholder farmers some security against the high risks of drought. If successful, innovative insurance systems of this type may provide a blueprint for reducing vulnerability to drought and other climate-related risks in other highly exposed regions of the world. Indeed, such schemes could prove key in terms of assisting developing countries in adapting to climate change and thus reducing disaster risk. For example, it could encourage farmers to develop agricultural practices that are capable of withstanding changing climates.

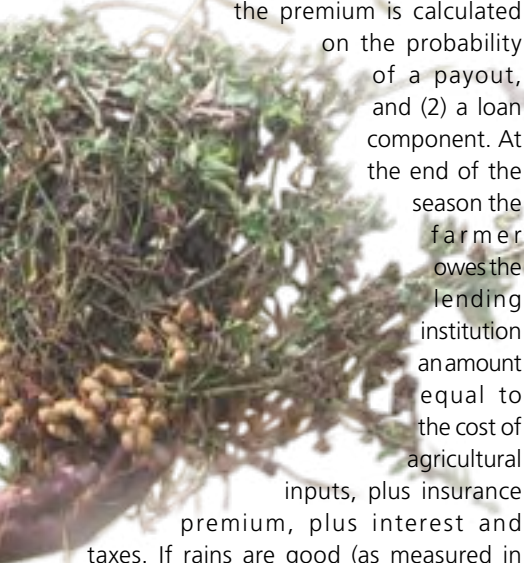
As a result, the World Bank asked IIASA's Risk and Vulnerability Program to evaluate a microinsurance pilot program for Malawi launched in 2005 by the Bank with technical assistance and other support. IIASA's researchers also investigated if the microinsurance scheme could be scaled up to provide security to vulnerable farmers around the world.



Table 1: Persons affected by hunger in Southern Africa

	Reasons, 1999	Reasons, 2000	Reasons, 2001	Reasons, 2002	Reasons, 2003
Angola	Civil strife	Civil strife	Civil strife	Civil strife	Civil strife
Lesotho				Adverse weather	Drought, frost
Madagascar		Floods, cyclones		Drought, economic problems	Drought, economic problems
Malawi				Adverse weather	
Mozambique	Drought in parts	Floods, cyclones	Drought in parts	Drought in parts	Adverse weather
Swaziland				Drought	Drought
Zambia			Adverse weather	Adverse weather	
Zimbabwe				Drought, economic disruption	Drought, economic disruption
Approximate number of affected persons (thousand)					
Southern Africa	1 825	2 350	4 425	16 700	9 500

Source: Hess and Syroka, 2005 Weather-based insurance in Southern Africa: The case of Malawi. *Agriculture and Rural Development Discussion Paper No. 13*. Washington, DC, Agriculture and Rural Development Department, The World Bank.



The Malawi scheme offers index-based weather insurance to smallholder groundnut farmers. While conventional crop insurance is written against actual losses, this scheme is written against a physical trigger, such as insufficient rainfall at key points in the growing season. In other words, the insurer will pay out if rainfall falls below a specified level regardless of crop damage: index-based insurance is against events that cause loss, not against loss itself.

Under this scheme, participating farmers are provided with improved agricultural inputs (i.e., seed) before the rainy season through a contract that specifies (1) an index-based weather insurance component, in which the premium is calculated on the probability of a payout, and (2) a loan component. At the end of the season the farmer owes the lending institution an amount equal to the cost of agricultural inputs, plus insurance premium, plus interest and taxes. If rains are good (as measured in a nearby weather station operated by the meteorological service), then the insurance company keeps the premium and farmers pay back the loan with proceeds from the (presumably good) harvest. If measured rains are below certain trigger values (based on critical stages of the groundnut growing season), then the insurance company pays part, if not all, of the loan to the bank.

By improving farmers' creditworthiness, this scheme also improves their ability to access credit for investing in higher yield/higher return crops. Banks typically have considered lending to farmers with no collateral as being excessively risky because of the high risk of loan default in the aftermath of droughts. By coupling bank loans with index-based weather insurance, farmers can receive the requisite credit for seeds and other agricultural inputs, and they can expect a net gain after repayment of the coupled loan–insurance contract.

Some 892 farmers took part in the first Malawi pilot and more than 2,500 signed up for the second season. In a survey of participating farmers carried out by IIASA,

86 percent said they would participate again, more than two-thirds indicated that they had encouraged other farmers to join the scheme the following season, and 62 percent answered that they were better able to cope

Table 2: The most and least trusted elements of the Malawi micro-insurance scheme

	Trust the most (%)	Trust the least (%)
Rainfall measurements	1	27
Club members	12	3
NASFAM	46	30
Insurance company	10	11
Lending institution (OIBM or IFRC)	23	15

Source: Suarez *et al.* (2007).

with drought and food shortages if they were in the insurance scheme. But the survey also highlighted less successful aspects of the scheme. Many participating farmers, for example, did not fully understand the index-based system and did not wholly trust the institutions in charge. More than a quarter of survey respondents did not trust the weather station data, and other concerns ranged from the quality of the seed to insufficient payment from insurance (Table 2).

Scaling up the Malawi scheme thus faces significant challenges, but the organizing body, the National Smallholder Farmers' Association of Malawi (NASFAM) is currently working to address these, particularly in terms of increasing trust and improving communication.

Can we do better than simply scaling up the Malawi scheme? The clear goal of the current scheme is to use the bundled loan–insurance concept to stimulate a set of climate-sensitive production choices that can reduce long-term drought risk. But a yet more successful scheme, argue researchers from the Risk and Vulnerability Program at IIASA, would take this concept one stage further by using research carried out by Dr. Dan Osgood of Columbia University and collaborators which integrates seasonal rainfall forecasts (based on El Niño–Southern Oscillation (ENSO) predictions) into weather insurance schemes.

Results of researchers' crop simulation modeling and financial calculations show that integrating seasonal rainfall forecasts can lead to substantial increases in gross revenues during La Niña years (when droughts are very unlikely) and thus reduce farmers' long-term vulnerability to climate variability and change.

These modeling techniques could also prove key in addressing climate change impacts over the longer term. Using a combination of climate modeling and dynamic financial modeling, IIASA researchers conclude that climate-change-induced stress will probably decrease the financial robustness of the Malawian insurance pool in the coming decade and, more significantly, 50-plus years into the future. Assuming that farmers cannot pay premiums higher than current levels, additional back-up capital will be necessary to ensure the Malawi program can continue.

The ability to estimate the effects of climate change on the near- and long-term future of microinsurance schemes serving the poor should prove invaluable to insurers and international development communities as they seek to scale up nascent weather insurance systems in Africa and beyond. Indeed, by providing technical assistance and infrastructure, such as weather forecasting stations, international donors can further help to successfully expand the microinsurance schemes. Furthermore, donors can subsidize the insurance payments of the very poor and provide insurance back-up capital for such insurance pools. The particular challenge is to assure the affordability of these schemes for the poor, which provides an opportunity for the donor community to re-orient from post-drought to pre-drought assistance. ■

Further information Suarez P, Linnerooth-Bayer J, Mechler R (2007). Feasibility of Risk Financing Schemes for Climate Adaptation: The Case of Malawi. Report to the World Bank's Development Economics Research Group.

Dr. Joanne Linnerooth-Bayer is the leader of IIASA's Risk and Vulnerability Program. **Dr. Stefan Hochrainer** and **Dr. Reinhard Mechler** are research scholars, and **Dr. Pablo Suarez** is an associate research scholar, all in IIASA's Risk and Vulnerability Program.

Micro insurance in India and South Asia

Building on IIASA's Risk and Vulnerability Program's expertise in analyzing the effectiveness of a micro insurance scheme for groundnut farmers in Malawi (see main article) the program has been asked to conduct similar research in India and South Asia.

In both studies sponsored by international donors, IIASA's researchers provide guidance to consortia of local non-governmental organizations, micro-finance organizations, and research institutes on methodologies for evaluating micro-insurance options.

The Indian study focuses on the drought and flood-prone regions of Uttar Pradesh in Northern India, where monsoon flooding left millions homeless in August 2007. The second study makes a multi-country analysis of micro-insurance schemes in five South Asian countries. ■

Green light for sustainability measures

A well-designed mix of (mostly) environmental policies can result in a win-win situation for both the economy and the environment in Europe

Since the Gothenburg summit in June 2001 the concept of sustainable development has been a dominant guideline for European Union (EU) policy. EU policymakers now demand that concerted efforts be made to link economic, social, and environmental policies to make them more compatible with sustainable development. Moreover, as Europe's environmental decision making clearly has impacts far beyond the borders of the community, EU policymakers are looking for a sustainable development strategy that works not only for Europe but on a global scale.

Tackling an issue of this magnitude is clearly no ordinary endeavor. Since 2003 the ambitious MOSUS (Modelling Opportunities and Limits for Restructuring Europe Towards Sustainability) project has aimed to pinpoint potential sustainable development strategies for Europe by quantitatively assessing the impacts of key environmental policy measures on the use of natural resources (i.e., materials, energy, land) on the one hand, and economic and social indicators on the other. Funded by the European Commission, the MOSUS project was undertaken by a consortium of twelve European research partners, led by IIASA's Land Use Change and Agriculture Program.

The MOSUS project concluded that the implementation of a well-designed mix of (mostly) environmental policies could result in a win-win situation for both the economy and the environment. Contrary to widely held popular belief, environmental policy measures do not need to raise costs, decrease competitiveness, and lower economic performance. Instead, a focus on sustainability could significantly improve the environmental performance of the EU economy in terms of energy and material productivity and emissions of carbon dioxide (CO₂), while at the same time stimulating economic efficiency. The result? Higher economic growth and increased international competitiveness on the part of European industries in international markets.

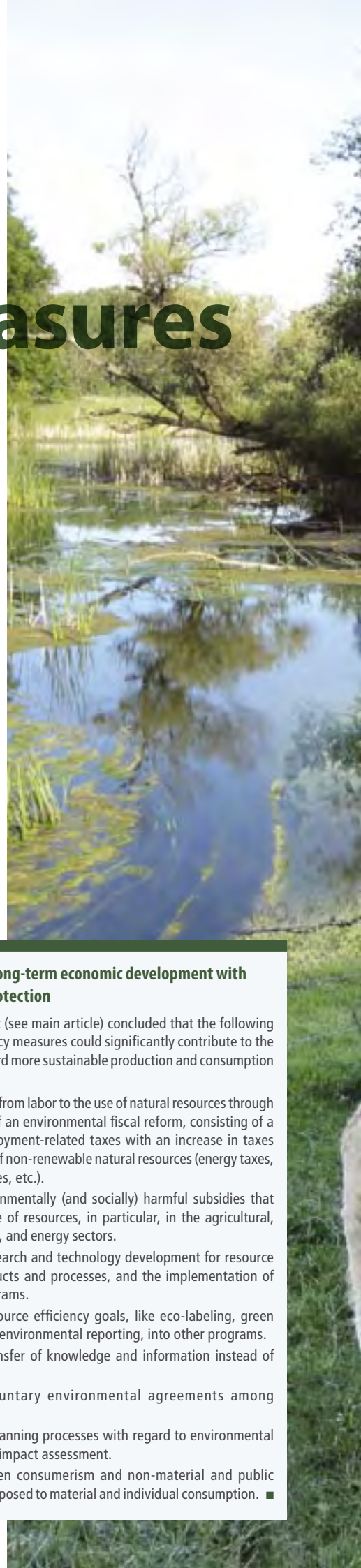
These conclusions are based on a new extensive environment-economic simulation model built and refined for the MOSUS project. The Global INterindustry FORecasting System (GINFORS) was developed to quantify the interrelations between socio-economic driving forces and the state of the environment. This multi-country, multi-sectoral, macro-economic framework includes trade flows within Europe, as well as between Europe and all other economically relevant parts of the world. The GINFORS model is also the first tool to directly integrate comprehensive bio-physical data (material and energy flows, land use data, and greenhouse gas (GHG) emissions) in European and global simulations up to the year 2020 and to relate these to indicators of social and economic development. Data for GINFORS have been drawn from a very wide range of sources. For example, IIASA and the Sustainable Europe Research Institute supplied data on land use and material inputs specifically for the MOSUS project.

Using this improved model, researchers formulated and evaluated different scenarios of the economic and social impacts of key environmental policy measures. These scenarios range from a baseline scenario which

How to reconcile long-term economic development with environmental protection

The MOSUS project (see main article) concluded that the following sustainability policy measures could significantly contribute to the transformation toward more sustainable production and consumption patterns:

- Shift of tax burden from labor to the use of natural resources through the introduction of an environmental fiscal reform, consisting of a reduction in employment-related taxes with an increase in taxes related to the use of non-renewable natural resources (energy taxes, material input taxes, etc.).
- Removal of environmentally (and socially) harmful subsidies that encourage overuse of resources, in particular, in the agricultural, fisheries, transport, and energy sectors.
- Stimulation of research and technology development for resource efficiency in products and processes, and the implementation of best practice programs.
- Integration of resource efficiency goals, like eco-labeling, green procurement, and environmental reporting, into other programs.
- Stimulation of transfer of knowledge and information instead of material goods.
- Fostering of voluntary environmental agreements among industries.
- Improvement in planning processes with regard to environmental and sustainability impact assessment.
- Promotion of green consumerism and non-material and public consumption as opposed to material and individual consumption. ■



Major (land use) categories of the 1×1 km pan-European land use database (used in MOSUS)



projects trends observed between 1980 and 2002 (but with no additional sustainability-orientated policy strategies and instruments put into force) through to a strong sustainability scenario that includes far more ambitious policy goals and instruments. The sustainability scenarios cover a range of future changes including:

- Technological improvements and their impact on agriculture, industry, and energy sectors.
- Government-moderated information and consulting programs that enable firms in the manufacturing sector to reduce their material inputs.
- Replacement of all existing taxes in the transportation sector with a kilometer charge.
- A material input tax and other measures to encourage business to recycle more and reduce their material inputs.
- A carbon tax for CO₂ emissions.

While the overall results from these sustainability scenarios are promising in terms of positive effects for the economy as well as the environment—a win-win situation for both—some important unresolved issues remain. For example, although the implementation of a basket of policy measures results in a significant improvement in the EU's environmental performance (in particular with regard to the achievement of the Kyoto targets), side effects are expected. The policies may shift the environmental burden to other world regions through international trade. The measures analyzed will also not be sufficient to solve high levels of unemployment in Europe.

Moreover, the sustainability policy measures implemented (for European countries only) in the different scenarios have only a limited effect on global trends. Worldwide resource extraction is expected to grow to around 80 billion tons in 2020 in the baseline scenario. But measures introduced in the EU in the strong sustainability scenario would cut world-wide extraction by only 2.1 percent. Moreover, with regard to CO₂ emissions, the largest possible reduction in global figures would be 2.75 percent. This limited impact reflects the fact that other world regions, in particular large emerging economies, will have an increasing impact on global environmental pressures. The European Union share, for example, in global CO₂ emissions will shrink from 14 percent in 2005 to 10 percent in 2020.

The MOSUS project clearly shows that policies aimed at radical improvement of energy and material efficiency in the EU can contribute to key objectives of the EU Sustainable Development Strategy. Yet, these actions will still have limited effect in terms of reducing global environmental impacts. If global unsustainable trends in energy and natural resource use are to be halted and reversed, all other OECD countries plus the big emerging economies must also agree to concerted action on reducing environmental impacts. ■

Further information Further details on the MOSUS project, including the full report, are available at www.iiasa.ac.at/Research/LUC/luc07/External-Mosus

Dipl Ing Günther Fischer is the leader of IIASA's Land Use Change and Agriculture Program, which coordinated the MOSUS project.



From QWERTY to Microsoft

Groundbreaking research by an IIASA scholar in the 1980s pioneered a new approach in economics that helped the U.S. government take legal action against Microsoft. It argues that small, random events could lead a technologically inferior product to dominate the market.

Today nearly every typewriter and computer keyboard in the Western world has the keys Q, W, E, R, T, and Y along the top row of letters. This is not the most efficient or practical way to organize the keys on a keyboard, yet the QWERTY keyboard dominates the market. Why? The winning videotape format, VHS, cornered the market despite its rival format, Beta, being technologically better. Again, why?

In the early 1980s conventional economics didn't provide an answer. Economist and engineer Brian Arthur, however, was convinced he had found it. He applied the concept of increasing returns to high-technology markets. But his pioneering work so challenged economic orthodoxy that it took six years and 14 rewrites before his IIASA working paper, *On Competing Technologies and Historical Small Events*, was published in the professional academic journal, *The Economic Journal*.

So why did the QWERTY keyboard dominate? "Before 1873 typewriters had a variety of keyboard designs including alphabetical order," explains Arthur. "But in 1873 engineer Christopher Scholes designed the QWERTY layout so that most words were spelt using keys from different parts of the typewriter. It was designed to slow down the typist, in order to stop the keys jamming."

"Then the Remington sewing machine factory in New York began to mass produce a typewriter with the QWERTY keyboard. More employers bought the keyboard and made more staff learn to type with it. In turn, this encouraged more manufacturers to produce the QWERTY keyboard, making even more typists learn it and so on, with the result that QWERTY eventually became the standard used by millions of people today."

In the 1980s conventional economics argued that free markets were stable, balancing supply and demand, and that they automatically found equilibrium by choosing the most superior product and making the most efficient use and allocation of resources. And so the case of the QWERTY keyboard was an anomaly.

Arthur argued that the QWERTY keyboard demonstrated something else. It showed a complex economy where small events in the past could, by chance, have enormous implications for the future. The reason is that QWERTY and other keyboard layouts show positive feedbacks to adoption. If more people adopt QWERTY, it gets ahead and other people—new typists, typewriter manufacturers—find it advantageous to go along with this. Advantage begets further advantage, or in economics terminology, QWERTY shows increasing returns. In this way small fortuitous events, such as who chose what first or unexpected orders, can lock an inferior technology into the dominant position in the market for a long time, regardless of the advantages of the alternatives. And, in turn, especially in the high-technology industries, the free market may not select the best products.

Yet in the early 1980s Arthur's work drew hostile responses. "If you are right, capitalism can't work," said one Harvard economist. "Your argument cannot be true," claimed an equally eminent Russian economist.

But Arthur was convinced he was right. While completing his PhD he had worked at the management consultancy McKinsey and saw how Germany's industrial heartland in the Ruhr Valley had built up organically rather than following the predictable path described



The QWERTY layout dominates the Western keyboard. Not because it is the most efficient layout, but because the typewriter market became locked into the inferior layout by chance events in the nineteenth century.

in conventional economic textbooks. In the mid-1970s Arthur's research on fertility and economic development for a U.S. think tank, the Population Council, taught him how deeply economics was intertwined with politics and culture, rather than being simply a matter of supply and demand. Such insights helped persuade him that increasing returns made sense of a lot of otherwise unexplained or unconsidered phenomena in economics.

If Arthur was to convince his academic colleagues, he would need tangible analysis rather than a series of anecdotes. When he arrived at IIASA in the 1970s he began researching outside economics, delving into other disciplines—molecular biology, nonlinear physics, and probability theory. He had first visited IIASA in 1976 and he eagerly returned the next year as a member of the research staff. "The free atmosphere of science, the time available to get work done, the Schloss and its surroundings—all these proved irresistible," he explains. And Arthur was to have an extremely productive time at IIASA over the following six years.

IIASA's unique environment, bringing leading scientists from different disciplines

and countries together in interdisciplinary work, was to be crucial. Indeed IIASA was probably the only place in the world at this time that a researcher such as Arthur could work closely and freely with different disciplines and nationalities. A physicist colleague at IIASA helped him look into the inner workings of liquids and solids. The physics described atoms and molecules interacting in massive numbers, with small initial differences leading to hugely different outcomes. This self-organizing system could arrange itself into a whole series of complex structures, and Arthur was astonished by the similarities he saw to increasing returns.

If physicists could prove what they described with mathematics, Arthur too wanted a mathematical framework to describe what he was observing more and more frequently. At the time many people at IIASA were buying Volkswagens and Fiats. "Suppose these were the only two models available," says Arthur. "You aren't sure which one to buy so you ask a couple of people. It so happens that these two people have VWs and they tell you the car works well. So you also decide to buy one. Now there is one more VW driver in the world. This also means that a future buyer is a little more likely to come across a VW driver. So the buyer is a little more likely to choose a VW

than you were. With enough lucky chances like this, VW can dominate the market."

Arthur asked several professional probability theorists for help in finding a tangible proof. No one could help until a Soviet mathematician stepped forward. Ironically, it was notionally in a Soviet's ideological best interest to show that the free market had flaws. Yet it was only at IIASA that such international research collaborations could take place free from the constraints of national self-interest.

In the early 1980s Arthur shared an office at IIASA with Ukrainian mathematician Yuri Ermoliev, an excellent probability theorist according to Arthur. One day Ermoliev asked Arthur to show him the problem. "I think I have an idea that will point toward a proof," Ermoliev said. Together with another Ukrainian probability theorist, Yuri Kaniovski, they developed a series of path-breaking approaches in mathematics to show increasing returns and how different random events can result in radically different outcomes.

While Arthur struggled to get this work published in an economics journal, Ermoliev

and his colleagues built on the approaches to establish what were, in the 1980s, new state of the art mathematical techniques. The benefits of the new mathematical approaches were quickly seen. They helped scientists better analyze the host of variables and uncertainties that are typical of socio-economic and environmental systems.

Finally, by the late 1980s Arthur began to reap the rewards of his work on increasing returns: he won a Guggenheim Fellowship in 1987 and the Schumpeter Prize in Economics in 1990. In 1989 he published a revised version of his IIASA paper in *The Economic Journal*. The economic community praised his innovative work. "Arthur's papers, while modeled according to the highest analytic standards, sometimes look different from standard economic analysis, and that is a compliment," wrote Economics Nobel prize winner Kenneth J. Arrow in 1994.



W. Brian Arthur worked at IIASA from 1977 to 1982, and again in the summer of 1983, when he developed a tangible analysis to show increasing returns.

And it wasn't just the academic world that recognized the value of positive-feedback economics. In the mid-1990s increasing returns provided the intellectual underpinnings for the U.S. government's antitrust case against Microsoft. Joel Klein, the head of the U.S. Justice Department's antitrust division, led the case that indicted Microsoft of improperly leveraging its monopoly in the market for PC operating systems to harm rivals in the Web browser market. Klein credits Arthur in particular with influencing his thinking on how high-technology markets operate. While a settlement was finally reached between Microsoft and the Justice Department in 2001, Arthur's work continues to provide vital insights for many governments and businesses all around the world who want to promote and develop technology. ■

Further information A list of sources can be found online at www.iiasa.ac.at/Options/sources.

W. Brian Arthur is currently an Institute Scholar at IIASA and member of the Board of the Santa Fe Institute, USA. **Iain Stewart** is the head of IIASA's Publications Department.

Negotiating the environment: Why such complexity?

Environmental issues cross national borders, require in-depth scientific knowledge, and affect a wide range of stakeholders

Environmental degradation caused by human activities is not a new phenomenon. From earliest times, shipbuilding activities along the Mediterranean Sea coast led to large-scale deforestation, causing erosion and possibly affecting climate. Yet it would take until the 1972 United Nations Conference on the Human Environment in Stockholm for the environment issue to become firmly established on the international political agenda. There, for the first time in history, the nations of the world sat down together "to seek better understanding of each other's environmental problems and to explore opportunities for positive action, individually and collectively," said a White House communiqué.

Part of the complexity of environmental issues is that they usually concern more than one country to different degrees and in different ways. The transboundary dimension of an environmental issue can be conceived of as a package of interdependent relations linking two or more countries. One example of a bilateral dispute is that between the Danish and Swedish governments over the Swedish nuclear plant at Barsebäck, a few miles from the Danish capital Copenhagen. Global problems like climate warming or the depletion of the ozone layer in the atmosphere affect all nations and all people in some way or another.

Just how complex and, indeed, "different" from the norm environmental negotiations would be was foreshadowed at the

Third UN Conference of the Law of the Sea (UNCLOS) in 1973, when talks began on the management of the resources of the seabed beyond national jurisdictions. Amid a growing dispute among the parties, scientists from the Massachusetts Institute of Technology presented a technical and economic model on the exploitation of the mineral resources of the deep ocean floor. According to Caitlyn Antrim in an IIASA's Processes of International Negotiation Program book, *Diplomacy Games*, this input allowed negotiations to be conducted free from partisan advantage and "through shared information and mutual compromise." It was one of the first times a formal model had been used "as a collaborative tool in a complex multiparty negotiation," Antrim comments.

Complexity in terms of a lack of an environmental knowledge issue may affect an ecological conflict in different ways. The parties involved may not be fully aware of an environmental problem and its consequences. And as happened at UNCLOS, an asymmetrical distribution of knowledge/information may also lead to variations in the awareness and understanding of issues across potential stakeholders. This will impede the development of a joint perception of both the problems and the consensual knowledge required to reach an agreement. In nations in an unfavorable situation, this lack of knowledge can also open the way for interpretations of a problem situation driven by ideology or prejudice.

The requirement for parties to understand and continually absorb new knowledge about environmental issues also contributes to the complexity of such negotiations. It is not hard to understand the notion of different kinds of pollutants from various land-based sources flowing into a lake or a large river and having a harmful effect on ecosystems. However, establishing and measuring these negative effects with accuracy and precision, fundamental bargaining points in many negotiations, is extremely difficult.

Moreover, environmental issues are typically pluri-dimensional in that they comprise several different layers of knowledge/information that are interlinked in a complex manner. To take the example of climate change, bottom-layer knowledge describes the emissions of greenhouse gases—their origin, magnitude, and ultimate transformation into concentrations in the atmosphere. Knowledge or information pertaining to the second layer concerns the immediate effect of expanding concentrations of greenhouse gases in the atmosphere—climate warming—what atmospheric temperature increases are expected and how fast the changes will occur. The third layer relates to the consequences of climate warming; the fourth layer to countermeasures to slow/stop/adapt to climate warming and its consequences.

Issue linkages represent another of the typical complexities characterizing environmental issues. An environmental issue will never be completely independent of other issues; for example, climate change has strong links to issue areas such as depletion of the ozone layer and desertification. Such coupling between environmental issues can both hinder and facilitate dispute settlement and conflict resolution.

Environmental issues are also often closely linked to and difficult to detach from policy areas outside the environmental sector. Water in a river represents a complex constellation of quite different stakes for the people and governments of riparian countries: a vital drinking water supply, an irreplaceable irrigation source, a cost-effective means of transporting people and goods; a natural border between nations. Such linkages may make it difficult, even impossible, to address water pollution separately and effectively.

The complexity of environmental issues also tends to mobilize a complex combination of stakeholders. With traditional diplomacy often inadequate when states quarrel over technically complex environmental issues, scientists have been drawn more and more into the processes of conflict resolution to address conflict issues that tend to be multifaceted and encompassing a number of scientific disciplines. Moreover, when international conflicts erupt around environmental issues, the influence of nongovernmental organizations, the media, and public opinion are inevitably felt by negotiators and frequently reflected in the final outcome.

A further complexity in environmental conflict resolution is that all aspects of the issue of climate change, as well as the causal relationships between them, are characterized by problematic uncertainty. Although there is agreement within the scientific

community that larger concentrations of greenhouse gases will warm the atmosphere, there are different views of how large this increase will be. Likewise, the effects of possible approaches to slow down or stop climate warming are also uncertain. For example, scientists cannot predict with reasonable uncertainty what positive effects will follow from a 20 percent global reduction of greenhouse gas emissions.

Since the 1972 Stockholm Conference on the Human Environment, most environmental issues have been institutionalized in an international treaty—the Convention on Biological Diversity, the Convention on Civil Liability for Oil Pollution Damage, the United Nations Convention to Combat Desertification, the United Nations Framework Convention on Climate Change, to name a few. However, the institutionalization of issues in regimes can have a significant impact on how parties act in ecological conflicts, actually constraining conflict resolution methods.

A new system of international negotiation, based upon principles of interdependence and global security, is emerging. Though security and economic issues remain the primary concern of governments, there are signs that priorities are shifting as nations begin to understand that environmental issues can threaten national and international security just as much as military issues. And interestingly, according to Victor Kremenyuk and Winfried Lang in their Introduction to *International Environmental Negotiation*, there is evidence that the very complexity of environmental negotiations, which require such a high degree of problem solving and international cooperation, are now contributing to the overall efficiency of international negotiations in general. ■

Further information IIASA's Processes of International Negotiation (PIN) Program at www.iiasa.ac.at/Research/PIN

Professor Gunnar Sjöstedt is a member of PIN's steering committee.

Environmental issues such as desertification, oil pollution, and climate change have been institutionalized in international treaties.

ENERGY FOR THE POOR



Global development and energy inequality

It was concern regarding the pervasiveness of extreme poverty around the globe, despite dramatic economic growth, more widespread prosperity, and major advances in technology over the last century that, in 2000, prompted nations to commit to the Millennium Development Goals (MDGs).

These goals, which aim to halve extreme poverty by 2015, provide quantified targets for addressing several of the multiple dimensions of poverty. However, despite growing recognition that increasing access to modern energy services is necessary for combating poverty, the MDGs do not explicitly address energy for the poor. What is being done to improve the situation?

A lack of adequate supplies of modern energy limits the productive opportunities of the poor and has a negative impact on their welfare, particularly the health of women and children who are often exposed to harmful emissions from inefficient cooking using solid fuels. The omission of energy from the MDGs has led to a renewed focus by academia and the international development community on assessing and analyzing the extent of energy poverty and on ways of increasing the supply and use of clean and efficient energy amongst the poorest.

Research within the Population and Climate Change Program at IIASA is analyzing the distribution of access to and consumption of modern energy sources across households within large emerging nations such as China and India. Several recent international publications by the International Energy Agency (IEA) and the United Nations Development Program (UNDP) have also helped refocus attention on this issue. But despite the growing interest, reliable data and analyses remain scarce, especially for those countries and regions where the situation is likely to be most critical. In addition, while there is a substantial body of work analyzing changes in world income distribution and international income inequalities over time, there is no examination of energy inequalities across or within nations and no assessment of how these have changed over time. This type of information is essential, if accurate assessments of the distributional impacts of energy and environmental policies are to be made.

Access improving, but distribution more unequal

Data on the share of population with access to electricity for different world regions over the last three-and-a-half decades show a distinct improvement in the distribution of access to electricity, with the rate for the world as a whole rising from about 50 percent in 1970 to over 75 percent in 2005.

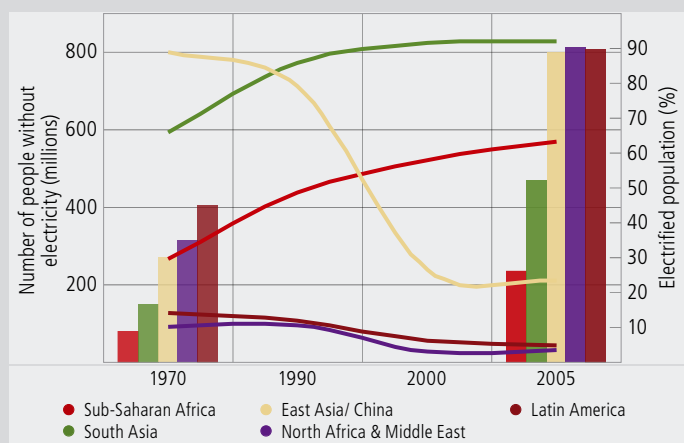


Figure 1 Unequal progress in improving electricity access across select world regions.
Data source: International Energy Agency

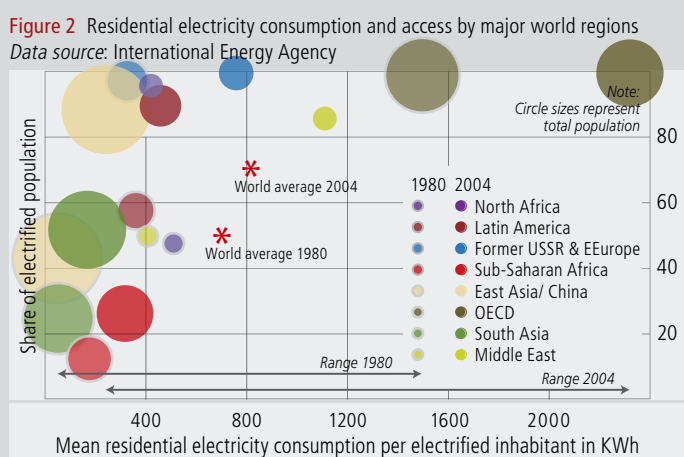


Figure 2 Residential electricity consumption and access by major world regions
Data source: International Energy Agency

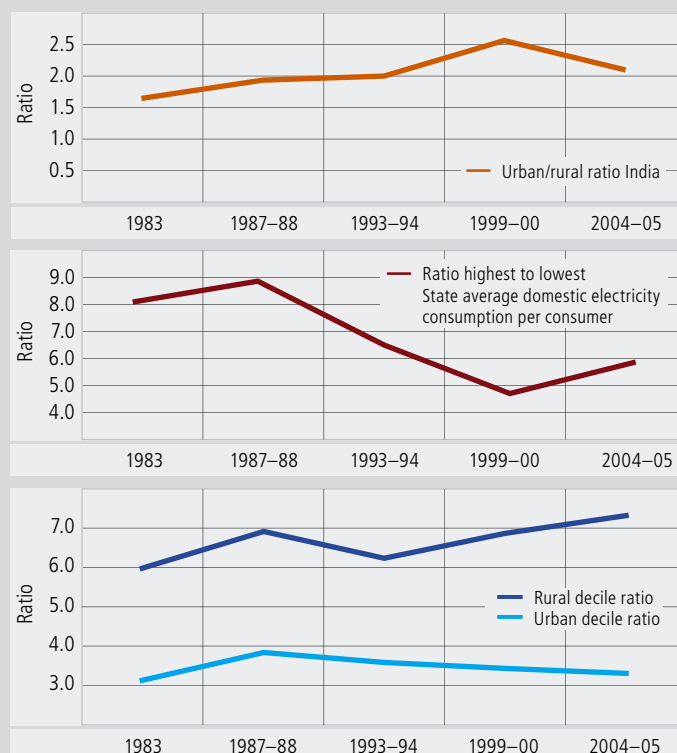


Figure 3 Comparing mean household electricity consumption across India.
Top: Urban versus rural electricity use. *Middle:* Highest electricity consuming state versus lowest. *Bottom:* Electricity use by richest 10 percent versus poorest 10 percent in rural and urban areas.
Data source: National Sample Survey Organisation (NSSO), Ministry of Statistics and Programme Implementation, Government of India, New Delhi. Data from several rounds of the household consumer expenditure survey.

However, this progress has been very unequal across regions (Figure 1). Even today, almost 75 percent of the population in sub-Saharan Africa and 50 percent of South Asians lack access to electricity.

According to IEA estimates, the actual number of persons without electricity access will continue to rise in South Asia until the end of this decade, and in sub-Saharan Africa until 2025. Furthermore, while many developing nations have made progress in providing access to electricity for their growing populations, particularly in urban areas, an analysis of the actual amounts of electricity consumed reveals growing inequality across broad world regions (Figure 2). The gap has widened despite annual growth rates in residential electricity consumption in the regions of South and East Asia that are three to four times higher than in the industrialized countries of the Organisation for Economic Co-operation and Development (OECD). Countries with the highest rates of growth in consumption have also experienced much higher population growth rates during the same period, with the result that per capita consumption has grown only slowly.

Inequalities in China and India

Such an aggregate analysis of inequality across regions masks how distributions are changing among countries within regions or even within individual nations. Global inequality depends to a large extent on changes within the most populous nations. Thus, developments in India and China are likely to have far-reaching impacts on the world as a whole. India alone is home to 30 percent of the 1.6 billion people in the world who lack access to electricity. Together, both countries account for almost half of the 2.5 billion people who are dependent on traditional biomass for cooking and heating. National statistics conceal considerable disparities and inequalities within these countries. While access to electricity across different segments of the population has become more equal in the two countries, the gap in consumption levels has grown between urban and rural households, between distinct administrative and geographical regions, and between the top and bottom expenditure deciles of the population (Figure 3). In many instances there has been a disproportionate increase in consumption among those who are better off.

The future

These deepening disparities may result in further disempowerment of those who are already at a disadvantage as well as greater social unrest in the future. While the positive achievements of rapid growth and development in these nations in terms of increased infrastructure provision and access to a wider array of opportunities and products are commendable, the trends toward increasing polarization are worrying. Concerted public policy efforts are required to redress the growing imbalances and to ensure a redirection of growth patterns in more equitable and progressive ways.

Clearly, further research and better data are needed to fully explore the extent and nature of inequalities and factors underlying the trends of rising inequalities, both within large populous nations and between nations.

Further information Pachauri, S (2007). *An Energy Analysis of Household Consumption. Changing Patterns of Direct and Indirect Use in India.* Springer, Berlin.

Dr. Shonali Pachauri is a Research Scholar in the Population and Climate Change Program of IIASA.

Global Development: Science and Policies for the Future

On the occasion of IIASA'S Thirty-Fifth Anniversary

14–15 November 2007
Hofburg Imperial Palace
Vienna, Austria

IIASA Speakers



The world at the beginning of the twenty-first century is deeply contradictory. Millions live in abject poverty, yet there is enormous personal wealth. Food is abundant in some places, while in others, people are dying of starvation. Massive environmental destruction exists alongside wonderful examples of conservation. What does the future hold for a world of such stark contrasts?

We cannot know exactly what the future will bring. We do know that the decisions we make today will have far-reaching consequences for our planet. We know too that only in-depth knowledge and analysis of social, economic, and environmental issues will help us chart a course toward the kind of future that we would wish for the whole of humankind.

It is in such a spirit that IIASA is holding this major conference to reach across national boundaries and among different scientific disciplines to rethink the current trends in global development and, through science, to identify successful policies for the future.

At thirty-five, IIASA's science has already greatly improved energy, environment and social policies around the globe. And as IIASA enters middle age, its international and interdisciplinary research is ideally placed to help countries face their local challenges which are becoming increasingly interwoven with the rest of the world.

Professor Jeffrey Sachs, Director of The Earth Institute at Columbia University, **Jorma Ollila**, Chairman of the Boards of Royal Dutch Shell and Nokia, and **Professor Lidia Brito**, former Minister of Higher Education, Science and Technology, Mozambique, are among over thirty distinguished speakers at the conference in November 2007. Eight IIASA scientists will make the following presentations.

Human Capital as the Key to Development

We live in a demographically divided world, where some populations are expanding rapidly, while others are shrinking and aging at a fast pace. The research undertaken at IIASA by the World Population Program (POP) is aimed at enhancing our knowledge and understanding of such trends and their implications for society and future policy. After an introduction to POP's projections and the insights they provide, research scholar **Dr. Anne Goujon** demonstrates that human capital defined by the number of people, their age structure, and their education matters for sustainable development. While it takes time and effort to increase a population's level of education, better education produces multiple benefits, boosting health, driving technological change and economic growth, and improving institutional efficiency.

Health and Global Development: Trends and Uncertainties, Challenges and Responses

A "business as usual" extrapolation of global income growth and rising educational attainment, together with improved medical technologies, shows more years of healthy life for all. As the burden of disease will be attributable to non-communicable disease rather than infections, demand for care, resulting from disability and chronic conditions, will likely increase. Wealthy countries are already claiming many human resources for health needed in poor countries, and pressures can only increase. Climate change and emergent infectious diseases, such as pandemic influenza, will most likely impose resource constraints on the health sector. **Dr. Landis MacKellar**, leader of IIASA's Health and Global Change Project, argues that the scientific arsenal to cope with such deadly episodes is strikingly

more developed than the institutional and political response. His presentation concludes with a review of donor priorities in the poorest countries, especially for HIV/AIDS.

Managing Climate Risks for Security and Development

Earthquakes, floods, and hurricanes destroy years of human progress and usually affect the very poorest. **Dr. Anthony Patt** of IIASA's Risk and Vulnerability (RAV) Program, highlights case studies in Africa to explain how RAV's research is helping people to apply information, such as climate prediction, for better risk management and also to use index-based insurance systems to spread risk and thus reduce indirect

The Global Fisheries Crisis: Acknowledged Causes and Elusive Cures

Worldwide, three-quarters of fish stocks are maximally exploited or over-exploited. Wasteful practices, ineffective enforcement, and disregard for scientific advice on fishing quotas have contributed to this. IIASA has been at the forefront of research revealing that fishing not only reduces fish abundance, but also changes genetic composition. This previously overlooked evolutionary dimension of fishing has unexpected consequences for economic yields and for the ecological stability and recovery potential of exploited fish stocks. The 2002 UN World Summit on Sustainable Development stipulated that



disaster losses. An innovative Malawi micro-insurance pilot program will be described, to which RAV is providing expertise, complementing technical assistance from international financial institutions. Delegates will also hear how RAV's work has led to the development of more efficient sovereign risk transfer instruments, which allow states to guarantee the provision of post-disaster services.

The Three Fs: Food, Fiber and Fuel

Substantial global economic growth, especially in transition and developing economies, will mean increasing demand for food, industrial wood fibers, and vehicle fuel. Many politicians believe that biomass is the solution to food, economic, and energy security, while preserving the environment. However, agricultural productivity is slowing and suitable new agricultural land is hard to find. Moreover, the forest industry is also looking for land: an additional estimated 150–200 million ha by 2030 to expand fast-growing plantations, especially in tropical regions. Biomass for production of heat and electricity and liquid biofuels—presently a hot topic—will require an additional 280 million ha of biomass plantations to power a global vehicle fleet of some 1,400 million in 2030. **Professor Sten Nilsson** of IIASA's Forestry Program discusses efficient policies with respect to future biomass utilization.

Clean Air and Development

Scientific assessment has been key to designing air quality standards in developed countries. After briefly assessing the success of IIASA's RAINS model for analyzing strategies to reduce acidification, eutrophication, and ground-level ozone in Europe, **Dr. Fabian Wagner** of IIASA's Atmospheric Pollution and Economic Development (APD) Program looks at the pressing air quality challenges being faced by developing countries. For example, in Asia, per capita sulfur emissions are lower than in Europe, but the higher population densities make remediation urgent. Dr. Wagner presents new results from the GAINS model developed with partner institutions in China and India, showing how simultaneous strategies addressing air pollutants and greenhouse gases are proving both effective and cost-efficient in Asia. This integrated approach is also seen as a way of advancing climate change mitigation on a global scale.

by 2015 all fish stocks should be restored to levels that can produce maximum sustainable yield. **Dr. Ulf Diekmann** of IIASA's Evolution and Ecology Program argues that achieving this goal requires rapid progress on multiple fronts, including a transition to ecosystem-based and evolutionarily enlightened management. We need to act now, or livelihoods will perish and seafood will be in jeopardy.

The Changing World: Energy, Climate, and Social Futures

Humanity is on the brink of a grand transition comparable with the agricultural and industrial revolutions two centuries ago—one that will transform the fabric of societies and establish new techno-economic paradigms. The exact dynamics and direction of change, however, are elusive. **Professor Nebojsa Nakicenovic**, leader of IIASA's Energy and Transitions to New Technologies Programs, explains IIASA's use of scenarios as "future histories" to assess the deep uncertainties associated with the wide range of plausible future developments, their consequences, possible tipping points, and response strategies. IIASA is one of the leaders in this area of futures research and its most recent set of stabilization scenarios outlines greenhouse gas mitigation strategies, technology needs, structural changes, and possible policy levers. Professor Nakicenovic also shows that much greater investment is needed in such research and diffusion of advanced technologies.

Coping with Uncertainties

Global change and rapid technological growth entail inherent and deep uncertainties that raise scientifically challenging problems for describing, communicating, and acting upon uncertainty. **Professor Arnulf Grübler** of IIASA's Transitions to New Technologies Program explains three important dimensions of uncertainty including epistemic, linguistic, as well as agency/contingency. Drawing on this taxonomy, he illustrates important empirical and methodological milestones of IIASA research that in many cases have pushed the boundaries of "state-of-the art" in systems science. He also illustrates how the concept of "robust decision making" under uncertainty is being applied in the fields of climate change and catastrophic risk, as well as technology management.

Further information A policy brief, a video summary, videos and transcripts of all speeches will be available at www.iiasa.ac.at/iiasa35 soon after the conference.



Where are they now?

Working at IIASA can have a profound impact on a person's career, opening doors to positions in academia, government, industry, and business, as these brief notes on five of our alumni show only too well.

Keep in touch with fellow IIASA alumni/ae by joining the IIASA Society.

www.iiasa.ac.at/IIASA_Society

JESSE AUSUBEL is currently Director of the Program for the Human Environment at Rockefeller University, New York. He was a YSSP member in 1979, then leader of IIASA's Climate Task within the Resources and Environment Program from 1979 to 1981.

Of IIASA, he says: "My experiences at IIASA profoundly influenced my career in every way: the problems I work on, the ways I approach the problems in a technical sense, the shift from a uni-national to a multi-national perspective, the networks of people with whom I work, and my belief in the contribution science can make to conflict resolution."

To maintain IIASA's importance in the future, he once advocated: "IIASA is a small institute. It can address only a few problems. But...whatever IIASA does, it must be politically and intellectually dangerous."

PETR AVEN, Foreign Economic Relations Minister of the Russian Federation and Russia's representative to the G-7 from 1991 to 1992, has been President of the Russian Alfa Bank since 1994.

He was a YSSP member in 1977, then principal researcher at IIASA for almost three years on the methodology of socioeconomic

comparisons, comparative economics, and economic reforms in centrally planned economies.

Ogonek magazine described Aven as one of the few Russian economists who can explain the most sophisticated economic concepts and phenomena in simple and understandable language. Though deliberately distancing himself publicly from politics, Aven is regarded as a highly influential man—one of Russia's "freshmen" billionaires, according to *Pravda*.

On YSSP, he says: "I participated in the first experimental YSSP program in 1975 and was there for the second time in 1977. For all (four) Russians, this time at IIASA was extremely interesting and helpful—it was not just IIASA but "the West." YSSP gave me a lot of information about the proper organization of scientific work, and a serious stimulus to come back, which I did 15 years later."

KIRIT PARIKH is widely known for the Report of the Expert Committee that he chaired on Integrated Energy Policy and as coeditor of the India Development Reports which provide a nongovernmental assessment of India's development and policy options. He is currently a member of the Planning Commission of India and Chair of IIASA's Indian NMO.

As the Leader of IIASA's Food and Agricultural Program from 1980 to 1986, Kiril Parikh pioneered the Basic Linked System (BLS), a modeling tool still used today to determine the effectiveness of policies to eliminate hunger. He left IIASA to become founding director of the Indira

Gandhi Institute of Development Research (IGIDR) in Mumbai, from which he retired in 2000.

THOMAS SCHELLING is Professor of foreign affairs, national security, nuclear strategy, and arms control at the School of Public Policy at University of Maryland College Park. He worked with several IIASA programs between 1994 and 1999, and was active in the YSSP program, as a much-appreciated advisor to several generations of summer students.

He won the Nobel Prize in Economic Science in 2005 with Robert J. Aumann of the Hebrew University of Jerusalem for research on game theory that, according to the *New York Times*, changed the way conflicts as diverse as trade wars and arms races are analyzed.

HARRY SWAIN spent 1974–1976 as Project Leader and Research Scholar in IIASA's Urban and Regional Systems Project. He rose through the Canadian federal government to become Deputy Minister at the Department of Indian and Northern Affairs and Deputy Minister at Industry Canada. He was also CEO of Hambros Canada and founded the Toronto office of Sussex Circle, a consultancy concentrating on strategic and financial advice for public and private sector clients.

Of IIASA, he says: "I got to work with scholars of outstanding quality on issues that have concerned me ever since—for example, the low-carbon futures work at the Centre for Global Studies at the University of Victoria, regarding which, as is only natural, I've turned to other IIASA alumni for help." ■

IIASA's driving force

Erich Kremsner loves his job—and it's not just because of the Mercedes

Trying to schedule an interview with IIASA's driver Erich Kremsner is like trying to get a date with Brad Pitt. There are dozens of people with prior and higher claims on him than I have. He has far more important people to see...at the airport, at the Austrian Foreign Ministry, in the Director's office, at the UN Commissary. He is, as they say, "in demand."

I have been begging him for a month for just half an hour of his time. Then, when he is finally ensconced in the interview room with the blinds down, his mobile phone rings three times in succession and, all of a sudden, there are loud German-speaking ladies invading our privacy: pleading, persuading, reminding... (Olivia? Shari? Cynthia?). Whatever... Erich soothes and reassures them in his unruffled, fatherly way, and then turns his attention back to our Day in the Life interview.

Writing "a day in the life" for someone like Erich doesn't somehow do him justice. For Erich, day merges into night as surely as daffodils come out in the spring. He thinks nothing of rising at 3am to pick up a certain distinguished program leader from the thirteenth district to connect with his flight to Beijing. And if a couple of big cheeses choose to arrive in Vienna on the last flight on Sunday from London, then Erich is there at Schwechat to pick them up.

And graciously, too. Erich is, above all, an ambassador for IIASA, the first person that most visitors to the Institute meet when they arrive at the airport or train station. Pride in his job is evident. Erich won't allow a photograph to be taken, he says, unless he can change his clothes, have a haircut, and polish the car first. Even the unsocial hours don't seem to get him down. He enjoys being his own boss and the freedom to run his working life. He would hate being chained to an office desk, he says, even though part of his job involves sitting at the computer working out the intricate scheduling (including sometimes the use of local taxi drivers) that ensures no one is left waiting in limbo while he drives someone else to a meeting. Erich is a systems analyst to the very core!

Meeting people, for him, is one of the most enjoyable parts of the job, especially if the IIASA guest in question has originated from an exotic place—like the USA! Erich himself is well traveled, having visited most European countries, done military service in Cyprus in 1972–73, and gone scuba diving in the Maldives, but the USA and Canada are high on his list of priorities for a visit "when he has time."

What would he do there? Go hunting, of course. In his rare leisure time, he likes nothing better than to travel to Burgenland to shoot clay pigeons or something more tasty. Cooking is also a way for Erich to unwind: the duck or hare shot by him or friends frequently go into the pot at home—one of his specialties being roast duck with dumplings and red cabbage. His belief is that living from nature is the best way, and from boyhood has loved roaming the countryside picking mushrooms, berries, and other natural delicacies.

He has met plenty of IIASA celebrities in his 30-odd years at IIASA, including the great Russian academician Jermen Gvishiani, whom he remembers fondly. He also has some riotous stories regarding IIASA people past and present, but Erich is nothing if not discreet.

In fact, you can vouchsafe your most intimate hopes and regrets to Erich from the passenger seat of the IIASA Mercedes, and rest assured that he won't breathe a word. ■



Erich's daily schedule*

- 03.00 Deliver program leader to airport in Schwechat
- 04.00 Deliver a researcher to airport in Schwechat
- 05.00 Breakfast
- 06.00 Deliver Deputy Director to airport in Schwechat
- 07.00 Start scheduling today's driving requirements
- 08.00 Call taxi drivers to see if they are free
- 09.00 Take Director to a meeting
- 10.00 Take program leader to a meeting
- 11.00 Go to Austrian Foreign Ministry
- 12.00 Commissary run for staff; sandwich lunch in car park
- 14.00 Start picking up program leaders from airport in Schwechat
- 17.00 Go home to prepare roast duck
- 20.00 Eat roast duck
- 23.00 Check airport arrivals (just in case)

*On a long day