IIASA 40th Anniversary Conference
Under the Patronage of the Federal President of Austria
24–26 October 2012
Hofburg Congress Center, Vienna, Austria
and IIASA, Laxenburg, Austria

Voices
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Voices
from the IIASA Conference 2012
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Voices summarizes the sessions of the IIASA Conference 2012 and provides a short-form version of all presentations. For a complete overview of presentations, it is recommended that readers watch the videos available on the conference Web site.

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Publications from the IIASA Conference 2012
Voices is one of a series of publications which, together, aim to provide a comprehensive overview of the IIASA 40th Anniversary Conference from different perspectives:

- A scientific synthesis of the conference by Dr. Jill Jäger, former IIASA Deputy Director (2013)
- Voices
- An IIASA Policy Brief that provides a short summary of the conference from the perspective of science journalist Fred Pearce, of the United Kingdom Guardian and New Scientist (2012)
- Selected papers from the conference, published as a Special Issue of a peer-reviewed scientific journal (forthcoming)

Online Conference Documentation
The conference Web site remains active as a documentary of the IIASA Conference 2012: conference2012.iiasa.ac.at
Under Conference Program, readers will find speaker biographies and video presentations, searchable by name or conference session. PDF files of the scientific posters from the conference are available under Poster Session, and Conference News provides news clippings, photos, and links to conference videos on YouTube.

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CONTENTS

page  vii  Foreword
ix  General Overview of the IIASA Conference

CONFERENCE DAY 1
1 OPENING SESSION
Welcome Statement: Pavel Kabat
Opening Addresses: Karlheinz Töchterle • Ban Ki-moon (Video Message) • Heinz Fischer

3 HIGH-LEVEL SESSIONS  Science and Policy Support for Global Transitions
Nisha Pillai, Moderator
Statements: Michel Jarraud • Carlo Rubbia • Thomas Schelling • Sergey Glaziev • Nina Fedoroff • Yuan-Tseh Lee • Kandeh K. Yumkella • Eun-Kyung Park • William Colglazier • Björn Stigson • Gusti Muhammad Hatta • Andrew Johnson • Johannes Kyrle

A WORLD IN TRANSFORMATION—EXPECTATION, POTENTIAL, REALITY

9 SESSION 1  Global Transformations—Understanding the World We Live in and its Possible Futures
Jacqueline McGlade, Moderator
Framing Presentations: Jeffrey Sachs (Video Message) • Nebojsa Nakicenovic
Panel Presentations: Katherine Richardson • Björn Stigson • Berrien Moore III

14 SESSION 2  Drivers of Global Change—People, Institutions, and Technology: A Systems Perspective
Dirk Messner, Moderator
Framing Presentations: Wolfgang Lutz • Charlie Wilson
Panel Presentations: Thomas Schelling • Yolanda Kakabadse • Adil Najam
Video Message: Justin Yifu Lin

A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS

18 SESSION 3  Respecting Nature’s Boundaries for a Fair and Secure World—Food and Water
Carlos Nobre, Moderator
Framing Presentations: Sabine Fuss • Ulf Dieckmann
Panel Presentations: Joseph Alcamo • Nina Fedoroff • Jacqueline McGlade • David Grey

23 SESSION 4  The Multiple Co-benefits of a Cleaner, More Equitable World—Energy and Climate Change
John Schellnhuber, Moderator
Framing Presentations: Keywan Riahi • Zbigniew Klimont
Panel Presentations: Carlo Rubbia • William Nordhaus • Kenji Yamaji

CONFERENCE DAY 2

27 SESSION 5  Eliminating the Unacceptable Social Ills of the 21st Century—Poverty and Equity
Martin Rees of Ludlow, Moderator
Framing Presentations: Shonali Pachauri • Joanne Linnerooth-Bayer
Panel Presentations: Lidia Brito • Ogulnade Davidson • Martin Parry • Youba Sokona

32 SESSION 6  New Concepts in Science Supporting Development
Johan Rockström, Moderator
Framing Presentations: Michael Obersteiner • Narasimha Rao
Panel Presentations: Dirk Messner • Soogil Young • William Colglazier • Diana Liverman

ALTERNATIVE WORLDS—NEW CONCEPTS AND NEW UNDERSTANDING

36 SESSION 7(i)  Addressing the Challenges Concurrently—Science and Technology for Sustainable Development
Detlof von Winterfeldt, Moderator
Framing Presentations: William C. Clark • David McCollum
Panel Presentations: Ralph L. Keeney • Andrew Johnson • Karl Sigmund
CONTENTS

page
40 SESSION 7(ii) The Role of Systems Analysis in Supporting Global Transformations
Pavel Kabat, Moderator
Speakers/Panelists: Simon Levin • Arkady Kryazhimskiy • Ulf Dieckmann • Buzz Holling • Janusz Kindler

44 SESSION 8 Worlds within Reach—The Way Forward
Guy Brasseur, Moderator
Panel Presentations: Pavel Kabat • Steven Wilson • Frances Seymour • Peter Lemke

CONFERENCE DAY 3

RESEARCH FOR A CHANGING WORLD
49 IIASA National Member Organizations (NMO) Sessions
Pavel Kabat, Moderator
Introduction: Raoul Kneucker

50 NMO Session 1: Science for Bridge-Building During and Beyond the Cold War
Framing Presentation: Alexei Gvishiani
Panelists: Gerhard Glatzel • Yinglan Zhang • Peter Lemke • Kazu Takemoto

53 NMO Session 2: Research for Smoothing Transitions: Economic, Ecological, Political, Technological, Societal
Framing Presentation: Kirit S. Parikh
Panelists: Maged Moustafa Al-Sherbiny • Lea Kauppi • Andrew Johnson • Yuriy V. Kostyuchenko

56 NMO Session 3: Systems Analysis for Informing Decisions: Broadening Awareness and Building Capacity
Framing Presentation: Dorsamy (Gansen) Pillay
Panelists: Ahmad Ibrahim • Adil Najam • Roger Levien • Semida Silveira

59 NMO Session 4: Supporting a New Global Network to Develop Solutions for Decision Makers
Framing Presentation: Kirsten Broch Mathisen
Panelists: Carlos Nobre • Leen Hordijk • Agung Wicaksono

61 Parallel Sessions
61 Parallel Session 1: Securing Ecosystem Services: Food and Water
Frances Seymour, Moderator
Panel Presentations: Mikko Heino • David Wiberg • Mario Herrero • Parviz Koohafkan

64 Parallel Session 2: Integrating Models of Socio-Ecological Systems
Marina Fischer-Kowalski, Moderator
Panel Presentations: Elena Rovenskaya • Markus Amann • Detlef van Vuuren

67 Parallel Session 3: Synergies and Trade-offs among Multiple Sustainable Development Objectives
Volker Krey, Moderator
Panel Presentations: Måns Nilsson • Nadejda Komendantova • Victor Kremenyuk

70 Parallel Session 4: Assessing Education, Human Capital and Vulnerability
William Butz, Moderator
Panel Presentations: Reinhard Mechler • Vegard Skirbekk • Jesus Crespo Cuaresma
Roundtable Seminars

73 Roundtable Seminar 1: Social versus Technological Solutions
Mark Howells, Moderator
Kickoff Statements: Michael Grubb • Karl Steininger

75 Roundtable Seminar 2: How to Meet our Needs in the Face of Pressures on Ecosystems
Steffen Fritz, Moderator
Kickoff Statements: William J. Cosgrove • Neville Ash

77 Roundtable Seminar 3: Green Growth
Yoshiki Yamagata, Moderator
Kickoff Statements: Sten Nilsson • Helga Kromp-Kolb

80 Roundtable Seminar 4: Bridging the Science–Policy Gap
Helga Nowotny, Moderator
Kickoff Statements: Leen Hordijk • James Syvitski • Peter Hennicke

83 Roundtable Seminar 5: Optimal versus Suboptimal Solutions
Manfred Grauer, Moderator
Kickoff Statements by Michael Thompson • Arkady Kryazhimskiy

85 Closing Plenary
Pavel Kabat, Moderator
Conference Summary: Jill Jäger
Poster Awards: Uno Svedin • Narasimha Rao
Summaries and the Way Forward: Pavel Kabat

89 Extra-Curricular Conference Events
Austrian Cross of Honour for Science and Art 1st Class: Norman P. Neureiter
Lecture: Tipping the Scales Towards Global Sustainability: Johan Rockström
IIASA/OeAW Public Lecture Series: William Nordhaus • Carlo Rubbia
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 IIA SA. It was the culmination of six years’ effort driven forward by both the US President Lyndon Johnson and the USSR Premier Alexey Kosygin. For IIA SA 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. Clearly, success at bridge building and successful science would go hand in hand. But neither was a foregone conclusion. This was the 1970s, and most research organizations focused on national issues. Few encouraged researchers from different countries or disciplines to work together for the greater good. To achieve its ambitious research vision, IIA SA would have to break down the barriers between nations and disciplines. This is exactly what international cooperation is all about: to confront innumerable global challenges, both long-standing and emerging.

For example, a study of water pollution carried out in the 1980s by a team of IIA SA chemists, hydrologists, and economists still forms the basis of modern water policy design in Japan, US and the former USSR.
IIASA’s conference provided a fascinating and interactive forum where all had the opportunity to have their say. This is truly the mark of a successful event. Question-and-answer sessions with our invited speakers, breakout activities each day, side-events, a poster session with awards, multi-media events, social occasions, and displays that focused on 40 years of IIASA scientific highlights—all of these provided opportunities for dialog and knowledge sharing that were enjoyable and educative for us all.

When I look back at those momentous three days, two at the Hofburg Palace in Vienna and one at IIASA, I recall their sights and sounds not only with immense pleasure but also with an overwhelming sense of achievement that so many great policymakers and scientists were willing and able to provide us with their latest insights and perspectives. We welcomed members of the Austrian Government to our stage, former and current IIASA scientists, our National Member Organization (NMO) representatives, Nobel Prize winners, and some of the best known names in today’s scientific pantheon. The Secretary-General of the United Nations, Ban Ki-moon, sent a video-taped message of congratulation. Many delegates came to Vienna from countries far afield to participate and, unusually for a conference that ends late on a Friday afternoon, the final plenary was packed.

We have called our conference brochure “Voices” because what we said and what we heard during those three days together represented a strong, distinctive, and collective voice for science at a time of huge transformation, when our scientific research and input to the policy process, as well as our engagement with stakeholders, civil society actors, business, and the general public, have never been more essential. “Voices” has been created to remind you of the suggestions, ideas, and trends that came out of the conference and to enable you to select the topics that interest you most and access the full original audio-visual presentation online at conference2012.iiasa.ac.at/program

I would like to thank all those staff members who put so much time and effort into organizing the conference. I would also like to offer my gratitude to Jill Jäger, a former Deputy Director of IIASA, who undertook the demanding but vital task of providing delegates with a daily summary of the main conference messages. Voices is one in a series of publications which IIASA is preparing as follow up to its 40th Anniversary Conference and when finalized will also include:

- A scientific synthesis of the conference
- An IIASA Policy Brief that provides a short summary of the conference
- Selected papers from the conference, published as a Special Issue of a peer-reviewed scientific journal.

Finally I would like to thank the conference rapporteurs, many of them young scientists at IIASA, for helping to bring together this succinct, yet substantive, record of an outstanding conference.
GENERAL OVERVIEW OF THE IIASA CONFERENCE


“A conference on an extraordinary scale. A conference to be proud of.”
— Pavel Kabat

The IIASA Conference was not only an opportunity to celebrate the successful evolution of IIASA over the last 40 years from an East–West scientific research institute into a full-fledged global think tank. It was also a chance to reflect together with colleagues, research partners, and stakeholders upon the fundamental changes that have occurred in scientific methodologies and related thinking over the five years since our last conference.

Science is, in a sense, only now getting to grips with some of the problems that face humanity. Our age—dubbed “the anthropocene” and stretching from humans’ first exploitation of forests for fire and food to the overt and frequent wastefulness of the present day—has seen many challenges accumulating: climate change, land degradation, biodiversity loss, dwindling water availability and quality, a burgeoning world population, pressure on agricultural land.

For the continued well-being of natural and human resource on our planet, we need to embrace a completely different way of living. We need, in effect, a transformation based on sustainability in all its different forms and expressions.

“A transformation to sustainability is needed because the scenarios we see coming out of the scientific and policy community do not show good progress unless we achieve that transformation. And the transformation must be underpinned by science.”
— Neville Ash

There are no ready solutions to Earth’s problems. These are complex, closely interconnected, fraught with uncertainties, and extremely hard to manage. Piecemeal solutions have been attempted, but as one speaker put it, these have been like providing a painkiller without diagnosing the underlying disease—under such circumstances, the illness will worsen.

The problems are systemic ones—failures in multiple and interlinked institutional, economic, social, and ecological systems. As such, only a holistic, integrated, systemic approach, as practiced at IIASA for 40 years, can get anywhere close to solving them.

The integrated approach has seen the development of large-scale integrated models and the creation of analytical tools capable of looking at the synergies and trade-offs available when multiple sectoral problems are tackled simultaneously.

A major example of this research by IIASA and its partners is the simultaneous analysis of greenhouse gases and air pollution. Integrated analysis, as several speakers contended, has shown high benefits in terms of costs and time saved over single intervention measures. Where different research areas like water and energy intersect—the nexus areas—analysis is yielding new insights which will be the basis of future research at IIASA and in its partner network.

To run large-scale integrated models, data are needed, and novel ways of collecting and correcting data have been developed at IIASA. These range from back projection of population data to the 1970s for every country of the world to crowdsourcing to build more detailed and more accurate maps of world land cover. The lessons learned in industrialized countries over the past decades are being used to benefit countries in the developing world so that they can better address problems of air pollution, deforestation, land use change, and energy.
“Science and innovation in support of sustainability that changes action on the ground, in business, in government, and in civil society . . . there is vastly more than changes in policy to target.”
—William C. Clark

Progress in climate change science, sustainable energy, and in tackling the world’s water challenges to meet the needs of a growing global population were among the most prominent tasks mentioned at the conference. However, challenges, great and small, occur at every level of society, and delegates concluded that a transformation is required in the way we live: business as usual is clearly no longer going to be an option. A new paradigm is needed. Paradigms rely on social consensus being formed: a critical mass of people agreeing that a thing or things need to change. Examples were given of the abolition of slavery and the end of apartheid. There is not yet a visible consensus for a new paradigm of sustainability for the whole of humanity, but the transformation has, in fact, already begun, for example, in Denmark and Korea.

Denmark intends to become the first country in the world to be free of fossil fuels by 2050. For Korea, investing in the green economy has been a successful way of pulling the country out of the 2008 financial crisis. China has also invested in green growth. The United States is offering prizes for the best sustainability inventions and projects. The Energiewende in Germany, one of the world’s most industrialized countries, is moving almost too fast for the country’s own best interests. After the disaster at Fukushima nuclear plant, Japan, while not abandoning nuclear altogether, is now leaning toward a greater share of renewables in its planned energy supply mix. Such progress, more than one speaker said, is worth emulating. The green race is on, and it is the best business opportunity that has come our way in generations.

“The science that we need to understand the nature of the forthcoming climate change is already with us; the problem is getting people to act on it.”
—Thomas Schelling

Investment in green technology, however, is problematic. Vested interests, like lobbyists, are dampening down enthusiasm for greening the economy; business-as-usual mentalities are prevailing; investors and bankers are risk-averse; bureaucracy in some countries holds back entrepreneurship; even lack of knowledge of English as the universal business language is preventing millions from joining the world economy.

Developing countries are transforming slowly because whole infrastructures are lacking—for the implementation of new or advanced technologies, on the one hand, and for sophisticated governance systems, on the other. There are countries in sub-Saharan Africa that are not yet hooked up to the electricity grid. In many parts of rural India, dirty biomass, like wood and dung, is being burned for cooking purposes; kerosene lamps are the main lighting source. A million lives a year could be saved by giving people access to clean sources of energy. Time spent foraging for biomass would be saved and education and more productive livelihoods undertaken.

Poverty is one of Earth’s most intractable problems. Millions are still hungry and even if they manage to save money, a natural disaster—likely due to climate change—can push them back into the poverty trap where just to survive, they need to undermine their already precarious lives by selling their animals, taking their children out of school, or having recourse to moneylenders. The poorest are the most vulnerable to natural hazards because they can only afford to live on marginal land that is prone to disasters like coastal flooding, hurricanes, and earthquakes. The scale of poverty is unacceptable both practically and philosophically in a world that must embrace sustainability to survive. If we fail to help the poor adapt to global warming, none of us will survive temperature rises that will almost certainly be 2–4°C higher by mid-century.
“We tend to believe in nation-state-based operations, but we must set up global mechanisms and global institutions to tackle global problems.”
—Yuan-Tse Lee

One of the reasons for the destiny of all people, rich and poor, being tightly interwoven is the sheer numbers of people—predicted to reach 10 billion by the century’s end. More mouths to feed mean more pressure on land for food resources and on water for consumption and irrigation. This augurs the need for the professionalization of farming methods with better access to seeds and new technologies for the small-scale farmers who provide most of the world’s food. Indeed, technologies will play a big part in the agriculture of the future. Techniques like aquaponics, a sustainable farming method that uses the wastewater from fish farming to enrich soil to grow plants, are already being developed. Bio-technologies are one way of achieving more productive plant forms that are resistant to disease, but although major “industrial” crops like corn and soy are already genetically modified, the expense of bringing new GM crops to market is high, as is the ideological resistance to GM foods on the part of many consumers.

Food proteins figure prominently in the diets of the future. Millions already derive their primary protein from fish and sea food; some fish stocks have already collapsed and many more are showing genetic changes due to overfishing, such as earlier reproduction at a smaller weight. Attempts to offset losses from oceans and rivers have resulted in the growth of unsustainable aquaculture businesses which cause pollution and disease. Moreover, with the growth of the middle classes in developing countries, prosperity is prompting dietary changes away from grains to meat. The sustainable production of animals for meat is a major problem for scientists and agriculturalists who are trying to balance the land use equation, as a growing need for animal feed will need to be factored into it. For those who remain poor, who do not eat meat, the outcome is higher prices for their staple loaf of bread.

One important antidote to population rises is education, particularly of women and girls: the fertility rate drops when the level of education rises. Education enhances human capital and hence fosters development; it removes the dependency on international assistance, and it allows new technologies to be more widely adopted and used to the benefit of society as a whole.

“If you observe civilizational shifts in our societies, they are always based on a social contract: a consensus within societies that we need to change direction.”
—Dirk Messner

The human spirit grew on surviving setbacks, and will no doubt rise to the occasion again in developed and developing countries alike. The only thing we are short of is time. The conference was mixed in its opinions as to how much time is left before, as one speaker put it, “we all disappear.” Would the current difficulties the planet is facing be a blip on the radar of time or would the dominant species on the planet extinguish itself and most other species in short order? One problem with the latter perspective is that human beings have an in-built antipathy to disaster scenarios. Just as former U.S. Vice President Al Gore’s An Inconvenient Truth had little effect on the way Americans voted in the next election, so, too, many human ears tend to be deaf to the warnings periodically outlined in the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) and outlooks from similar bodies.

A new approach was suggested at the conference, namely, that the narrative of despair should be changed into one of hope. The overriding sentiment was that we can live within our planetary means, but that this way of life needs to be furthered and supported among scientists, policymakers, civil society, businesses, and stakeholders in general. Thus, a good way of effecting improvements would be to work at the local level and
engage people in the transformations. Local solutions were, in fact, the only way to go, according to an African speaker who stated that educational and scientific infrastructure—including research institutions—should be local, not only to stem the current brain drain to the better facilities and funding available at universities overseas but also to ensure that local solutions are developed for local problems rather than solutions that “worked” in wealthier countries being imposed from outside.

“The next stage in how we might do science is to bring citizens and citizen science into the very fabric of what we're doing.”
—Jacqueline McGlade

The individual has a part to play in the transformation. One technique envisaged for adapting to our warmer future is urban farming—even gardening on roofs by individuals and families, as this will cut down the transport costs of produce from the countryside to urban consumers. Growing climbing plants on building facades and planting shade trees will help keep interiors cool as temperatures rise. With bee hives failing—possibly because of the widespread use of neonicotinoid-based fertilizers on crops—beekeeping in cities was put forward as another sound adaptive practice that will promote swarms and increase biodiversity.

Key to helping scientists look at the local solutions are the members and activists of civil society organizations who know what is happening on the ground and where the best sources of expertise are. All countries needed a better science education infrastructure not only to generate local researchers per se, but also to infuse private citizens with a feeling of familiarity with the scientific aspects of daily life from conservation to recycling. Beyond this, countries and regions need to co-design and co-produce scientific projects with local specificities. Science has a reputation for being “too difficult.” Yet in India citizens living by the River Ganges have been helping the Indian Government by taking water potability readings from rivers. City beekeeping has flowered in Copenhagen. Sea temperatures are being monitored along the Arctic coast by fishermen. Gourmet chefs are bringing back wild foods like samphire on to menus.

“What the global business community struggles with are the systems analysis issues. How do we understand the nexus between energy, food, water, land use and similar issues? There needs to be more engagement between business and the scientific community.”
—Björn Stigson

Everywhere green-based initiatives, like aquaponics mentioned above, are proving to be sound bases for new business ventures. The vehicle manufacturer, BMW, is experimenting with wood-based cellulose to replace plastics in the car of the future. The tragedy of the commons, whereby Earth’s biodiversity and natural wealth is plundered for national, corporate, or individual enrichment, was widely discussed at the conference. Cutting down rain forests and replanting them with trees can mean an 800-year carbon debt: equally, it is far easier and quicker to deplete a fish stock than to build it back. While engaging citizens in science and biodiversity conservation, for example, can be helpful especially over a longer-term perspective, the conference looked at how countries and individuals can be “persuaded” or even “obliged” to join local and global efforts to keep human activities within safe planetary boundaries. Game theory shows how selfish behavior (free-riding) with respect to shared resources can be overcome through mutual coercion, mutually agreed.

In the context of the failed Kyoto Protocol to the United Nations Framework Convention on Climate Change, the conference heard of a new possibility for “persuading” states to engage in binding reductions of greenhouse gases: a climate club. This would be a strong club unlike the weak Kyoto Club,
with membership dues to be paid (cut emissions to an agreed standard), and incentives to be gained (join a free trade mechanism) to be reaped. Cutting emissions would therefore cut barriers to trade. Whether such measures will help underpin a kind of governance that is strong enough to effect the changes needed for sustainability to become the new paradigm remains to be seen.

“The present unsustainable pathways are not ethically correct.”
—Nebojsa Nakicenovic

Ethics was much debated at the conference. The ethics of scientists, for example, would be based on ensuring that their work is properly grounded and evaluated, that it includes up-to-date information from people on the ground, and that it is not just a pulling together of statistics. On occasion, scientists had been publicly faulted for making mistakes, resulting in loss of trust by the wider community. Scientists needed to check their results with the actuality on the ground and evaluations had to be much more thorough.

More than that, however, the ethics of everyone living on the planet came into question. Was it perhaps possible, one delegate asked, for people to be persuaded that a life based on intrinsic values was more satisfying than one dedicated to buying and consuming unnecessary products? How, in fact, was it possible to reach those who pay lip service to sustainability by using sustainable energy, then spending the savings on air travel? How can the benefits of cooperation, so clearly seen in game theory transactions, best be communicated to a mass market in a world where science education had sometimes been under-prioritized.

“Many issues are very difficult for policymakers to deal with but science can often create new opportunities, things not thought of, that can actually get around some of the political problems and create new options for policymakers.”
—William Colglazier

Communication was the key to embedding sustainable ideology in our various cultures, and clear communication with policymakers is a duty of scientists. The title of the conference encompasses this idea. Yet delegates heard that such communication was far from straightforward, as policymakers had to manage more inputs than just scientific policy advice. Getting the message across to policymakers was sometimes a matter of timing or even of luck—this was disadvantageous to decision makers themselves and to the broader society, as science holds the key to resolving many of the greatest challenges we face today.
At the Opening Session, Pavel Kabat, Director and Chief Executive Officer of IIASA, welcomed delegates. He thanked H.E. Heinz Fischer, Federal President of the Republic of Austria, for accepting the invitation to open the conference, and Karlheinz Töchterle, the Federal Minister for Science and Research of Austria, for his opening address. He also thanked United Nations Secretary-General Ban Ki-moon who had sent a video message of congratulations to mark IIASA’s 40th anniversary.

“The purpose of the conference is twofold: to share IIASA’s scientific advances and to draw on the thoughts and perspective of participants on the current transition to a more sustainable world.”

I would like to welcome the nearly 800 delegates who have come to IIASA’s 40th Anniversary Conference, and I extend my personal thanks to President Heinz Fischer of Austria, a great friend of IIASA, for his personal patronage of the conference and for agreeing to speak at this Opening Session. The Austrian Government has given sustained support to IIASA over 40 years. It has provided headquarters for the Institute at Schloss Laxenburg in Lower Austria and also, for the next two days, the conference facilities at the Hofburg Palace in Vienna. My thanks go to the Austrian Federal Minister for Science and Technology, Karlheinz Töchterle, and his staff for facilitating the conference arrangements.

I would further like to thank all discussants: those who came in person, as well as those, like Secretary-General Ban Ki-moon and Dr. Jeffery Sachs, who recorded messages.

Thanks are also due to the Deputy Director of IIASA, Nebojsa Nakicenovic, and his team for organizing the conference.

“The international collaboration that IIASA promotes is just as important as the grand scientific challenges it is tackling.”

Forty years ago in 1972 when IIASA was established, it was an honor for Austria to host it. The idea of founding an institute to further scientific contact between East and West during the Cold War was promoted by the Soviet Union and the United States. It was an outstanding idea. Over the 40 years of its existence, IIASA has become a symbol for cooperation between nations, and over the last few years, for cooperation at the global scale. Nowhere is this international cooperation to be seen more closely than in the IIASA Young Scientists Summer Program (YSSP), which is co-financed by the Ministry of Science and Research of Austria. Through this program, gifted young scientists studying in countries with IIASA National Member Organizations are sponsored to conduct research at IIASA for three months, working in collaboration with IIASA programs. This is an ideal opportunity for young people from different countries to get to know and work with each other. It is also a chance for them to learn the multidisciplinary systems analysis methodology, chosen in 1972, which allows deeper and wider analysis of our complex world.

Even though the Cold War is over, science cooperation still needs to take place across borders, as nations working alone have neither the human or financial resources to solve the size and type of problems confronting us. Nor can these so-called grand challenges be solved through conflict.
“I look forward to IIASA and the United Nations continuing a mutually productive relationship in the years ahead, and to your research which will contribute to making the world a better place through a stronger United Nations.”

It is a pleasure to provide a short welcoming statement at IIASA’s 40th Anniversary Conference. IIASA is well respected within the United Nations—both for your scientific contributions and for your success in bringing countries and scientific disciplines together to cooperate in a truly international and non-political environment.

For the United Nations, these principles of international cooperation are particularly important as we confront, and respond to, some unprecedented social and environmental challenges. Many of the issues being discussed by you over the coming days are at the heart the UN Millennium Development Goals and other significant UN initiatives, for example: ending poverty and hunger; achieving universal education; gender equity; and environmental sustainability.

I acknowledge the membership of IIASA scientists on several UN committees and involvement in many UN activities, most recently my Advisory Group on Energy and Climate Change and your contribution to the Sustainable Energy for All initiative. Energy is critical for human progress—for health, education, job generation and economic competitiveness. For the developing world, energy poverty is devastating and is jeopardizing the achievement of the Millennium Development Goals. Transforming energy systems is also critical for minimizing climate change and averting further human suffering.

I acknowledge and thank IIASA for your contribution to the recent Rio+20 Conference on Sustainable Development, and I note with interest that an important aspect of your Program over the coming days will be an analysis of the Rio+20 outcomes.

“Austria is proud of the work being done by IIASA and wishes the Institute many good years ahead.”

IIASA is an excellent forum for extending discourse and cooperation on many scientific issues of high political importance, like sustainable development, energy, climate, equity, poverty, and food and water.

IIASA was founded in 1972, and I remember very well the time when the Institute was still an idea. I was a young member of Austrian Parliament and Bruno Kreisky was our Prime Minister, when presidents Lyndon Johnson and Alexei Kosygin agreed that international community cooperation should be increased between the Eastern and Western blocs. In autumn 1972 IIASA negotiations successfully finished, and the Austrian Government reported happily to the Austrian parliament that the offer by Austria of Laxenburg Castle as IIASA headquarters had been accepted. The history of IIASA in Austria was ready to start, and IIASA had full support from West and East.

Perhaps the collapse of Communism could have created difficulties for IIASA because, with this, its raison d’être ceased to exist. However, IIASA successfully overcame its difficulties, and is now in a period of advancement and success.

In 2011 IIASA launched its Strategic Plan to 2020, which reflects how the world has changed since the turn of the millennium. Transformations occurring now would have been unthinkable a decade ago, with everything and everyone becoming increasingly interconnected and much more focused. Powerful solutions being needed to improve human well-being and I well know that IIASA will make a large contribution to discovering new solutions.
Two high-level sessions followed the Opening Session: “Science Support for Global Development” and “Policy Support for Global Development.” As both covered common ground, but from alternative perspectives, their main themes and highlights have been integrated here.

The session on “Science Support for Global Development” asked if the science of today was capable of addressing the great transformations of the anthropocene. According to discussants, systems analysis with its emphasis on applied solutions is vital for tackling global complexities. However, purely theoretical research, which can reveal innovative, even surprising, approaches, must not be neglected. A major problem is that scientists are failing to get important messages across to policymakers and the wider public. Not enough action, for example, is being taken on scientific research aiming to lift people out of poverty, help the disenfranchised, or persuade the developed world to embrace a more sustainable lifestyle by consuming less. Such failures may be due to a number of things: confusing multiple messages, a poor science education infrastructure, young people not being attracted to study science as it is “too hard,” the nature of the human belief system itself, or the fact that all the communities involved in development—politicians, business, scientists—are working to different timescales.

The session on “Policy Support for Global Development” looked at how science could be more easily communicated, better understood, and respected by the people and those elected to serve them. The post-2015 agenda to define sustainable development goals is complex because it requires communication and cooperation among many actors such as science, business, politicians, stakeholders, and citizens, plus the traditional development community. In addition, the relationships among sustainable development actors need to be based on trust and commitment. For instance, together, scientists, who depend on peer-review to validate their research, and business people, who value pragmatism, can bring more pressure to bear on policymakers.

Communication means developing strong positive narratives that encourage stakeholders to act because of the opportunities involved. International science breakthroughs will garner greater trust if filtered through national scientific bodies. Furthermore, science must be more option-oriented rather than aim for policy advocacy, which can also invoke mistrust. Finally governments need to facilitate science education not just for the young but for bureaucrats and politicians working in the science arena and offer incentives to people to develop and live sustainably.
“Human beings are changing their environment. The actions that we are taking now, or even not taking, will have an impact for centuries.”
—Michel Jarraud

Since the industrial revolution began 150 years ago, unfettered human development has been at massive cost to the planet’s population and environment. However, there is an apparent lack of concern about human and environmental issues in the public and policy arena.

This may be a case of society simply not keeping pace with scientific development: a “new form of illiteracy,” according to Carlo Rubbia. The public and policymakers lack an appreciation of the perilous outcomes at stake if we fail to act swiftly and appropriately on climate change and related problems. The extreme urgency of the situation was stressed by Nobel prize winner Yuan-Tseh Lee, President of the International Council for Science (ICSU).

“Science is powered by curiosity, and findings cannot be seen as mere deliverables. With science, surprises are of the essence.”
—Carlo Rubbia

The electoral debates taking place around the world have been restrained with respect to transformation issues. Thomas Schelling spoke of the November 2012 elections in the United States in which climate change had been a low priority for both main parties, noting that such problems were taken more seriously in Europe. One knock-on effect of political unconcern had been reduced funding when scientific advances are crucial.

“I think the world’s problems result largely from the fact that we have not learned how to cooperate in dealing with issues like climate change and, in particular, with the fact that climate change threatens mainly the poor in poor countries.”
—Thomas Schelling

More than one billion—one in seven people—live on less than $2 a day. “If, as a result of climate change, those poor people lost half their income,” Thomas Schelling said, “that would be less than $365 billion per year, which is about one-half of one percent of the whole world’s income.” Losing half your income in a developed country is survivable, and there are safety nets
in place. For a poor person in a poor country, it is often catastrophic. Yet such losses, which frequently occur after drought, natural disasters, and failed harvests in the poorest regions like South Asia and sub-Saharan Africa, make barely a blip on the radar screen of the world economy.

“Science and technology is about 90% of economic growth.”
—Sergey Glaziev

While the public did not need to know all the details of the science, Sergey Glaziev felt that we were now moving toward a society where there needed to be a compulsory 15 years of education for all, with special education for bureaucrats and politicians, as science and technology are vital to growth. This is already happening in parts of the world.

“Part of the collaborative process and one of its difficulties is simply the barrier between disciplines.”
—Nina Fedoroff

While formal education is important, Eun-Kyung Park remarked that the UN Decade of Education for Sustainable Development would come to an end in 2014. Led by UNESCO, the initiative aims to institute informal and community-based education so that people, and especially children, can acquire the knowledge, skills, attitudes, and values necessary to shape a sustainable future. These types of activities are important for the future to help to move human belief systems forward.

“We are facing serious global problems, and what we are doing is not adequate. We need a global science.”
—Yuan-Tseh Lee

Various descriptions exist of the type of science we need for the anthropocene. The terms “holistic science,” “sustainability science,” and “complexity science” are all gaining greater currency. At Rio+20 in 2012 the need to work toward a sustainable world was agreed, and Jeffrey Sachs spoke of the introduction of new Sustainable Development Goals as a post-2015 successor to the Millennium Development Goals.

To meet the multiple challenges of reducing poverty, ensuring food security, delivering energy access to all, and improving health, a holistic scientific framework
is required based on both fundamental and solution-oriented interdisciplinary research. Applied approaches will be worked out with, for instance, farmers on the ground to meet immediate practical challenges. Along with a fundamental review of science, values need to be reviewed and morality introduced, so that people cannot be disenfranchised or left to suffer in poverty. Intergenerational responsibility must be part of the new scientific morality and is best enhanced by bringing the public into the debate, since they care about leaving an inhabitable Earth to their children and grandchildren.

“The nexus issues are the biggest challenges we have.”
—Kandeh Yumkella

A major research focus for systems analysis at IIASA is science related to the “nexus” areas where issue areas such as food, energy, water, and environment overlap. Research into interactions within and between Earth systems, as well as the interconnected impacts of human activities, is providing new insights for sustainable development.

Kandeh Yumkella, in his new role as the UN Director-General’s Special Representative for Sustainable Energy for All (SE4ALL), highlighted the use of effective narratives. The narrative of fear that former U.S. Vice-President Al Gore, for example, used in his book, An Inconvenient Truth, did not necessarily change U.S. climate policy. Yumkella asked: “Can we use science to create a new narrative of opportunity for sustainable development and green growth?”

“To get more scientists and more policymakers engaged in these global 21st century problems, we need some education of informal organizations like museums, youth centers, and social institutes becoming educational institutes as well.”
—Eun-Kyung Park

The doom and gloom around climate change, Andrew Johnson agreed, had scared people in Australia and had caused collateral damage in public thinking related to all the major contested public policy issues. Winning back public trust was essential. William Colglazier commented that communication between policymakers and scientists in the United States had elucidated most of the scientific issues, and that these and their uncertainties were well understood. However, in the USA, complex economic considerations and vested interests always had to be taken into account in policymaking.
“The main ingredient is actually more interaction between the policymakers and scientists so that they understand each other’s culture better.”
—William Colglazier

Kandeh Yumkella praised the U.S. National Competitiveness Council which brings research people into a multi-stakeholder space where they talk with business and policymakers about the day-to-day issues that politicians relate to. UNIDO is using the Council as a model for bringing science, policy, and relevant stakeholders together around the world to look at sustainability issues. Reducing taxation on business ventures aimed at increasing sustainability and other such stimuli were a noted part of U.S. policy.

“If science and business can talk to each other in a way that we can understand each other, and we join hands and tell the politicians what is really needed, then we will have a tremendously higher impact than we are having today.”
—Björn Stigson

Some governments had already seized the initiative on green growth and sustainability, such as the Danish parliament’s passing in 2012 an ambitious green economy plan. Denmark will generate 35% of its energy from renewable energy by 2020 and 100% by 2050. The South Korean Government has made a clear top-down move for green growth as a national policy, putting finance into its new path to industrialization and providing it with legal underpinnings.

Sergey Glaziev stressed the important role of the National Member Organizations of IIASA which facilitated interactions between bodies within their countries with IIASA scientists, and through the IIASA research program with institutions and policymakers in other countries. Johannes Kyrle spoke of the tremendous impetus that IIASA, together with the other Vienna-based international organizations had given to scientific research, particularly energy.

“There is no single factor that has caused the world’s problems. Therefore science efforts in the future must be holistic, adaptive, and collaborative.”
—Gusti Muhammad Hatta

William Colglazier, while agreeing that science needed to be conducted at an international, interdisciplinary level, said that in every country policymakers wanted to rely on their own...
scientific community’s views, as all the major decisions are made at the national level. While Andrew Johnson advised against scientists crossing the line to become policy advocates, Björn Stigson also warned: “If you want to influence, you cannot sit on the sidelines.”

“Science has to engage much more effectively with industry leaders as a pathway to engaging with policymakers.”
—Andrew Johnson

Business was struggling with the complexities associated with the new nexus research. “How does business deal with the nexus between energy, food, water, and land use?” Björn Stigson asked. If the right platforms could be established for interaction between science and business, a greater impact would be achieved on the policy front.

“Internationally supported research is something that is absolutely needed. Vienna is emerging as a security research hub with the IAEA, IIASA, UNIDO, the OSCE, and other international organizations being hosted for many years by the Austrian Government.”
—Johannes Kyrle

Kandeh Yumkella pointed out that nexus issues had already been addressed with respect to the Millennium Development Goals through research related to energy, in which IIASA science was fundamental. Energy issues had not been included in the MDGs, even though energy cross-cuts every one of them—from extreme poverty, through gender equality, to education. A narrative of energy for development thus had to be created to allay politicians’ concerns about the geopolitical energy narratives they were most familiar with. The energy-for-development narrative, which took five years to take hold, necessarily relied on nexus research findings. “IIASA is well placed,” Yumkella said, “to begin to put the nexus together.”

For the immediate future Eun-Kyung Park noted that the new water scenarios currently being developed by IIASA and its partners, with their holistic pathways, will be an excellent showcase of nexus science for policymakers.
A WORLD IN TRANSFORMATION—EXPECTATION, POTENTIAL, REALITY
Global Transformations—Understanding the World We Live in and its Possible Futures

This session of the conference focused on characterizing and better understanding the unprecedented global changes taking place in today’s world, and their main drivers. The panel explored the status quo, the transformations leading to the way we live today, and possible futures for the world. It also considered how people, institutions, and technology might combine to determine the dynamics and the direction of change.

“Business as usual is neither likely nor desirable.”

Today, the reach of human activities is so profound that it is changing the face of the planet. While scientific and technological discoveries over the past two centuries have vastly improved quality of life, human activities have now intensified to the point where humans themselves are the biggest force of nature. The so-called anthropocene—the era during which human activities have been impacting the Earth—is characterized by an unprecedented perturbation of natural conditions: biodiversity losses; increasing greenhouse gas concentrations and stratospheric ozone depletion; ocean acidification and overexploitation of global freshwater; deforestation, desertification, and soil loss; and changes in the global nitrogen and phosphorus cycles. Technology—a democratizing force which offers opportunities for progress and change but also raises ethical questions—is also changing everything, from the way we use information to the way we do business. While change is essential in every aspect of our lives and environment, it is important to ensure that the changes are managed effectively so that sustainability is the outcome.
A WORLD IN TRANSFORMATION—EXPECTATION, POTENTIAL, REALITY
Global Transformations—Understanding the World We Live in and its Possible Futures

“We have a growing catastrophe of anthropogenic environmental change. Whether it’s climate change, ocean acidification, habitat destruction, or massive pollution loadings of more than 125 estuaries around the world, all are likely to get worse.”

The challenge of sustainable development that defines our era is characterized by the triple bottom line: economic development (particularly for the poor); social inclusion (for people of both genders, and all races and socioeconomic classes); and environmental sustainability (for all Earth systems). IIASA’s systems approach addresses these interlinked and interdependent challenges, integrating social, economic, and environmental considerations into its rigorous analyses.

Four central drivers characterize the world we live in: globalization, population growth, environmental damage, and technological breakthroughs. Although globalization has made economic convergence possible, some countries have been left behind, and these are also the countries with the highest fertility rates that continue to experience the highest population growth.

Environmental damage results from economic and population growth. The 70 trillion dollar economy is affecting every ecosystem and every basic commodity from minerals to fisheries. Greenhouse gas emissions and pollution are disrupting planetary cycles. These trends are extremely damaging, and humanity is unprepared to deal with them.

On the positive side, this era has seen remarkable technological breakthroughs with the ICT revolution. This conference’s name “From Science to Policy” speaks not only to the science of warnings but also to that of solutions.

The billionfold increase of capacity that has occurred during the last 50 years to store, transfer, and manipulate data will fundamentally transform all aspects of the world economy. At the same time, however, it must be remembered that technological change comes with what Joseph Schumpeter called the “gales of creative destruction.” Harnessing this technological revolution will require embracing the disruptive changes accompanying it. These “fundamental transformers” are a balance of dire risk and tremendous opportunity.

The Millennium Development Goals helped the international community to focus on several challenges, and enormous progress toward them has been made. Now there is a need for a global agenda focused on sustainable development goals, which means using resources to meet human development needs on an equitable basis. These should be based on: ending extreme poverty; social inclusion; de-carbonizing economies; building a resilient food system; stabilizing global population numbers; and ensuring good governance on the part of governments and the private sector.
"I have great hope that we can manage the anthropocene, but for that business as usual is not an option. We need a major transformation."

To face the current challenges of the Earth system, it is useful to look back. Until about 10,000 years ago, humans lived as a hunter–gatherer society with a population of about seven million. With the Neolithic Revolution, the human population grew a hundredfold to 700 million. Then, with the Industrial Revolution, the population increased tenfold to seven billion, economic output grew a hundredfold, and greenhouse gas emissions grew thirtyfold. As a result of these changes the planetary boundaries today are being approached or have already been overstepped. Continuing with business as usual is not an option. A major transformation is needed.

What is known about the major transformations of the past? There are four main drivers of past transformations: visions, crises, technology, and knowledge. None of these drivers happened in isolation. The abolition of slavery was driven by the industrial revolution when human and animal power was replaced by machines; but it was also driven by a vision of equity. Participatory governance and large associations of states like the European Union offer great hopes for change. Crises can also drive change because they send a signal that business as usual is not working and they offer, too, a window of opportunity. Technology and the rapid diffusion of innovation, as in the IT revolution, provide an opening for the pioneers of change.

What is completely new today is the knowledge society and the fact that scientific changes have also introduced a moral dimension to human activities. Sustainability in every aspect of human life on this planet also means a shift to equity and inclusion. Illegal and immoral pathways do not play a role in sustainability, and this can be seen through the three grand transformations that are already occurring: (i) education: some 80% of the global population has primary school education and half has secondary or better; (ii) democratization: half the world lives under participatory government; and (iii) urbanization: half the world lives in cities and up to 90% in industrialized countries, and this proportion is growing around the world.

There is still work to do on moving humanity to cleaner energy systems. As shown by the Global Energy Assessment, which was the result of five years’ work by 500 scientists around the world, huge investments are needed to solve the energy challenges society faces today, but doing so will have enormous co-benefits for other sectors like food and water.
"We need active management and stewardship of the biosphere and the Earth system in order to keep the human demand for these resources within the supply of the resources."

The Government of Denmark is intent on becoming the first country in the world to be free of fossil fuels by 2050. While some are skeptical that this is achievable, visions like the Danish one are vital to transforming the perceptions of human about the future. Moreover, if we don’t try to transform, we will transform more slowly or not at all.

It is difficult to understand why human beings cannot accept that there are limits to how much of Earth’s resources can be consumed for their own purposes, as shown in clearing forest land to make way for commercial crops and polluting the atmosphere and water supply. One reason for this is the different perceptions and misperceptions that humans have about their relationship with the Earth. Some religions have taught that humans are above nature and can use it for their own needs. Science, however, has played a distinct role in reshaping this belief. Darwin, for example, showed that humans are actually a part of nature and a species just like all the other animals. The fact that the combined activity of one species can influence how whole world works is just as difficult for society of today to swallow as Darwin’s work was in 1859.

It is important that a vision be developed for planetary stewardship. Management of the planet can take place according to the vision of planetary boundaries or any other vision that helps humans acknowledge the limits to how much of the Earth’s systems can be taken and how far resources can be exploited.

"Green development in the next decade is the biggest opportunity the world business community has ever seen."

The consequence of the trends we are currently observing—more people, higher living standards, and urbanization—is that the world is both resource- and pollution-constrained. Leading countries and companies have realized that addressing these challenges is a strategic priority. A green race is under way about who will be the leading suppliers for resource-efficient, low-polluting solutions. Many businesses realize that they have a huge role to play in this transformation.

A report recently published by the World Business Council for Sustainable Development, written by 30 of the world’s biggest companies, examined the business perspective on this future world. The “Vision 2050,” which these companies came up with, was that of nine billion people, living well, within the limits of the planet.

In reaching this vision, these private sector leaders concluded that it offered the biggest business opportunity ever seen in global business but that business and markets cannot take advantage of it on their own. While markets are good at many things, they are too slow to support transformational change. For that, business needs very strong support from government regulations and incentives, which are not yet in place.

Business also needs new partnerships with science and academia. However, working across these different sectors presents a specific challenge: time frames. While scientists deal with long time frames (decades), business is constrained by the financial sector which, at best, looks at the next quarter. Dealing with governments means dealing with people who are looking at the three- to four-year election cycle. Thus, there is a major disconnect in the concept of looking at long-term investments for sustainability.

This time disconnect is also present in the education of business leaders. Almost all formal business education today draws on the successes and failure of past experiences, while the real need is for business leaders to be educated on how the future might look and how best to address the challenges it will offer.
A WORLD IN TRANSFORMATION—EXPECTATION, POTENTIAL, REALITY
Global Transformations—Understanding the World We Live in and its Possible Futures

“We need to look at the world with very clear glasses regarding how big the problem is; and we must not waste any more time.”

Understanding the world entails looking at what is known, what is thought to be known, and what is not known about the world we live in.

Using the example of climate change, what is known for sure is that CO₂ concentrations are 40% above pre-industrial times. When IIASA began in October 1972 concentrations were around 325 ppm; on 14 October 2012 they were around 392 ppm. It is known that CO₂ is a greenhouse gas that stays in the atmosphere for a long time, that the primary reason for the CO₂ increase is the burning of fossil fuels, and that fossil fuel use is today tightly connected with the world economy.

What is thought to be known is that the Earth is warming. According to the IPCC 4th Assessment Report, this is very likely due to human activity. Furthermore, it is thought that warming cause changes in precipitation and that even if CO₂ concentrations in the atmosphere are stabilized, which will require an 80% reduction in fossil fuel use, the climate will continue to change. It is also believed that the climate system is connected to the carbon system.

What is not known is if there are going to be changes in severe weather and extreme events. It is not known how sensitive the climate system really is or what the nature of the changes in precipitation would be. In sum, what is really not known is what surprises there are in store. Importantly, it is not known how to switch the energy system from one that is dependent on fossil fuels to a carbon-neutral energy system.

BERRIEN MOORE III
Dean, College of Atmospheric and Geographic Sciences;
Director, National Weather Center;
Vice President, Weather and Climate Programs, University of Oklahoma
Panel Presentation
Earth Systems Boundaries

Videos of presentations: conference2012.iiasa.ac.at/speakers
A WORLD IN TRANSFORMATION—EXPECTATION, POTENTIAL, REALITY
Drivers of Global Change—People, Institutions, and Technology: A Systems Perspective

How does education affect demographic processes or economic development? What will it mean to add another three billion, predominantly urban, healthier, and longer-lived people to the global middle class? What differences do distributional and spatial income variations make to the behavior of the coupled social–environmental systems? What technologies, norms, and institutions are effective in propagating sustainable production and consumption? What are the new challenges in modeling drivers and scenarios to depict alternative development pathways? Many questions need answers.

“Demographic, economic, and technological developments are generally recognized as basic drivers of transformative change. Research into how the dynamics of each interact with the others is a major challenge.”

As stated by Tom Schelling earlier in the conference, the science that we need for the anthropocene is already well understood. Less well understood are the challenges that emerge at the interface of the different parts of the puzzle, not just between science, research, business, civil society, and education per se, but among the factors that drive each of these sectors: the interplay between them.

The most important resource for human beings moving through the grand transformation is knowledge, supported by ICT and other technologies. To achieve sustainability, however, people need to be open to new knowledge, to discard the collective mind map that may still partly be rooted in the internationalism of the 19th and 20th centuries and embrace the civilizational shift to becoming fully global.
"Let’s educate everybody, at least to completed secondary education, and use our brains as hard and as long as we can. This will help bring down world population, enhance our adaptive capacity to unavoidable climate change, and help us live longer and happier lives."

Although world population is often discussed from the Malthusian perspective, people can be seen as actual human resources for sustainable development. IIASA research, by integrating health and education data into population analysis, has shown the benefits of education for both development and health. When humans struggled for survival, birth rates were high. In the late 19th century, the death rate began to fall in Europe and North America, but the high fertility rate, a norm that is embedded in our culture, took time to come down. When after World War II mortality in developing countries fell, the world saw a “population explosion.” Into the future, there are huge uncertainties regarding population changes. In Eastern Europe, the fertility rate is shrinking as fewer women enter reproductive age. In other parts of the world like sub-Saharan Africa, the population explosion continues, with the birth rate expected to double or even quadruple. Meanwhile, aging societies are the trend in Europe, Japan, and North America.

The future population of the world depends numerically on how much education people receive in order to build “human capital.” Better educated women have a lower fertility rate, thus higher levels of female education can contribute to bringing the population down. Providing universal access to primary and secondary education means the rapid expansion of an educated labor force. Although future life expectancy and its potential extension are unknown, there are suggestions that living an active and engaged life can extend the lifespan.

“Innovations in energy end use insure us against potential innovation failure in any of the low-carbon energy supply technologies.”

Technological change is central to economic growth and to societal development more generally. It is both cause of and cure for the environmental impacts of growing populations and affluence. While technology is frequently seen as hardware, it is in fact a fusion of many different inputs. These include hardware, software, as represented by the ideas and know-how embodied in human capital, and the diverse range of actors and institutions—not just those in R&D laboratories—known as “orgware,” a term coined at IIASA. Technology sometimes also exemplifies artisanal craft and art.

As part of the Global Energy Assessment (GEA) these essential constituents of technology were explored. The findings are now collected in a book by Arnulf Grubler covering 20 historical case studies on successes and failures of technological innovation. The most successful was found to be the Danish wind turbine industry. A major failure, measured against its own goal of reducing dependence on imported oil, were U.S. efforts to develop synfuels.

Modeling for the Global Energy Assessment revealed that efficiency changes in energy end use (buildings, vehicles, and appliances) could contribute half of the reductions currently required in order to stabilize greenhouse gas emissions. Improving energy end-use efficiency would also have a positive impact on economic production, provide broader energy security benefits, and increase learning to improve performance and thus market appeal. The development of technologies to improve end-use efficiency have also been found to help increase the options available for energy supply, while improving energy supply technologies (power plants and refineries) has no such flexibility.
“English is bound to become the only possible universal language for people in the developing world, and a very important part of their education if they are to participate in the world economy.”

English must be included as one of the many drivers of global change, as it is a universal language among the educated people of the world. In some areas of Africa, English enables people from different linguistic communities to talk to one another. A knowledge of English can also enable individuals and companies to participate in the world economy and to benefit from the “world library”—now available through technology that can be held in the hand. Indeed, the impact of the mobile telephone on welfare and economics in Africa is enormous, enabling farmers to find out the prices of the goods they have to sell, either on the Internet or at the market.

Girls’ education is a driver of development, as shown in work carried out by the Copenhagen Consensus Center, a project that seeks to establish priorities for advancing global welfare. Whatever the problem of the poorest of the poor around the world—be it the birth rate, HIV Aids, or the way women are treated in society—it is clear that girls’ education, though taken increasingly seriously, nonetheless fails to receive the attention garnered by boys’ education. Being so correlated with reduced infant mortality and population decrease, girls’ education and its role as a driver of development is worth particular emphasis.

Development itself is driving changes. The Chinese Ministry of Health was already worried in the 1980s about the increase of meat in the Chinese diet, especially in the urban population, and its health effects. The higher people’s income, the more they spend on meat. However, it takes several calories of grain to make a calorie of meat. The demand for meat is such that food prices, especially of grain, will go up because of the extraordinary demand for grain to feed animals and the adverse effects of climate change on food. This particular driver will impact on the poor who do not eat meat but are going to have to pay more for a loaf of bread.

“What we are doing today in terms of production and consumption—and waste—is absolutely irrational, unsustainable, and definitely destroying the very fundamentals of human life and of life on Earth.”

Civil society organizations, like the World Wide Fund for Nature (WWF), are at the nexus of science and policy. They have always been driving the agenda of the environment. Working with local communities and authorities on the ground, they look for pragmatic and concrete recommendations to improve people’s quality of life and everyday well-being. They are able to analyze and translate citizens’ needs in a way that scientists—botanists, zoologists, physicists, economists—and policymakers can understand and respond to.

Currently, the unsustainable production and consumption patterns of society are high on the civil society agenda. There are many diverse types of civil society organizations. They share a drive and a passion that allows them to think out of the box, as well as a critical attitude to the business-as-usual way of doing things. They put uncomfortable questions to society, such as whether increases in GDP represent real growth and development. Their fearlessness leads them to activism, and they are shaping think tanks to bring experts and scientists from all fields together with decision makers. With their emphasis on the transparency and accountability of all sectors of society and of civil society groups themselves, such organizations represent a moral force within the development community as a whole.
“If planet Earth were a country, it would be an extremely poor country, a divided country, a degraded country, an insecure country in every measure of security that we’ve ever been able to come up with, a poorly governed country, an unsafe country. We live on a third world planet.”

The whole of Earth cannot be governed as if it were Austria or Sweden. Different governance mechanisms need to be examined, depending on who is involved in governance and how best to govern in different social and economic circumstances. Governance has changed since the 1980s when government was perceived to be the solution, civil society the monitor, business the problem, and science the advisor. In the 2000s business is perceived by many to be the solution, government the problem, and civil society the catalyst through which advice can be passed to governments. What is needed, however, is a real partnership between science, civil society, and business. It remains to be seen if planetary challenges can be effectively managed by a global system of governance, as truly innovative solutions will be required to bring this about.

“Green investment in the long run can help solve the issue of global warming and create a space for structural reform to help countries get out of financial crisis.”

The world is facing the long-term challenges of global warming and the immediate challenge of the global financial crisis which began in 2008. The global financial crisis may be an opportunity to address global warming.

The crisis-hit Eurozone countries, the United States, and Japan require a demand boost to create the space for structural reform. This will increase competitiveness in the future but is deflationary in the short run. Traditionally, a crisis-hit country could devalue its currency to boost exports as a way of creating the space for reform. Because of the global nature of this crisis, however, such an option is not available. A concerted investment in the green economy globally can have a similar effect to devaluation with respect to boosting demand. Such an investment is a win–win opportunity for now and for the future.

Governments can use green technology and research to boost their economies, which would also help mitigate global warming in the long term. The example of Korea and China investing in a green economy to help them recover quickly from the financial crisis in 2008 is a very strong one. In the developing countries, there could be support from the international community for financing appropriate infrastructure.
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS
Respecting Nature’s Boundaries for a Fair and Secure World—Food and Water

This session of the conference considered how new technologies, investment strategies, policies, and institutional innovations can ensure sufficient food and water resources for the planet, while at the same time enabling those resources to develop to meet environmental sustainability objectives and also ensuring that everyone, especially those living in poverty, receive their share.

“In the wake of Rio+20 this conference is bringing to the fore a discussion of the three interconnected scientific pillars of sustainability: economy, social inclusion, and environment.”

In a much hotter world—where the temperature may be up to four degrees warmer than now—it is important to know whether the boundaries for food and water consumption have been reached or even overreached. With a growing population, society must ensure that the limits of land for food production are not exceeded while still being able to feed a growing world population. What options are available to make the land more productive? With stocks of freshwater for drinking and irrigation greatly reduced due to climate change and lack of global water management, care must be taken not to pollute the available supplies of freshwater. The ocean, a source of food for many, especially the poor, is being depleted of fish stocks. What options are at hand to cut down overfishing and return the oceans to being a sustainable food source?
“There has been some progress in reducing the number of undernourished people in the world, but even in the latest period from 2010–2012, 870 million remain chronically undernourished, and most of these people are living in the developing world.”

With 870 million people still chronically undernourished in developing regions, according to the FAO definition of food security, there are a number of challenges to tackle with respect to food. These include understanding the short-run dynamics of food prices and food price volatility and the many long-run factors that intersect with these and with each other. Whatever approach is taken has to ensure that planetary boundaries, which represent a safe operating space for humanity, are respected.

Dealing with such a diversity of factors—population growth and associated food demand, changing diets, competition for land for biofuels, the dynamics of investment in food systems research, pressure on natural resources like water, and migration and political factors—necessitates an integrated approach.

Using the GLOBIOM model it has been possible to look deeply at the four climate scenarios which will be used in the upcoming IPCC Report (the Representative Concentration Pathways) and their potential agricultural impacts. The GLOBIOM analysis concludes that because of the large disagreement on the level and distribution of future climate change impacts in the agricultural sector due to the uncertainty surrounding carbon concentration pathways and GCM results, there is no single solution that would be superior in all climate scenarios. Uncertainty leading to adaptation to one scenario leads to lock-ins in terms of production systems in another scenario. This, in turn, implies substantial losses if a different climate scenario materializes. It is therefore advisable to choose an adaptation strategy which supports easy switching between production systems and activities.

Flexibility-enhancing methods, like access to irrigation, seeds, and fertilizers, and markets are being examined to develop a robust strategy for an uncertain world. Resolving uncertainty and planning robustly can lead to substantial savings. These include reducing the extent of over- and underproduction and the related environmental implications of land use change.

“Production growth in seafood in the past 50 years has been 480%; this is sometimes referred to as the conquering of the blue continent. One can argue that this conquering has been too successful and that we are overstepping the natural boundaries of these marine systems.”

One billion people are reliant on ocean and freshwater resources as a primary food source, and many coastal communities also rely on fishing for livelihoods. The annual per capita consumption of food from aquatic resources is 90 kilos. With a total annual revenue of 225 billion dollars, and 7,700 million livelihoods supported, fishing plays a major role in the world economy. Only 2% of motorized fishing is due to large industrial-scale fishing, the other fishermen being part of smaller or artisanal concerns. At an average per capita of 19 kg per person, seafood makes a substantial contribution to world diet.

The rampant overfishing of the oceans has been recognized over the last two decades. Major collapses of the past, like that in 1992 of the northern cod in Canadian fisheries, could have been prevented, had the science of today, which shows feedbacks and non-linearities in the system, been available. Nevertheless, currently 50% of the world’s fisheries are fully exploited and 25% in a state of collapse or recovering. Equally disturbing are the evolutionary changes in fish stocks, where fish are reproducing at younger ages and smaller sizes due to fishing, a fact that until recently has been a blind spot for fishery policymakers. Evolutionary changes take place at a decadal scale but it takes much longer to reverse them. Using a systems-wide approach with process-based modeling, IIASA is working with the International Council for the Exploration of the Sea (ICES) to introduce Evolutionary Impact Assessment, to assist...
the evolutionary changes resulting from over-exploitation of the sea—a common global good—are taking place, scientists are also starting to factor in ocean warming effects based on climate change, which could possibly amount to 2°C in the Barents Sea, resulting in a 25% increase in growth in the case of the northeast cod, leading to contingent ecological problems.

“We have a lot of options that we didn’t have in Europe and North America when we started contending with our own water quality challenge 40 years ago.”

There has been a rapid degradation in water quality in developing countries. Paradoxically, this has come about partly because of the progress made on achieving the Seventh Millennium Development Goal on access to safe drinking water and sanitation. While hundreds of thousands of systems have been installed, only in 10–20% of the water supply in developing countries has provision been made for treatment of wastewater, and there, at best, only partially. Thus waste is being collected in communities and delivered to rivers and lake. This affects ecosystems within these waters as well as human health, for example, when people come into contact with wastewater as they bathe or wash clothes.

As well as wastewater being discharged to the environment, monitoring of Lake Tanganyika since the 1920s shows that anthropogenic climate change effects are exacerbating the problems. Decreasing precipitation in some areas has led to warmer water with less dissolved oxygen and lower production output. Three billion people partially depend on freshwater ecosystems for food in the developing world. In Africa 3.5 million people are fishers, and 60 million people worldwide work in freshwater-fishing related activities. In the tropics alone, freshwater supports the green economy to the tune of $6 billion a year.

Many of the problems with wastewater have global connections such as climate change and transboundary air pollution. Wastewater also carries the residuals of internationally traded pharmaceuticals that can disrupt aquatic and, via the food chain, human health. This is a problem faced many decades ago in the West, and there are well-worked out methodologies and management models that can also be applied to emerging problems. Global science-policy cooperation through global institutions to solve these problems is important. The United Nations Environment Program (UNEP) in 2013 will launch an assessment to support the development of international water quality guidelines. In the wake of the assessment, the creation of global institutions to monitor and oversee implementation of the guidelines would be of profound importance, especially in deciding where best to place future investments.
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS
Respecting Nature’s Boundaries for a Fair and Secure World—Food and Water

“There is plenty of room for increasing agricultural productivity. We can feed 10 billion people, but will we? We continue to overregulate or completely prevent the use of most modern methods of crop improvement. None of these are science or technical problems. They are policy, regulatory, financial, and social problems. Will we solve them? I don’t know.”

Population projections put humanity at nine to ten billion by mid-century. However, arable land area has not increased for half a century, aquifers are depleting on an increasing scale, and our staple crops were developed to thrive in a temperate world, which climate change will make warmer. How, in such conditions, can the global population be fed?

Farming everywhere needs to be professionalized as it has been in the developed countries, using a system that integrates land, water, nutrients, and energy. Thinking out of the box is essential. Farming on city rooftops would, for instance, prevent heat penetration into buildings and allow food to be produced locally, cutting down transport needs. For some food crops, technologies like “fertigation,” hydroponics, and aquaponics have shown greater yields than crops grown in the soil.

Fish and shellfish are the most efficient forms of animal protein needing one-tenth as much feed per kilo as beef. However, aquaculture does not need to be polluting. At the National Prawn Company in Saudi Arabia, 20,000 tons of sustainably produced shrimp are produced in advanced facilities off the Red Sea coast without pollution and without antibiotics, making better use of nutrients that other farms would have discarded.

The dangers of genetic modification (GM) are an “urban myth.” Exploiting the hybrid vigor in crops has been done for centuries based on farmers selecting which seeds they want to sow.

GM crop acreage has increased rapidly worldwide to 160 million hectares. In 2011 bio-tech crops were being grown in 29 countries by 16.7 million farmers. Contrary to widely held suppositions, 90% GM crops are grown mainly by smallholder resource-poor farmers. Genetically modified crops can be produced to repel insects, and inhibit the growth of fungi that produce microtoxins that harm human health. As it costs $35 million to bring a genetically modified crop through the necessary regulatory procedures and on to the market, only the big staple crops like soy beans, cotton, corn, and canola are being grown.
“We need more people involved in the science of monitoring, helping us to collect quality-assured information, and then we need to act upon it.”

As science comes increasingly under pressure from the effects of funding cuts, “people power” can be tapped into. This will help achieve the scientific aims of observation and data collection on the one hand and genuinely bridge the gaps between the science community and the public on the other.

Using “people power” can help change mindsets about how humans live and utilize complex resources. Citizen science has been supporting water quality and quantity in India. Local communities are now regularly sampling their water and sending the results by mobile phone direct to the relevant ministry. This is enabling accurate figures to be posted about water potability.

The European Environment Agency is part of a community venture to promote beekeeping in the city of Copenhagen, with hives being kept on the Agency roof. Bee populations are falling in the countryside as the bees may be sensitive to exposure to neonicotinoids in fertilizers. Even though heavy metals are present in city air, it has been found that bees can deal with these and other contaminants by divesting themselves of pollutants through their internal organs. Beekeeping in the city, as well as being a citizen science initiative, helps to promote biodiversity within urban settings.

Citizen science is a perfect adjunct to scientific modeling work, tailored to local needs and the need to know what is happening “on the ground.” It is engaging communities of practice with traditional, lay, and local knowledge throughout the world.

“ Our one blue planet requires a manifesto of understanding, knowledge, and management from the local level to the planetary level.”

Water security can no longer be defined as a local problem. Only in the last century has it moved beyond river basins to become a transboundary issue. There is a massive North–South divide. Although both Africa and Europe have 700mm of rain a year, Africa has only 10% of the monitoring stations Europe has. Thus, there is a massive shortfall of information in Africa, making it very difficult to manage water. There is an inverse correlation between hydrological complexity (variability and unpredictability of rainfall and run-off) and poverty and economic growth.

There are 260 international rivers in the world, and 90% of all nations share rivers. Guinea is upstream on 13; Mozambique is downstream on nine; China has 110 shared rivers and lakes with 18 neighbors whose combined population is 3.5 billion, yet there is no scientific cooperation and no shared institutions among the countries to manage these.

Many countries are secretive about data, which leads to misconceptions and fears. Water knowledge must be seen as a global public good. There is also a massive adaptation deficit in water management which is already causing worldwide problems. The 2010 drought in Russia, for instance, led to an export ban on grain, pushing up the price of food in the Middle East.
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS

The Multiple Co-benefits of a Cleaner, More Equitable World—Energy and Climate Change

Lack of access to modern energy services imposes significant health costs and impedes economic development, while the use of fossil fuels by modern, industrialized societies threatens to irreversibly alter the Earth’s climate. Transformation to a low-carbon and low-pollution energy system is thus critical. This panel focused on reframing the climate change debate, using energy system transformation as the catalyst for green growth, sustainable development, and resource-efficient economies.

“It’s not true that the climate case has been lost. It can be done.”

The tragedy at Fukushima prompted an immediate energy U-turn on nuclear energy, not in Japan but in far-away Germany, a situation that relates to continued civil society protests over 40 years. What indeed has worked in Germany to promote renewable energy sources are feed-in tariffs. Before the introduction of the feed-in tariff in Germany 15 years ago solar and wind energy contributed 2% of national electricity. In September 2012 this had risen to 27%, and the prediction is that it will be 50% by 2020. This has been achieved by the world’s second-biggest exporter with a heavy industry share of 23% in value production.

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Videos of presentations: conference2012.iiasa.ac.at/speakers
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS
The Multiple Co-benefits of a Cleaner, More Equitable World—Energy and Climate Change

“Recent analyses indicate that energy access problems can be solved by investments of $35–40 billion per year to 2030. This is just 0.5% of investments into the energy system and would save one million lives each year.”

The Global Energy Assessment (GEA) looks at the major transformational pathways to sustainable energy and how to address the major challenges that energy transformation might bring about. It is one of the bases of the UN Secretary-General’s Sustainable Energy for All initiative.

Energy access is currently a big impediment to human development. The hotspots of poor energy access are sub-Saharan Africa, South Asia, and Pacific Asia where there are 1.3 billion without access to electricity. To solve energy access problems over the short term, $35–40 billion in investments is needed. This represents 0.5% of all investments into the energy system, but if investment is made now, one million lives could be saved each year between now and 2030.

Dirty fuels and poor combustion—for example, the traditional cooking over open fires—cause severe air pollution which, unless new policies are introduced, will be greatly exacerbated in 2030 and will certainly not meet World Health Organization guidelines. By strengthening regulatory stringency and combining this with energy access policies, 2.6 million lives could be saved each year.

With respect to climate change, greenhouse gas emissions (GHGs) need to be reduced, starting with an immediate slowdown of their growth. GHGs need to peak by 2020 and thereafter be reduced by 30–70% compared to today’s levels by 2050, then reduced to zero or negative, in order to avoid dangerous climate change. Toward the last decades of this century the energy system needs to become a sink for carbon rather than a source through the implementation of various carbon capture technologies in combination with renewable primary energy sources.

A transformation is required in the energy system. First, the way energy is used needs to be fundamentally changed in terms of supply and demand, putting more investment into the demand-side technologies. One of the major options is the introduction of energy saving measures to enhance energy efficiency and bring about behavioral changes in using energy. Efficiency enhancements in end use (buildings, appliances, vehicles) can bring about a 50% reduction in energy use. Another characteristic of a transformed system is the phasing out of fossil fuels in the long term to half of today’s level with a 50% share of renewables by 2050.

Taking an integrated approach to climate change and air pollution cuts policy costs because of the synergistic effects of transformation. In terms of tackling energy security, air pollution, and climate change, solutions that address these three problems simultaneously are just marginally more expensive than tackling climate change alone. This, however, means significant changes in today’s policies.
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS

The Multiple Co-benefits of a Cleaner, More Equitable World—Energy and Climate Change

“Something that IIASA is good at is integration across sources, impacts, and different scales.”

It was the United States space agency NASA that, controversially, first proposed the removal of black carbon from the atmosphere to help mitigate global climate change. Ten years later, an international team of researchers under the auspices of the UN Environment Program (UNEP) revitalized the issue and added an array of new issues to it.

Especially in developing countries, controlling greenhouse gases (GHGs) is not seen as important as controlling air pollution. However, if done properly, addressing mitigation of GHGs and air pollutants simultaneously is synergistic. That is because air pollutants are also short-term climate forcers and low-carbon energy sources are among the cleanest fuels.

The RAINS model was first developed by IIASA to look at the impacts of air pollution on health and vegetation, as in the example of acid rain. Over time, the scope was extended to add greenhouse gases to the analysis, as GHGs and air pollutants often come from the same sources and can be combated simultaneously. Using the GAINS model, the successor to RAINS, IIASA has been able to identify numerous least-cost options to reduce health and crop damages related to air pollution while also controlling GHG emissions.

Most air pollutants, for example, ozone and black carbon, lead to near-term temperature increases at the Earth’s surface. IIASA scientists identified 16 key measures that, together, could reduce the global warming potential of short-lived air pollutants by up to 60%. These include mandatory installation of particle filters on diesel engines, improved biomass cook stoves, and a ban on cropland burning.

NASA’s Goddard Institute for Space Studies then modeled the 16 measures to identify those with the greatest climate benefits—14 in total. The results were widely reported, including in the 13 January 2012 edition of Science.

A new global climate initiative based on the 14 measures was announced in February 2012 by U.S. Secretary of State, Hillary Rodham Clinton. It is currently supported by 18 countries, the European Union, and 14 non-state organizations, including the World Bank.

“Coherent and innovative science and technology are needed to catalyze innovation.”

The goal of 350 ppm of CO₂ in the atmosphere by 2100 to avoid dangerous anthropogenic climate change has been endorsed by leading scientists. However, this goal will be unattainable without innovative technological options for energy supply. Here some possible ideas are screened.

Given the present state of technology, the sequestering of CO₂ emissions underground and beneath the sea is risky because of the possibility of toxic leaks. Equally, geo-engineering a cooler planet by injecting sulfur into the lower stratosphere is not only a very short-term solution but could be dangerous, for instance, disrupting the monsoon season on which crops rely. Hence these are not recommended options.

The best solution we have is to reduce greenhouse gas emissions. Fossil natural gas can be transformed to produce hydrogen for energy and black carbon using the methane cracking process, a process that is free of greenhouse gas emissions.

There are also potentially inexhaustible supplies of carbon-free sustainable energy, like solar, wind, and biomass energy. To become viable, these need to be more cheaply converted and better storage solutions devised. In the case of solar energy, which would need to be transported long distances through power lines, improved superconductors using, for example, magnesium diboride with a cryogenic coating to minimize energy loss are showing much promise.

Nuclear energy currently represents 6% of energy used and is growing by 3% per year. Currently, nuclear energy, though carbon-free, is under severe public scrutiny. Moreover, nuclear fission and fusion as energy sources have limitations which will not be overcome in the time frame required to maintain global warming within the agreed limits.
“How are we going to get countries to cooperate on reducing emissions? This is a largely neglected area.”

So far, the only known workable solution to the problem of how to control emissions of greenhouse gases at a societal and economic level is the pricing of carbon. Yet, unfortunately the Kyoto Treaty should be considered a failed club, as important countries did not join from the start, while others withdrew. Therefore the question that must be asked is how to design a treaty that works, delivers real reductions, and is attractive so that more and more countries join.

A major new idea is to couple the obligation for mitigation at home with the incentive of preferential terms of trade between the willing countries. As long as the advantage from preferential trading terms is (seen) as bigger than the necessary investments for mitigation, this club of the willing countries, to start probably with the EU, will be attractive to join. The bigger the trading zone thus created, the more interesting “membership” will be. Non-members would have to pay duties on imports. This is a radical idea because economists are very much attached to free trade; but this is the only benefit that could be offered so that countries will want to join, and that would be a high enough incentive.

“Public opinion in Japan is now diversified, but the importance of mobilizing demand side resources is now recognized. I think this is the right direction.”

The disaster in 2011 at the Fukushima nuclear power plant, which blew up after a tsunami, has caused Japanese people to lose their trust in nuclear energy. Whereas the Japanese Government pre-Fukushima had a target of 50% share of nuclear in primary energy supply, it has been forced to revise that target downward because of public opinion. Tellingly, however, Japanese energy strategy to 2030, while looking at the implementation of smart grids with feed-in tariffs and the decentralization of energy sources, is still keeping the carbon-free nuclear option.
“Will the Earth fall silent or will it settle down sustainably? Which of those happens depends on the dominant species: Us.”

From an astronomer’s viewpoint, an appropriate “cosmic vignette” related to sustainability could be that of aliens watching the Earth from space over its 4.5 billion year history. The aliens would observe that changes take place slowly: ice ages would come and go, species arise and become extinct, and continents drift. Then suddenly after 45 million centuries, in a single century, vegetation patterns would start to change. Parts of Earth would become light at night, and levels of CO₂ would rise tremendously fast. Aliens would know that Earth was doomed in a few billion years when the sun flares up and dies, but what would they have made of this “spasm” halfway through Earth’s existence? If they watched for another century, would there be silence, or would the Earth settle down sustainably? Which of those happens depends on the dominant species: Us.

What the aliens would not easily be able to see from space are the big divisions on Earth: especially that between North and South. They would be unaware of the poorest people, “the bottom billion,” who are the most vulnerable to disease and disasters, have shortages of food and energy, and whose problems are aggravated by climate change.
Poverty is increasingly defined not just according to single monetary indices of poverty but in the multiple dimensions of social, human, institutional, and financial capital. Inequities in energy use mirror inequalities in income. Some 20% of population earns more than 60% of income and uses 60% of final energy. Moreover, 20% of the world population uses no electricity because they have no access to it.

The United States was one of earliest countries to provide electricity for its population and did so over three to four decades. Many of today’s emerging economies, though starting from lower per capita income levels, electrified over two to three decades. However, many developing countries still need to provide electricity for a large proportion of their population. For example, South Africa still has a quarter and India a third of its population without access to electricity.

Meeting this gap will require different strategies. Overall it has been found that if electricity is integrated within wider development efforts, the successes are greater. The benefits of electrification are multiple. We know that electricity can transform lives and contribute to human well-being, but the tangible benefits are harder to estimate and quantifying them remains a challenge for science.

Achieving universal energy access by 2030 is possible if sustained government commitment, ambitious targets, increased investment, and increased capacity building are present. Research at IIASA, which has centered around how electrification can take place in order to maximize benefits for poorest of the poor, has developed three main insights.

First, regions differ and thus solutions must too. The areas of least access in sub-Saharan Africa and South Asia differ in terms of population density, the former being low and the latter high. Second, populations are heterogeneous and changing over time. In the poorest rural households in India kerosene dominates in meeting lighting demand today because there is no access to electricity. In urban households, electricity is predominantly used for lighting. People’s paying capacity, incomes, and demands which change over time, must also be taken into account.

Finally, the benefits of universal access are multiple and their estimation is vital. Universal electrification, in monetary terms alone, could save the Indian Government between 0.6 and 0.7 billion dollars a year in saved subsidies.

IIASA is at an exciting and interesting phase in its research into poverty and equity, and systems analysis is important for understanding of these areas. Researchers are planning to analyze two main areas contributing to eliminating extreme deprivations and inequities in the next years by: (i) gaining a deeper understanding of the multiple dimensions of poverty, their interlinkages and drivers; and (ii) leveraging synergies in investments by identifying and estimating multiple benefits and gains from better coordination across policy domains.
“Why don’t governments provide more assistance after disasters? One important reason is that many governments lack capacity, even taking into account what they can expect from the international community.”

Losses from natural disasters are far greater as a percentage of income in low income countries than in the developed world. Some 95% of deaths from disaster occur in developing countries and the poorest of the poor suffer the most.

Some 98% of humanitarian aid is after the event. One of the issues linked to climate change is the responsibility for losses and attribution of costs. According to the World Bank, aid is too often too little and too late. In a paper published in Science in 2005, IIASA scientists argued that with new modeling techniques for estimating and pricing the risks of natural disasters, the donor community is now in a position to help the poor cope with the economic repercussions of disasters by assisting before they happen.

Some coping mechanisms by the poor after a disaster can trap farmers in poverty, like recourse to money lenders, selling fungible assets, and taking the children out of school. As an alternative to poverty-trapping strategies, IIASA is working with the World Bank, Red Cross, and insurance companies on examining the potential of financial instruments for the poor.

Outside assistance plays only a small role and governments often lack the capacity to render assistance even taking into account international assistance. After the 2006 drought in Ethiopia, the World Food Programme was highly innovative in developing a weather derivative based on rainfall index that would provide funds to the government in the case of drought. The idea of protecting governments through insurance measures has been put forward by IIASA for the Climate Adaptation Fund. Another potential service that an adaptation fund could render would be to support micro-insurance projects. Currently over 50 micro-insurance pilot projects are under way. Proponents stress the advantages to farmers of having a reliable safety net and to donors of leveraging tight aid budgets. There is a great deal of excitement about these new approaches, but it is still unclear whether donor-based financial instruments are a silver bullet for the 1.3 billion farmers facing weather risk.

While most schemes have had difficulty in scaling up, it remains very important to integrate promising instruments into multiple policy domains. A YSSP—Young Scientists Summer Program—study at IIASA showed if insurance schemes were pooled across Ethiopia, capital requirements would be greatly reduced.

Education can play a role in reducing disaster losses across the board and for risk transfer systems, as can governance and trust in institutions. This, however, is no time for marginal steps, and we need to think how we can make transformative changes in natural disaster assistance across multiple dimensions.
“We need to finish with poverty in this world.”

If sustainable development depends on the capacity to produce, appropriate, use, and access knowledge and technology, then the biggest challenge is to make sure poor people can access the resources available to them. This is not just about education as a means to ending poverty, but about quality science education for all—from primary through secondary to university level.

Integrative research is also necessary to allow developing countries to face the global challenges that must be met nationally and internationally. However, it has to be spread around the world and not just concentrated in “power houses” that produce knowledge with other regions being expected to appropriate it directly. Nor is it just about co-designing and co-producing development projects within the international community: every region must have the scientific capacity to produce knowledge that is relevant to that region. “Research about the poor” should be rephrased to “research for the poor.” This must be reflected in the way scientific questions are framed and communicated: good science should be framed as being for those who need it most.

There is sometimes the criticism that in developing countries there is not enough political will to act. In fact, there is not the human capacity to function properly or capital—even a mobile telephone, allegedly a low-cost facilitator of development, is still expensive.

One important development has been the decision by the UN Secretary-General to found the Scientific Advisory Board, spearheaded by UNESCO, which is starting to tackle climate change and poverty eradication issues. This will help to build a framework as a basis for public policies that really work in developing countries and show that the world is ours and that we have a role to play here.

“...the world is ours and that we have a role to play here.

We should think about establishing skill schools for junior secondary school graduates in African countries.”

Energy poverty affects significant numbers of people in sub-Saharan Africa, especially in rural areas; millions have inadequate energy services, rely on traditional rather than modern sources of supply, and have an unreliable source of supply. This affects their productivity, health, and education; so that these people are not only energy poor but also socially and economically poor.

The vicious cycle of no cash, low productivity, and no modern energy access must be broken. Intervention has to be via a package of financial, technical, institutional, and social intermediation. Financial intermediation can result from reducing transactions costs, introducing subsidies for rural areas, as well as a system of guarantees and investments. Technical intermediation is doing very badly in most African countries. After junior secondary school, people have nothing to do and some of them are tempted by joining rebel movements, especially in rural areas. Vocational schools are needed: welding, carpentry, maintenance—owned by the village themselves. Villages need to be involved in selecting the technologies they are given. Governments have to strengthen institutional intermediation by creating a policy environment that encourages participation of national agencies, by developing schemes to incentivize the private sector, and by improving coordination schemes for funds and grants. Rural administrations also have to be supported through subsidies, for instance, for energy pricing.
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS

Eliminating the Unacceptable Social Ills of the 21st Century—Poverty and Equity

“We must place the needs of everyone on our planet at the core of development. Otherwise, the worst impacts of environmental change will ripple out to affect us all.”

The effects of climate change fall upon the weak, the elderly, the poor, and the young; and as stated in the last report of the Intergovernmental Panel on Climate Change (IPCC), they have the potential to ripple out to affect everyone.

It is not possible to adapt without transforming to a world with fewer and less marginalized people. If this transformation is made, a great deal of damage can be avoided. Ten years ago, adaptation was a dirty word because we expected to mitigate our way out of the crisis. In fact, both mitigation and adaptation are needed. It would be wise to adapt for a 4°C temperature rise; there is a one in four chance of a 2°C rise but we will have to cut emissions by 80% to achieve this. In a business-as-usual world with climate change, there would be 100–200 million more hungry people, three million more at risk of coastal flooding, and two billion more people short of water.

It is planned to put aside $50 billion a year by 2030 to spend on adaptation, that is, a doubling of current overseas aid.

“We need to sell hope rather than desperation.”

There is a choice to mitigate or not; there is no choice but to adapt. Poverty is a complex issue and one of the top priorities in sub-Saharan Africa. To come out of poverty, the continent requires economic growth. Paradoxically, the economy of Africa has been growing for the last 15 years but most of the sectors of growth are climate-sensitive, where the large uncertainty regarding temperature rise and water availability in the century needs to be taken into account. However, by 2030, the costs of climate change will represent 2.7% of African GDP, meaning that all or most of the economic growth will be going to adaptation.

Four concomitant actions are urgently needed: (i) A new narrative, that has to be based on selling hope rather than desperation on climate change; (ii) New types of institutions that can think out of the box to remedy failed governance in Africa; (iii) Capacity and financial resources; and (iv) Work at all time scales, both short and long term.
A WORLD OF INTEGRATED SOLUTIONS FOR SUSTAINABLE DEVELOPMENT—THE POWER OF SYSTEMS ANALYSIS
New Concepts in Science Supporting Development

There has been such rapid economic growth in many regions that conventional concepts of development need to be urgently rethought. “Green growth” that respects planetary boundaries has been embraced as a new opportunity for achieving environmentally sound development. This paradigm requires a change in the way we think about global, national, and personal development, all of which must now be based on a fully integrated, holistic approach.

“We are going from the old definition of sustainable development—which has largely been about a sector approach to minimizing environmental impacts—to the new agenda of global sustainability, which affects us all, at all scales and sectors.”

The fact that the world is on a trajectory to a 4°C temperature increase shows that the current development paradigm is not working. While attempts are made to bring millions out of poverty, the biggest driver of the challenges the world faces is affluence, as more people adopt a lifestyle equivalent to the one that caused the problems in the first place. Changes are needed not only in lifestyles, but in food and energy use. Green growth is a new approach and new agenda and, as such, will require experimentation at all scales and sectors. Not all the answers are to hand. Demanding the development of a new value base which will affect relationships between industries, cultures, and religions is an enormous enterprise for the world. Putting the right price on carbon and on payments for ecosystem services will take the world a long way toward a green growth trajectory, but there must be care that the rich do not “vacuum clean” the resources as a result.
“Reconciling different sectors and goals is a wicked problem for scientists.”

According to research carried out by Johann Rockström and his team, humanity has already moved beyond “safe” planetary boundaries on biodiversity loss, climate change, and the nitrogen cycle, risking severe impacts in the future.

The Ecosystems Services and Management Program (ESM) at IIASA has used an integrated modeling approach to see if integrated policies at the nexus of the planetary boundaries and land use could bring the globe back within the safe boundaries. It was found that although an integrated approach yielded co-benefits, policy alone was insufficient.

Transformative technologies are needed, such as those presented by Nina Fedoroff at the conference. However, much more data are needed to improve land mapping. ESM are harnessing the power of social media and networking through Geo-Wiki. The Geo-Wiki “hackathon” on Ethiopia to map settlements and cultivated land helped achieve a land cover map that is far superior to any currently available. This open-source map can now be used as a risk map with respect to land acquisitions, so-called land grabbing.

“A million lives a year can be saved in the developing world by switching to modern cook stoves and not burning biomass for cooking.”

Three billion people burn coal, wood, and dung to cook their food, leading to indoor air pollution which causes the premature deaths of many women and children. Some 1.4 billion people in developing countries lack access to electricity, which impinges on the quality of life and denies good health, livelihood, and education. Some 1.7 billion face water shortages because there is no delivery infrastructure, and the sanitation situation is worse. One billion lack access to all-season roads and thus to markets to sell their products.

There is a correlation between the amount of energy countries use and development levels. There is no country that has achieved high levels of development by consuming less than 100 gigajoules of energy per capita. The growth imperative is strong especially for poor countries, but to achieve the growth they need, they must have a three- to fourfold increase in energy supply. This represents an opportunity, as developing countries are not locked in to any particular energy system and technologies can be developed for developing countries, and be made affordable.

Vehicle growth is also associated with increasing affluence. In the developing world, over half the trips made are by cycle and on foot, but this is changing with growing affluence and it is expected in the next 20 years that the vehicle stock will increase by a factor of three in India and factor of five in China. This is happening in most polluted cities in the world with levels four to five times higher than recommended as being safe by the World Health Organization. Reducing particulates provides co-benefits for health and for the climate.

Affordable household fuels are needed. In achieving 100% access to modern electricity and technology, much less fuel is used as the process is more efficient. Although CO₂ is produced by using modern cook stoves, this is negligible in comparison with the greenhouse gases, like methane and carbon monoxide, emitted by burning biomass. A million lives a year can be saved by not burning biomass.
“We are moving toward a non-Western world order. This is a huge driver of global change. We see stagnation in every field of international politics.”

To achieve the great transformation toward sustainability, profound and fundamental changes are required. In particular, a change in human belief systems and human behavior is required that will enable a new contract between the social actors to emerge.

While transformative policies can drive change, for example, in education and economics, the whole system cannot be steered from the top. The transformation will come about through co-evolutionary processes between arenas of change, and science can provide a better understanding of these.

The concept of a social contract stems from thinking by Kant, Rousseau, and David Hume. Civilizational shifts have only worked in the past based on a consensus within societies that there is a need to change direction. This has held true for the abolition of slavery and child labor, the Universal Declaration of Human Rights, democracy, and the abolition of apartheid.

However, a social contract implies that there is an emerging legitimacy within society for change. Currently the world is an “in-between” place where sustainability is not high on the social agenda and society has no stable set of expectations about it. Science needs to look more closely at the human factor and how to shape human behavior.

Elements of a social contract include a culture of stewardship for the Earth system, a culture of obligation toward future generations, participation and democratic responsibility, and global fairness. A social contract for change is particularly important in a world undergoing tectonic power shifts, which can no longer be organized along G8 and G20 lines. The current “G-zero” world obliges us to reinvest in some of the basic ingredients of cooperation, rebuilding trust and reputations so that the old and new powers can, together, create narratives to bring about a new social contract for sustainability.

“Green growth dynamism has taken root in Korea.”

The Korean Government has vigorously pursued a green growth agenda. Four years ago it introduced a comprehensive strategy going beyond environmental and energy policies and covering all sectors of the economy that sets a green growth development strategy to 2050. The green growth policy is steered by high-level politicians and private sector actors. This green growth approach is the right narrative to motivate the politicians to act. But to do this, the popular perception that green growth is costly has to be removed.

Developing countries currently lack the capacity to pursue green growth. At the G20 Summit at Las Cabos, Mexico, countries called for the provision of knowledge, resources, and technical and institutional capacity building as an architecture for green growth in the developing world. Korea is assisting in this enterprise.
“I have talked with science and technology representatives of many governments around the world at all stages of development, and they all place at the top of the agenda the relation of science and technology to innovation and economic development to ensure a prosperous future for their citizens.”

Many countries are now placing science and technology at the top of the agenda to drive innovation and economic development. They are making new investments and revising policies to achieve this. The USA has effectively used open challenges and prizes to stimulate innovation in the developing world. The United States Agency for International Development (USAID) has implemented “Grand Challenges for Development” which has had three themes to date: saving lives at birth; all children reading; and powering agriculture. A fourth on stopping human trafficking is in the pipeline. There were 600 entries, half from outside the United States. Twenty-two were shortlisted and invited to Washington to display their ideas which were then funded by public–private partnerships. The initiative “LAUNCH” is another competition which helps bring development ideas to fruition and generated $40 million for investment.

“Scientists need to do a better job of evaluating their science and development projects if we want development itself to do a better job.”

Many scientists are not doing enough to validate the models that they use. If scientists are to contest accusations of failure, for example, in climate change, then science output needs to be much more carefully validated.

False assumptions made in the past also mean that scientists have to readjust models to take account of new information. For example, the assumed “dumb farmers” of the past were not so dumb, but in fact the most adaptable sector to climate change. Recent population models have turned around the argument of exponential population growth by taking into account, for example, that the education of women has reduced fertility. The effect on climate change of Asian diets with their greater demand for meat now has to be taken into account by scientists, who must also realize that the whole system is affected by such changes, not just crop yields.

There have been enormous claims by scientists and conservation groups for the success of environmental markets that have reduced deforestation and emissions. Their efficacy has now become accepted wisdom, but as many important studies do not compare like with like through the study of matched deforestation cases, some comparisons are not legitimate. Visiting communities on the ground to find out the actuality, rather than relying on literature sources, is also vital for science results.

Multiple sources of evidence need to be used and longstanding assumptions questioned. Longitudinal studies are needed to enable scientists to learn from their successes and failures, which would have a long-term benefit for scientific accuracy. Again, very carefully designed evaluation is called for, and funders need to provide money for evaluation.
ALTERNATIVE WORLDS—NEW CONCEPTS AND NEW UNDERSTANDING
Addressing the Challenges Concurrently—Science and Technology for Sustainable Development

This session focused on the ultimate research goals of human development, equity, and well-being and the mechanisms used to achieve them. It also sought new and innovative insights into why and how progress toward them is constrained. Discussants explored the alternative, more sustainable, and more just worlds that could emerge from transformational change.

“IIASA is strong in using systems analysis to look at the intersection of problems and to solve them jointly and concurrently rather than sub-optimizing small parts of them.”

Under the new strategic plan of IIASA, which began on 1 January 2012, three coupled areas were chosen for research into achieving sustainability: Energy and Climate Change, Food and Water, and Poverty and Equity. These were deliberately selected to capitalize on IIASA’s expertise in systems analysis whereby closely linked problems are solved jointly and concurrently.
If people are going to act on knowledge that really affects their lives and livelihood, they have to trust it. And to trust it, it has to have been, in some sense, collaboratively produced.

When IIASA was founded, there was nothing approaching a community looking at human–environment interactions. The crucial period was in the 1980s when the first contagions happened between energy, complex systems, and system dynamics, for which IIASA was an incubator. A relevant scientific literature began to emerge, and the field gelled at the turn of the millennium, as researchers began to know about others working in the field and to cite each other in their publications.

The new “sustainability field” had a deep commitment to linking theory with actions and to trying out solutions in the field. The field has advanced, and today there are multiple formalizations and framings for it, none of which are the whole story. However, it is self-contained and critiquable enough to allow the science to advance.

Sustainability is grounded in a goal of well-being, both intra-generational and intergenerational. It deals with stocks and assets which can be measured and evaluated to give an indication of how sustainable a course of action or policy will be into the future. These stocks include manufactured assets like factories, homes, and roads; human capital, like population, education, and health; and natural systems like ecosystems and their services. The latter are only now beginning to be recognized and folded into the system. All these assets are modulated by institutions, norms, expectations, and our ability to innovate.

The problem for science is how to measure sustainability and to design interventions that take into account these complex, interdependent systems, which operate at multiple scales from local to global, are highly non-linear and contagious across fields, and adaptive in terms of having selection measures that allow scaling up and replication of what is successful at a local level.

However, the notion that science “figures it out” and tells society what to do is wrong and probably indefensible. In sustainability science, knowledge is science combined with local experiential knowledge; it integrates not just the practical context but also uses quality control and is collaboratively produced so that people are vested in the process and feel that their own evidence and needs are being taken into account. Science will provide support rather than instructions.

Finally proper scientific engagement in sustainability science will mean getting out into the field, working with different disciplines, working creatively, and communicating effectively.
“There are still too many people who breathe unsafe, dirty air on a daily basis; too many countries that are dependent on a limited number of energy carriers from a limited number of energy sources. And despite two decades of talks, there is still no global agreement to control greenhouse gas emissions.”

Among the many challenges of energy sustainability are alleviation of energy security concerns, climate change mitigation, air pollution reduction, and the affordable provision of energy services, all of which are interrelated. On each of these fronts, there has been varied progress in recent decades, but there is still a long way to go before the challenges are overcome.

Why the lack of progress? One barrier is the time scale and sense of urgency. Energy security and air pollution are seen as short-term concerns, whereas climate change is viewed as more of a long-term phenomenon. Another is the geographic scale, with some problems requiring local/national solutions and others needing to be considered at the global scale. Thirdly, some problems like air pollution can potentially be overcome using add-on solutions—for example, sulfur scrubbers and particulate traps at industrial facilities or catalytic converters on cars—while climate change, or rather the mitigation of it, requires more structural, fundamental changes to the way society produces and consumes energy.

Integrated analysis was carried out in the context of the Global Energy Assessment, where integrated assessment modeling tools were used to analyze policies of varying degrees of stringency. It was found that synergies from energy efficiency and decarbonization accrue in multiple dimensions. As discussed by others at the conference, there are co-benefits for (i) air pollution and human health; (ii) improved energy security; and (iii) policy costs.

“There are some opportunities for methodological contributions that are not often in systems analysis models.”

IIASA is in a unique position to make methodological contributions that are not often in typical systems analysis models. However, when there are gaps relating policy inputs to outputs, the power of the insights of systems analysis to inform policymakers are less than what they could or should be.

One of the gaps is in the model front end. You cannot choose which scenario you want and get it. You may have a goal but because of the uncertainties, you may not achieve it, which is why multiple scenarios are worked out. There may also be gaps in the back end relating indicators to impacts. While a 2°C temperature rise may be indicated, very few people have an insight into what this means in terms of impacts; they want to know, for instance, which people might lose their homes in flooding, and this can be modeled.

The outputs of the integrated model must be linked to economics and the human behavior based on economic and other incentives, the consequences of which are of direct interest to policymakers. You need an idea of what types of consequences might be better than others, and to evaluate alternatives and their uncertainties.

A separate value model based on stakeholders, the people impacted, and policymakers, calculates the desirability of alternatives, accounting for the risks of success in achieving the multiple objectives. A value model combines multiple objectives and risks in terms of economics, social sciences, and psychology. Here there are real opportunities for IIASA, since if you build a value model you can get an extra 10% of insights.
“The use of participatory approaches in Australia has raised very fundamental questions, challenging the way science engages with society to achieve real action on the ground.”

Over the last two decades in Australia, there has been significant growth in participatory research approaches to underpin research and investment. This has raised many questions, and in particular, it has challenged the way science has engaged with society to solve the problems on the ground.

With respect to decision support, there has been a preponderance of technically focused rather than user-focused applications. This has resulted in unfulfilled expectations, irrelevance, inflexibility, inaccuracies, waste of investments, and lack of trust of public and policymakers in scientists.

Australia has had some successes. In late 2007 Australia was facing its 12th year in drought. The Murray-Darling Basin was in ecological and socioeconomic crisis. The Australian Government agreed to a fundamental reform in the way the crisis was faced. To their great credit, they recognized the need to provide a sophisticated nuanced and dynamic approach to the decision support needed to underpin that reform process.

They engaged with the scientific community through the Commonwealth Scientific and Industrial Research Organization (CSIRO), and asked searching questions about the implications of different scenarios. The project was delivered on time, on budget, and on scope and, most importantly, a deep, rich, comprehensive process of engagement with community, industry leaders, and policymakers.

There were some key learning effects about the relationship of science to policy and science to the community: (i) The criticality of ensuring legitimacy and mandate from the end users and communities who benefit from these process, including that they understand the context of such initiatives and come to own the outcomes; (ii) The importance of not producing results that are convenient to methods; and (iii) The need for unprecedented effort around transparency, community trust, quality assurance, and the importance of robust communication protocols.

“Beneath all the social and political concerns lurk legal and moral issues—such as fairness, commitment, and solidarity—that can be approached using the mathematical tool of game theory.”

IIASA has a proud and long history of using game theory to examine human behavior. Evolutionary game theory can explain the emergence of social norms, that is, laws that govern society’s behavior. Before game theory, metaphors were used to explain human behavior like free-riding—a situation in which individuals or organizations consume more than their fair share of a resource or shoulder less than a fair share of the costs of its production. Pre-game theory, Jean-Jacques Rousseau used the stag hunt metaphor to explain this type of behavior. Now, mathematical models are used.

A prime example of free-riding is seen in consuming wood from forests to make profits in the short term, knowing that the long-term survival of the planet is dependent on the ecological services forests provide: not least their capacity to act as a sink for CO2. Free-riding can be punished. Research using mutual aid games indicates that the threat of punishment can curb free-riding but punishment is costly with the result that those who refrain from punishing, yet are content to let others punish for them, are effectively acting as “second-order” free riders themselves.

Can parties be coerced into losing their self-interest and playing fairly? Can companies be forced to go green? Using evolutionary game theory, one can show that cooperation emerges more easily if the joint enterprise is voluntary, rather than compulsory. In fact, if the game is compulsory and players cannot abstain, free riding takes over and actors are caught in a social trap. Voluntary participation, however, is a catalyst for prosocial behavior, that is, behavior that cares for others. The Nobel Prize winner Elinor Ostrom observed these forces of fairness and equity at play in small-scale societies with respect to sharing common meadows and fisheries.
For 40 years IIASA has spearheaded the development of innovative approaches to understanding and managing the complex systems that underlie social, economic, and environmental changes around the globe. IIASA’s novel methods of analysis and newly available datasets enable unprecedented insights into system interactions and dependences, revealing unexpected risks and opportunities.

“This session is one of the most fundamental for IIASA for it looks at how systems analysis will contribute to the major transformation we are facing.”

Narrowly focused, single-disciplinary science alone cannot adequately underpin policies and solutions to resolve major sustainability challenges. For science to play a pivotal role in addressing the green growth and sustainability challenges of Rio+20, or the UN Millennium Development Goals, intellectual and economic investments must be rapidly refocused toward multi-scale, integrated, interdisciplinary approaches that consider social, economic, and environmental aspects, look across and between borders and sectors, and identify feedbacks or the co-benefits of a policy or management decision before it is made.

One example of the systems approach is the Global Energy Assessment, which links energy to climate, air quality, human health and mortality, economic growth, urbanization, water, land use, and other factors. The GEA scenarios find that energy access for all (by 2050) is possible with the co-benefits of limiting warming to 2°C, improving air quality and human health, and stimulating economic growth within a green economy framework. A similar analysis on water resources will be undertaken by IIASA, UN-Water, and the World Water Council.
“Sustainable development must focus on macroscopic features, recognizing that these emerge from microscopic interactions, but do not depend on all the details.”

The modeling of environmental systems goes back to Vito Volterra’s work on fisheries 100 years ago, and its classical approaches are embedded in dynamical systems theory, which remains an important part of IIASA’s work on optimization and control theory. Management of marine fisheries still concentrates on single species. There have been calls for an ecosystem approach but to date we do not have very good theory for doing that.

Sustainable development has to focus on macroscopic features of ecosystems, while recognizing that these emerge from microscopic interactions. How do you scale from the individual to the macroscopic properties of whole systems, given that the macroscopic emerges from the microscopic but cannot be dependent on the fine details?

That introduces a number of mathematical challenges involved in studying sustainable development.

Can we develop a statistical mechanics of ecological communities, human societies, and the biosphere, which involves crossing scales and integrating human and environmental systems? There are ways of helping us simplify these complex, large-scale systems to obtain reduced dimensional descriptions of them and understand them better. We cannot expect to exactly predict the dynamics of every species, but there are ways to project at the ecotype level. We have to understand at what level we can expect to predict and develop new methods.

Another challenge is to illuminate the dynamics of collective phenomena and collective decision making. Describing the dynamics of individuals and their opinion dynamics leads to modeling of, for example, voting systems to try to understand how consensus is reached in systems of humans. Modeling the dynamics of social norms is also part of collective phenomena, for instance, how one develops schemes of enforcement and punishment. Research has shown that punishment is a social norm and that humans will indeed punish others who deviate from social norms, even at cost to themselves. Ecosystems and the biosphere are complex adaptive systems made up of individual agents that interact with each other, and based on these interactions, behaviors change and there are emergent patterns which feed back into the systems.

Socioeconomic systems, too, with which ecosystems are interlinked. This introduces another challenge: how do we understand ecosystems and identify indicators of impending critical transitions between states and of the mechanisms underlying robustness and resilience. Systems that are more and more complicated as they become more over-connected, have the potential for collapse, which was the basis of Buzz Holling’s work at IIASA in the 1970s on spruce budworm in Canadian forests, where budworm outbreaks can cause the forest system to collapse. Six months before the banking collapse, Levin co-authored a paper, “Ecology for Bankers,” in which banking systems were likened to food webs, as being highly connected and getting more connected. Since food webs are prone to collapse, why are the banking systems not collapsing, in particular subprime loans, the authors asked.

Another mathematical challenge is how to achieve cooperation in the Global Commons—where we all have an interest in sustaining something, but none of us have a sufficient incentive to play our part, as was illustrated in Karl Sigmund’s talk.

Summing up, the following are key areas of research interest to IIASA: (i) scaling from microscopic to macroscopic; (ii) early warning indicators of critical transitions; (iii) lessons for the design of adaptive management especially in the face of uncertainty; (iv) game-theoretic methods for dealing with global cooperation, including pro-sociality (caring for others); (v) mechanism design for achieving cooperation.
“No single model captures the system entirely.”

IIASA has numerous modeling methodologies for application to different problems. Most of IIASA’s analyses are of complex systems of different kinds, usually social and environmental systems. However, if an economic model is introduced, it may overlook the ecological effects. One way to compensate is to introduce an ecological model, so that there will then be two outputs; or a family of models can be introduced with the same complexity and scale, each model complementing the others’ focal points. This is a multi-model approach which generates integrated knowledge about the system on the basis of the use of partial models, but even this approach can fail to capture some aspect of the complexity. However, as long as the models are structurally compatible and consistent, the model will not produce misleading results.

A family of models can be composed of models of the same degree of complexity that view a system from different perspectives. An example of the use of that sort of family of models was a recent study carried out by the Transitions to New Technologies (TNT) Program at IIASA. The study focused on modeling the historical evolution of the global energy system, and the basic model used views of the emergence of new technologies as a random process that reflects the unpredictability of technological innovation.

The analysis led researchers to global conclusions, in particular, that the simulated evolution goes through a period of growth and complexity, a complexity peak, and then declines in complexity. Another finding was a strong tendency to decarbonization, that is, a decline in the carbon intensity of the global energy system. Thus the conclusions integrate pieces of knowledge according to alternative pieces of individual knowledge that show the hidden generic features of the energy system.

“What IIASA can contribute in its capacity building and academic training is to find a way of communicating to the new generation of scientists the value of systems analysis, this conceptual framework, the language of dynamics, and to allow them to apply this way of thinking, even when there are no analytical models.”

Systems analysis is increasingly knitting together large databases, and there is a return to the use of big interconnected models. However, there is still too much of a physics paradigm in the way that thinking is structured in systems analysis. Many of the best ideas have been around in ecology for two to three decades and deserve to become better integrated into systems analytical practices. Buzz words like interconnectedness, tipping points, systemic risks, uncertainties of parameters and underlying processes, evolution, adaptation, tragedy of the commons all exist in ecology and are waiting to be transformed into the practice of systems analysis.

It is deplorably often the case that practitioners running large computer models producing highly multi-variate output do not have the language or the conceptual framework to deal with understanding such complex systems. This tradition exists in physics and mathematics; in ecology it needs strengthening. The discipline and diligence of setting up a good model, even when there is no analytical basis, are worth expanding. It is easy to be disciplined when setting up a simple model, but when designing complex models, this discipline can be lost.

In fisheries we find that the lack of disciplinary skills is limiting the progress of the field. Ecologists and economists are helping to broaden the modeling perspective, to find ways of reaping insights into the evolutionary effects of interference by humans in ecosystems, and this is leading to policy-relevant advice that did not exist previously. This did not occur on its own. Systems analysis and thinking were required to make the transition to a new perspective.
“Powerful vested interests rigorously oppose and stop ameliorative measures getting implemented.”

An environmental crisis is taking place around the world. Yet, the most difficult task for scientists and policymakers, even in developed countries, is to move away from recommendation to implementation. Given the political reality, it is surprising that we have got as far as we have. The biggest hurdle is how to bridge between experts, stakeholders, voters, business, and national politics. The linkages are lamentably weak. In the wake of the 2008 economic collapse, vested interests stopped environmental interests being implemented. An important new approach is to deeply integrate citizen science with professional science, as practiced, for example, by the Resilience Alliance. Eddie Carmack, Canada’s award-winning oceanographer, had been going out with ice breakers monitoring the three oceans of Canada’s Arctic each year to show how climate change is being manifested in the Arctic. This work alerts people to early signs of collapse of part of their system. It also builds a community of voters to tell politicians what to do.

“Among IIASA’s most valuable products are the individuals who leave IIASA and then apply the systems analytical approaches and tools they learned at the Institute.”

The first water resources research program began some eight months after IIASA’s foundation and, like almost all of the projects that followed, had a regional character. Severe regional water shortages, localized flooding, or local water supply contamination were the focus. Various-sized regions were selected as research “laboratories” to test and evaluate the research results. Most of the water resources studies were done in close collaboration with regional, national, and international institutions concerned with the particular issues being investigated.

In 1965 a forecast of water use in Skåne in Sweden had been made by extrapolating past trends. A comparison of forecasted water use levels with the locally available resources indicated that there would be a serious future water shortage in the area. A decision was made, therefore, to develop a new source of water from Lake Bolmen some 150 km north of Skåne. By the mid-1970s the earlier forecasts had proven to be incorrect. The effects of environmental legislation enforced in the late 1960s had not been anticipated. These laws had led industrial water users to install new water recycling equipment with the aim of cutting the costs of complying with the new water quality standards. The incidental effect was to substantially reduce water withdrawals. These withdrawals took place in spite of a substantial increase in industrial production over the same period.

IIASA research in the mid-1970s showed that the effects of environmental legislation enforced in the late 1960s had not been anticipated. This classic case illustrates that demand uncertainty involves not only random variations around some estimated mean future demand, but also abrupt structural shifts in the evolution of demand.
ALTERNATIVE WORLDS—NEW CONCEPTS AND NEW UNDERSTANDING
Worlds within Reach—The Way Forward

This interactive session discussed what “future worlds” are possible, and what obstacles must be overcome to make those worlds a reality. The natural and social sciences have been using a top-down approach, but as demonstrated at the conference, there is also a growing field of bottom-up approaches from individuals and groups and also motivated by scientists and researchers with the aim of increasing stakeholder involvement.

“Different professional communities are involved in the process which IIASA is bringing together and linking to the policy and business community.”

Scientists study the dynamics of the planet to develop solutions that involve new methods, infrastructure, governance, capacity building, information, communication, and education to support sustainable development. This is a complex undertaking, subject to turbulent and complex activity in the economy, society at large, and governance, as well as external influences, like international agreements. IIASA is bringing the various professional communities to work together to overcome the many different barriers to attaining sustainable development.
“In five years’ time IIASA will become the global hub for systems analysis in support of sustainable development.”

The vision for IIASA is grounded in the work of all scientists and in the legacy established by previous directors. IIASA is facing exciting times. IIASA is healthy, mentally and financially, and is responding to the Earth system challenges.

Twenty countries nominated their member organizations to be on the IIASA Council, and seven more are in the waiting room. IIASA will not be growing endlessly to become some sort of United Nations, but carefully, respecting two main pillars: science excellence and geo-political relevance.

IIASA’s research budget has been increased by 30% over the current year by making internal shifts in the budgetary balance. It has been decided to reward IIASA programs based on indicators of research excellence and policy excellence or competitiveness in international markets. About 40% of budgets are going not to the disciplinary programs but to very specific nexus programs, Energy and Climate Change, Food and Water, and Poverty and Equity, and another 20% to very specific projects in the cross-section areas between them. Incentive is in the system again.

Flagship projects are being started at the level of regions and subcontinents, combining an engaged scholarship concept, and involving stakeholders. These will address specific issues that some of our National Member Organizations wish us to look at, like the integrated futures of the Arctic Ocean (seven of the nine Arctic countries have NMOs), the “Russia+” economic space, and the future of the tropics (through NMOs, Brazil, Indonesia, and Malaysia).

This year, IIASA had two Young Scientists Summer Programs (YSSP), one at IIASA and one in South Africa. This program will be expanding with a second YSSP intermittently in South America and Asia. IIASA is thus responding to the many calls heard at the conference for more science education.

On behalf of IIASA, I met with Ban Ki-moon, Secretary-General of the United Nations, who said: “There are 10,000 NGOs and IIASA is the only one talking directly to me.” IIASA supported the Secretary-General in the energy field and will be giving support in the near future on water. There were calls at the conference for more effective communication with policymakers. In a recent IIASA visit to Indonesia, the President and Science Minister called senior policymakers together to discuss issues. Out of this came an idea for running summer courses for senior policymakers at IIASA on the advantages of the systemic approach to problem solving.

IIASA is also starting a Systems Analysis Forum, including scientists and policymakers, which would advance IIASA further in becoming the hub of the systems world. An invitation is extended to all policy and scientific institutions who would like to become members.
“Future Earth builds on the links between human and natural drivers to look at the
dynamics of the planet, understand change, and make future projections about change,
for example how to achieve food, water, and energy security while remaining within
safe planetary boundaries.”

Future Earth is an initiative of the International Council for Science (ICSU),
which is working to strengthen international science for the benefit of society.
Future Earth builds on successful global change programs sponsored by ICSU:
Diversitas, IGBP, IHDP, WCRP, and ESSP. It is an alliance of partners: scientists, funders,
information providers, user organizations in the UN system, who all wish to take
“the next step up” in sustainability research to understand the risks generated by
global environmental change and identify the opportunities.

The foundational research carried out under Future Earth points to major challenges to
future sustainability and has five main pillars: (i) to bring people into research on Earth
systems, by looking at the impacts on them and their own responses to global change;
(ii) to foster a more integrated approach to the problems by bringing science together
with other stakeholders, to engage more broadly and improve two-way communication;
(iii) to extend scientific thinking beyond policy users, for instance, to business users,
but particularly to establish a more direct dialog with the exposed and vulnerable;
(iv) to co-design a research agenda with those most needing to benefit from
research interventions; and (v) to look at the broader questions of the policies needed
for science in terms of education, career structure, rewards, and funding solutions.

“The good news is that the international community woke up to the significance
of climate-relevant emissions about five years ago. REDD+ is one of the more
promising areas of agreement in global climate negotiations, and most heads
of government are now talking about forests.”

There are a number of “convenient untruths” about forests.
The first convenient untruth is that poor people are the main cause of deforestation.
However, spatial analysis shows that it is really caused by commercial-scale land
clearance for industrial agriculture to produce internationally traded commodities.
Thus, all those who consume soy, beef, oil palm, pulp and paper, are the agents of
deforestation. It is more true to say that deforestation causes poor people, as local
communities, especially the women, depend on the forests for their livelihoods and
forests are an important environmental buffer against the extreme weather events for
poor people. In fact a body of research founded on Elinor Ostrom’s work is showing
that local communities do a better job of safeguarding and managing the forests
than governments.

The second convenient untruth is that forests need to be sacrificed for food cultivation.
Forests are not only a direct source of food but also a source of income to buy food.
On average, forest-based income comprises 24% of household income, more than
from agriculture: these data are missing from national accounts. Forests are also
a source of hydrological regulation and pollination. More research is needed
to strengthen scientific knowledge regarding forest-based goods and services,
including rural diets, and the institutions needed to protect them.

The third convenient untruth is that forests need to be sacrificed for food cultivation.
The best thing, in fact, is to protect the trees already standing. One egregious
example of mistaken thinking is that you can convert natural forest to large-scale
oil palm plantations. If, for example, you convert peat swamp in south-east Asia
to oil palm and use all the oil produced for biodiesel, it would take 800 years to
get back the carbon debt incurred by that initial pulse from land use change.
The fourth convenient untruth is that the relevant policymakers in this sector are ministers of forestry in forest-rich countries. As most drivers of deforestation, however, are extra-sectoral—mining, agriculture, infrastructure—and there is over-capacity in wood processing, the relevant policymakers are from multiple other sectors. Governments have to put in place and enforce policies that reward sustainable forest production, like certified timber and carbon storage, and punish illegal and wasteful forest destruction. The private sector needs to remove deforestation from the commodity chain. However, as markets are no good at catalyzing transformational change, civil society is needed to demand transparency, and science is needed to inform them all.

“One of the great challenges of Earth system science is the combination of the different approaches in physics of the climate system, biogeochemistry of the ecosystem, and socioeconomics of the human system.”

The three main Earth systems, the climate system, the ecosystem, and the human system are all interlinked, but the level of understanding is different in all three areas, and this is what gives rise to the great challenges the world now faces. In fact, one of the great challenges of Earth system science is to combine the different approaches so that the future evolution of the Earth system can be assessed.

Two hundred years ago, in the golden age of classical mechanics it was assumed that the universe was predictable, and the future was just the integration of differential equations. It is now known that the system is complex and turbulent, with non-linear systems, which are also characterized by a variety of dynamical time-scales and complex feedback processes. With respect to climate change, statistical calculations are needed to look at a longer time scale. The ecosystem is much more complex and much less well understood, with the parts relevant to the carbon cycle being the best understood. The human system is the least understood in terms of data and of the dynamics required for projecting its future evolution. There is plenty of work for IIASA to do with respect to the interlinkages between these parts.
Advice the government on research policy issues
Finance and stimulate public and private R&D
Create arenas for cooperation and knowledge distribution
Promote internationalisation

- IIASA – an important arena for international cooperation

Presented by
Kjartan Broch Mattson
The Research Council of Norway and IIASA Council Vice Chair
IIASA’s influence, its ambitious research goals, and its financial and intellectual independence are based on a network of National Member Organizations (NMOs) from 20 nations around the globe. In the first session of Day 3 of the Conference, representatives of IIASA’s 20 NMOs explored the Institute’s role in supporting international policy decisions, past and future, and in expanding the application of a systems approach to international and national challenges.

“Do we understand what systems analysis really is?”
Systems analysis is one of IIASA’s fundamental reasons for existence. The Institute, on a daily basis, contributes to exploring the major transformations we face, using systems analytical methods.

Yet on my first day at IIASA, I held a staff meeting at which I invited all those present to write to me describing what systems analysis is all about. By midnight I had received around 70 emails from staff outlining their views on systems analysis, and all of them were different.

So there are many different interpretations of the term systems analysis. Do we really know what it is? And are we all interpreting it differently as we work together. This is something that I hope this panel can elucidate for us.

“At the end of the Cold War, IIASA needed much more than a restyling. It needed a new political strategy, followed by a new institutional strategy.”

By 1993 IIASA had lost its unique position as a bridge-builder of the Cold War era, and its relevance came into question. By the 1990s some countries had run into severe financial difficulties, and many European countries considered leaving IIASA based on cost-benefit studies and the fact that, with the lifting of the iron curtain, bilateral and multi-lateral relationships could now be freely established. The United Kingdom, France, and Italy had terminated their memberships, and new negotiations had failed to bring them back in. It became clear that the statute of IIASA was outdated: it had no provisions for orderly withdrawal and the issue of contributions was inflexible. As an international non-governmental organization based in Europe, IIASA was also not eligible to participate in European research programs. Without the intervention of the Austrian government with respect to research for the 4th and 5th Framework Programs, IIASA could have received no funding.

The host country, Austria, called for a governmental conference in 1994 “to secure IIASA’s future development.” Dr. Erhard Busek, the then Vice Chancellor and Minister for Science and Technology of Austria and IIASA Director Peter de Janosi prepared a conference document for discussion. The representatives of the 17 member countries agreed to the final statement of the Chair, which had the following provisions: confirmation of the non-governmental status of IIASA as a global research institute; the North-South research axis to be established and mirrored in the programs; future research to be associated with that of United Nations programs; and the science-policy axis to be a priority. New priorities, projects, and programs followed. The governmental conference foresaw that from time to time there should be more conferences and that these would be reported upon, as IIASA needed the support of governments to continue.
With the end of the Cold War, the nature of economic and cultural gaps in world view changed, but the need for IIASA to help build bridges remained. IIASA’s NMOs, now and in the past, provide the fundamental networks that allow the Institute to play that bridge-building role.

“IIASA is very strong and successful now, so the main challenge is to achieve the same political importance it had at the beginning.”

IIASA was an important scientific instrument that bridged East and West and its creation was driven by Cold War protagonists, the USA and the Soviet Union. One person not often mentioned was McGeorge Bundy, who was science advisor to John F. Kennedy and instrumental in IIASA’s foundation. When scientists of the two countries first started to work together at IIASA, contacts between East and West were very weak. During the Cold War, bridge building was important scientifically and politically. IIASA played a very important political role, and large-scale research projects began among all the countries; ranging from data exchange to the highest level of political discussions.

IIASA was very successful in the beginning but encountered hard times afterwards. On the tenth anniversary of IIASA, the USA decided to leave IIASA and although it was not officially announced, the Soviet Union was privately having the same idea about its own membership. Their arguments were overturned by IIASA leaders, particularly Roger Levien, although from then on, a special private academy was set up by the USA to liaise with IIASA rather than the previous NMO, the US National Academy of Science.

In this multi-polar world IIASA is bridge building with states through the strong involvement of its NMOs in scientific research. NMO representatives not only appreciate being included in evaluations, but also the visits by IIASA directors to our countries, the workshops, the regional activities, and the YSSP Program at IIASA and in 2012 in South Africa.
“Science is not embedded in the logic of many people.”

It is very frustrating today that so few political decisions are based on science and knowledge. The toolbox of scientists is no match for that of lobbyists which may contain poor/phony science, be media-funded, and even involve corruption. Lobbying results in erosion of trust in democracy. It is even more serious today that decisions based on the will of the people show a distrust in science, amounting to a reversion to fundamentalist and over-simplistic pre-Enlightenment perceptions of complex phenomena. Science is not embedded in the logic of many people. The catchwords of equality and sustainability are being used without any explanation of the complexity they involve. For instance, a family might invest in insulation for their home in the interests of the environment, then with the money saved on energy fly off on a skiing holiday and spend the local environmental savings at the global level. Science is not reaching the ordinary citizen, and a massive effort needs to be made to bridge at all levels of education. Teachers and schoolchildren need to understand that things are not as simple as they made out to be.

“China was the first of ten National Member Organizations to have joined IIASA in the last ten years.”

The Chinese NMO celebrated its own ten-year anniversary of being an IIASA supporter in Beijing. It was a good decision to join, especially when one realizes that ten National Member Organizations have joined IIASA in the last ten years and that China was the first. The change in IIASA from East to West, then North to South, and now global is enormous. The global problems that drive IIASA research will encourage more countries to join. Our foundation is a funding agency, and we have a very active and productive collaboration with IIASA especially through the YSSP Program to which we have sent 50 students since we joined. The Chinese NMO believes that working together in the multi-cultural atmosphere of IIASA will bring a harmonious future for us all. The scope of collaboration has become larger and we hope it will also become tighter, more strategic, and more managed by the NMOs. We look forward very much to these initiatives.

“In the 1970s and 1980s, IIASA was one of the few places that East and West Germans could meet.”

In the late 1990s, the German state had an observer status, and one of the requirements put forward by the government of the reunited Germany was that it would become a full member again if global problems were addressed. This has happened and Germany became a member again in 2003. The German NMO is very happy with IIASA’s current course, especially with the new water research.
RESEARCH FOR A CHANGING WORLD
Science for Bridge-Building During and Beyond the Cold War

“The Japanese NMO has committed itself fully to IIASA, with the topics of energy and water being of particular interest to us.”

Japan was a founding member of IIASA, and I had personal experience at IIASA working on the decision-making analysis team for a year and then as a liaison between that program and the modeling team. Peter de Janosi gave me a special mandate to explore decision support in other Asian and Pacific countries of which Japan was the only member in those days. Now we have many member countries in this region. This is an amazing change and I am very happy to be a part of the historical trend. The Japanese NMO has committed itself to making full use of the experiences and benefits we have had as a member of IIASA, in particular on the topics of energy and water.

KAZU TAKEMOTO
University of Tokyo; IIASA Council Member
Panelist
"Technology may help to provide the solutions we need. IT and the Internet, and cheap forms of communicating, have created rising expectations, but also a questioning of values and some reactive fundamentalism."

The pace of technological change is accelerating and the world is in a state of perpetual transition, which is having impacts on the economy, policy, society, and the environment. In the economy, new products keep entering the market place, and these need increasingly larger markets if investment in them is to be recouped. Growth has put stress on Earth’s natural resources and the sustainability of life is being threatened.

Changes can be anticipated through research; scientists can account for interdependencies, define appropriate options, create awareness at the global to local level, and help form global attitudes and create capacity. India has this global awareness, combined with the viewpoint and energy of a developing country.

India is in the process of drawing up an integrated energy policy, accepted by the cabinet, which has been using India-specific models and feedbacks based on IIASA work. The development of the RAINS and GAINS models has helped us carry out research in 20 Indian cities on vulnerability to climate change.

Looking at hunger in the world, it can be seen that many commonly held ideas are wrong. It has been shown that interdependencies are significant, for instance, trade liberalization in one country leads to hunger in another. The most effective way of dealing with hunger in India is through the National Employment Guarantee scheme under which 100 days of employment on real wages are guaranteed to all families in rural areas.
**RESEARCH FOR A CHANGING WORLD**

Research for Smoothing Transitions: Economic, Ecological, Political, Technological, Societal

"Egypt plans to send students to the YSSP, and to join the schools of excellence, both of which are fine initiatives."

Egypt is committed to working with IIASA. In terms of our politics and society, we have a very unique situation at the moment. Systems analysis can help us explore why countries like ours have unskilled youth at a time when technological tools are available to everyone. No one is immune to these problems, and our particular situation can be studied to gain a future perspective. The Western world has undergone considerable development. Egypt has plenty of resources, including our youth, our sand, and our sun and our country needs to close the gap, environmentally and technologically, that exists between North and South. We plan to send students to the YSSP, and to join the schools of excellence, both of which are fine initiatives.

"The work that IIASA does is very relevant to Finland, the best example being the acid rain problem which was extremely urgent, particularly in the Nordic countries."

IIASA contributes to political and practical solutions. Its work on the RAINS model laid the foundation for cooperation in the field of environment. Finland has a very small and open economy, yet is facing the same global problems as all countries. Even more seriously we are facing major structural changes, with traditional industries moving out of Finland. IIASA today is providing us with valuable scientific support in this context. The Arctic area is an upcoming area of research because of the increasing exploitation of the region. All countries around the Arctic would like to find sustainable options, and in this respect would like to see IIASA picking up on the topic, given especially that seven of the nine Arctic countries are members.

"Building global capacity to deal with mega-shocks like price hikes for energy, pandemics, and extreme weather events will be vital."

The shift from being an East–West to a North–South institute should help IIASA reposition itself for the current Asian century and for the African century that will follow it. Demographic studies show that in the next 25 years, people over 60 will outnumber people under 15 for the first time, urbanization will increase rapidly, and how Asia engages with its rapidly aging population remains to be seen. There is increasing connectivity between people, the downside of which is a flux of information. As a result people struggle to discern quality advice and trusted information. Building global capacity to deal with mega-shocks will be important, including price hikes for energy, pandemics, and extreme weather events.
“IIASA results are respected enough to make Ukrainian policymakers revise their policy paths in the light of them.”

For a long time, IIASA has contributed smart and scientifically grounded solutions to Ukraine, and these have been implemented into Ukrainian policymaking structures. It has been really easy to influence policymakers because of IIASA’s uniquely high reputation. Ukrainian policymakers respect IIASA results so highly that they have frequently revised their policy paths in the light of them. Our collective knowledge at IIASA has resulted in productive actions especially given the new initiative for NMOs to join in horizontal actions. The new project on the future of the Russia+ economic space is very satisfying for both the Russian and Ukrainian NMOs.

YURIY V. KOSTYUCHENKO
Ukrainian Academy of Sciences; Ukrainian NMO Secretary
Panelist
The term “systems perspective” has become a commonplace in scientific and policy rhetoric, but it has always been central to IIASA’s mission. Every country requires more skills to recognize and analyze systemic challenges, and IIASA’s NMOs are working with the Institute to develop innovative ways of building more capacity to place scientific and societal issues in a systems context.

“South Africa held a southern hemisphere YSSP to build capacity through a new generation of researchers. This could also be done in other countries.”

The phenomenal increase in membership of IIASA by developing countries shows the value of IIASA’s work in global modeling and integrated assessment in all research areas and for the common challenges humanity faces. IIASA NMOs are coming together to present our countries as laboratories for interconnected research. The capacity building being carried out through IIASA means that NMO countries can optimize their existing capacity, and can also draw from the experiences of other NMO countries. In South Africa there is a need to build capacity through a new generation of researchers. For this reason, a southern hemisphere YSSP was held in South Africa. This could also be done in other countries. IIASA is a wonderful opportunity for the critical analysis of information to generate knowledge and inspire the enthusiasm needed to find answers.
“What Malaysia can learn from IIASA will benefit us as we move to being a high income society.”

Malaysia and Indonesia are the biggest producers of palm oil in the world, sharing 80% of production and 90% of the market. Palm oil production causes deforestation, but there are green energy opportunities, as 90% of the biomass from palm oil remains unutilized. Thus what we can learn from IIASA will benefit both countries, as will working with Brazil on land use change and the tropical agenda planned by IIASA.

“Life on this blue and green planet needs reinterpretation.”

In the photograph of Earth from space, no boundaries and no people can be seen. This can, on the one hand, make us think of ourselves as global citizens, and on the other realize how arrogant we are to say that we can save the planet. The world can exist without people. The scientific research agenda is about to get very wet, with more water falling from the sky, sea levels rising, and icebergs melting. However, the picture of the available freshwater on our planet is serious and sharing our water knowledge at IIASA will be vital in the years to come.

“Everyone who has passed through IIASA has the language of systems analysis, and we should think of alumni as people who are spreading that language.”

I was involved with IIASA before IIASA existed. President Lyndon Johnson wanted to build an institute that addressed the common problems of the industrialized world. He asked the Rand Corporation to come up with a conceptualization of this Institute. I was at Rand, which was where systems analysis was first developed within the context of 1940s military strategy. As a basis for discussions, I authored a paper on an institute focused on systems analysis. Underlying that paper was the view that using systems analytical methods would be a good means of building capacity and that pulling such methods into policy would be globally beneficial. Systems analysis was not widely practiced outside the USA. The importance at that time was to try and develop a common language in order to face the problems, as Rand had done for analyzing nuclear conflict. This common language had been useful in the Cold War because it had enabled the USA and USSR to come to a common understanding of the conflict so that agreements could be reached that would, otherwise, have been extremely difficult. My hope was not only to create a common language and framework, but to spread it around the world. This would mean that when people sat around negotiation tables in the future, diplomats and technical specialists would have a common language to help negotiators reach agreement. Everyone who has passed through IIASA has this language and we should think of alumni as people who are spreading language, that have risen in their countries, and have a different, yet common, understanding of global problems and solutions.
RESEARCH FOR A CHANGING WORLD
Systems Analysis for Informing Decisions: Broadening Awareness and Building Capacity

“NMOs can improve individual and institutional capacity through IIASA.”

There is a long tradition of studying climate change in Sweden. Sweden intends to be emission-free by 2050, a decision that has implications for many sectors.

In the transport sector, Sweden is using systems analysis to improve transport flows in cities and is gathering a large amount of strategic real-time data with a view to making cities more livable and to improve welfare of city dwellers. Because it has a large amount of data, Sweden is an interesting laboratory especially in population studies, for example, migration. Systems analysis is being used in business in different ways to analyze products and global industry cycles, for instance, by the companies Skandia and Saab. Sweden has an agency to support and connect business and policy systems, and we are getting to the point where we are talking about systems of systems. Another interesting application, which will trickle down to the local level, is to use systems analysis to enhance modeling transparency for participatory purposes. NMOs can improve individual and institutional capacity through IIASA. Sweden is in favor of the broadening of research that IIASA is engaged in and its growing links with the social sciences.
IIASA research can provide credible insights for decision makers. Its NMOs are supporting new initiatives to connect the Institute with policymakers through workshops and forums to define the questions and examine the implications of the analyses considered by IIASA.

“To secure the relevance of IIASA’s research for decision makers, it is important to improve the dialog with NMOs.”

IIASA is in a unique position to contribute to international cooperation on knowledge production and research of the highest quality in a neutral and independent way to meet global challenges. IIASA’s advice to Norway has been very beneficial and one of Norway’s priorities for research on the Arctic will be carried out at IIASA. The Arctic climate is changing, ice is melting, fish stocks are migrating, and new transportation routes are opening up through the region, which will have impacts well beyond the Arctic.

Norway does not take enough advantage of the opportunities offered by IIASA; we have only one scientist working in the institute and hardly any YSSP applicants. For the future, Future Earth is an important initiative; it needs the integrated approach that IIASA can bring. To secure the relevance of IIASA’s research for decision makers, it is important to improve the dialog with NMOs, to continue educating the next generation of scientists, professors, and decision makers, and to make IIASA more visible.

KIRSTEN BROCH MATHISEN
The Research Council of Norway; IIASA Council Vice Chair
Framing Presentation
"Brazil recognizes that IIASA can play a fundamental role in new development concepts for the tropics."

Brazil has been an IIASA member since 2011, and before that collaborated on the Global Energy Assessment. A major issue of concern to Brazil is the sustainable development of global tropics. In 10 years’ time I would like to hear that deforestation has been halted and that most tropical countries have seen other ways of development without deforestation.

Brazil recognizes that IIASA can play a fundamental role in bringing tools of systems analysis and its considerable intellectual power to bear on new development concepts for the tropics. Brazil’s current model of development—and this is a warning for the Arctic not to follow our route—is unsustainable, with 28% destruction of the forests, which is an environmental disaster. Deforestation has also been an economic failure for Amazon forests and brought no substantial poverty alleviation. We need to realize that the greatest gift we have in the tropics is biodiversity and that commercial successes like palm oil are decreasing that biodiversity. So little is known about biodiversity that we are unaware even of what we are losing. I see IIASA coming up with cross-cutting ideas for a new development model for the tropics.

"More can be done at IIASA to integrate the social, environmental, and economic spheres."

I first encountered IIASA in 1978 and have been involved at different levels since then. IIASA’s three tiers of relationships—global, European Union, and the Netherlands—can be improved.

Globally, it is important for IIASA to have close interactions with Future Earth, especially as it has been involved in current and now ending associated programs. IIASA can continue to provide helpful advice and work.

At the EU level, quite a few of the NMOs are in Europe, in the EU, or closely associated with it, like Norway. Impact assessment is a major part of the EU way of assessing policies, and several IIASA programs are contributing to this work. More can be done in terms of integrating the social, environmental, and economic spheres. Under Horizon 2020, the new Framework Program for research, there will be plenty of opportunities to intensify cooperation.

At the Netherlands level, there are currently several bilateral efforts under way with academic institutions and ministries. A Dutch GAINS model has been made and testing at the Dutch level is being carried out. The Netherlands will organize in a way that allows it to contribute more effectively to the YSSP and postdoctoral programs in particular.

"Indonesia, from the central government level to local heads of districts, needs support from IIASA."

The IIASA Council member for Indonesia, Dr. Kuntoro Mangkusubroto, is head of the President’s Delivery Unit for Development Monitoring and Oversight. Dr. Kuntoro’s interest is in forest sustainability and he chairs REDD+ in Indonesia. As the person responsible for overseeing the nation’s development and sustainability goals, he wishes me to reiterate why Indonesia, from the central government level to local heads of districts, needs support from IIASA. Indonesia is the third-largest democracy in the world and currently undergoing major transitions.

Indonesia currently has a rice challenge. Unlike gas and electricity, increases in the price of rice could bring down the government. The president has set the goal of cheap, plentiful rice; to achieve this we need to execute a plan for growing and distributing rice and to tackle it from the perspective of science. When Dr. Kabat visited us in Jakarta, we discussed holding workshops with IIASA on the green economy and to discuss the price of rice and rice surplus.
Four parallel sessions featured IIASA’s cutting-edge research and the ways in which it is positively impacting the world. In Parallel Session 1, speakers discussed the tremendous dietary changes taking place in parts of the world as affluence increases. These changes are not only adding to pressures to find sustainable solutions for food and water security, but are also affecting biodiversity.

“Overcoming the forest governance obstacles to reducing emissions from deforestation and forest degradation is one of the most critical challenges of our time.”

Forests are central to all global problem areas studied at IIASA. They are an upstream contributor to production of goods and services; they provide an aquatic habitat for coastal and freshwater fisheries; they are an important input to livestock providing a great deal of fodder; and they promote agricultural sustainability through a range of ecosystem services. However, the research basis for forests is not as empirically strong as forestry scientists would like it to be.

FRANCES SEYMOUR
Adviser, Packard Foundation; Former Director General, Center for International Forestry Research (CIFOR)
Moderator

NIKOLAY KHABAROV
Research Scholar
Ecosystems Services and Management (ESM) Program, IIASA
Rapporteur
“Can we reverse the decline in the fisheries and take better care of the resources we have?”

Fishing has an evolutionary dimension. For example, the cod stocks of the Barents Sea—an important resource for Norway and Russia—have been experiencing earlier and earlier sexual maturation since the 1920s. With the methods developed at IIASA we have been able to make a stronger case that the decline is caused by evolution due to fishing. This has also been documented by others for stocks of plaice, haddock, sole, and Coho salmon.

One simple robust solution is to fish less. Fisheries scientists have been advising this for a long time for other reasons, but it is not easy to achieve. They are shared resources and managing the commons is difficult. A framework is needed to assess costs and benefits of evolution, taking into account other considerations. In this context, Evolutionary Impact Assessments are being developed at IIASA.

“In many areas withdrawals are exceeding local renewable water resources and extractions are greater than recharge.”

A new initiative is being undertaken at IIASA to investigate water futures with a focus on identifying adaptive, flexible, and robust solutions to the many global water challenges. These will be used as a tool for the development of stakeholder-based scenarios that are both interdisciplinary and multi-sectoral.

IIASA has excellent experience in interdisciplinary studies of the nexus areas in which water plays a significant role. IIASA is also the repository for water-related data from research carried out for the Intergovernmental Panel on Climate Change and WATCH, and from the Global Energy Assessment, World Population Program, Global Agro-Ecological Zones, and the GAINS model, all hosted at IIASA.

“We must improve livestock diet quality. The better we feed cows, the less methane per kilogram of milk they produce.”

One of the challenges ahead is to feed 9–10 billion people by 2050 (one-third more than now) at a lower environmental cost and in a socially acceptable way through local solutions. A livestock revolution is going on, with extremely fast growth in the sector due to population growth, urbanization, and better incomes. These are almost doubling the demand for livestock products globally. The problem is how to sustainably intensify livestock production in the developing world, where productivity has grown only weakly yet animal numbers have increased, adding to resource stretching.

IIASA has produced data and modeling for ILRI on global greenhouse gas efficiency per kilogram of animal protein produced. Improving sustainability would create huge improvements in the efficiency of the livestock sector. Much better integrated assessments are needed of the problem of managing the demand for livestock products via discouraging obesity while promoting the food choices of the poor. No assessment has yet shown any of the social and nutritional impacts. Though combating obesity could be land-sparing according to some theories, a new generation of global assessment tools is needed to look at reducing animal protein in diets in terms of the impacts this would have on livelihood systems.
“Was it a good idea to increase production so much? There have been great achievements in agriculture, but still 870 million people are hungry and great damage has been caused to natural resources.”

Over the last 50 years, the world’s cultivated land has increased by 12%, the irrigated area by 117%, agricultural production by 200%. Investment, however, has favored intensification and growth of single crops and systems, and this has damaged natural resources. For example, it has encouraged sand dune encroachment, climate change, and migration. There has been a great achievement in terms of the green revolution, but still 870 million people are hungry because of this type of increased production. How can food security and preserving ecosystem benefits be balanced? The main challenge and opportunity are with small farmers who produce 60% of world’s food, but they need help to improve the quality of their production. These small farmers could be the custodians of natural resources at the same time. It is important to remember that a sustainable food system has dimensions like scientific and traditional knowledge, human and ecosystem health, cultural and spiritual values, and accessibility and affordability of markets, none of which have been the subject of an integrated approach.

The FAO/IIASA Global Agro-Ecological Zones (GAEZ) methodology is a very important tool for the FAO, which will be used soon at the national level to analyze livelihood systems. Other important FAO initiatives are the Globally Important Agriculture Heritage Systems (GIAHS), which are 200 systems around the world with unique heritages representing indigenous knowledge, livelihoods, and beautiful landscapes and would take billions of dollars to recreate if they were lost; and the Global Soil Partnership which emphasizes soil diversity as an important part of sustainable agriculture.
Parallel Session 2 looked at a key challenge of systems analysis—to find common dimensions that work across multidisciplinary divides. Too often the approach is simply to monetize environmental and human health flows, but more attention is now being paid to alternative methods of interlinkage. The session presented some of the work carried out by IIASA and its collaborators to bridge these gaps through the use of various goal functions that can accept data from multiple currencies.

“Social metabolism is a key interdisciplinary concept linking material and energy flows to the economy, to decision making and quality of life.”

Studies of social metabolism, that is, the energy and materials use of socio-economic systems across history and across scale levels, have shown the need to decouple resource use and environmental impacts from economic growth.

MARINA FISCHER-KOWALSKI
Institute of Social Ecology, Vienna; Professor, Alpen Adria Universität
Moderator

BRIAN FATH
Research Scholar, Advanced Systems Analysis (ASA) Program and YSSP Scientific Coordinator, IIASA; Professor in Biological Sciences, Towson University
Rapporteur
“Integrated assessment modeling is not only important for accumulating all the knowledge available, but it allows clear presentation for the wider community.”

In the complex world of the early 21st century, a multi-model approach is needed. This has been introduced, but its possibilities have not been fully appreciated by the social and environmental science communities.

A multi-model approach, for example, has been used in an IIASA project on the optimization of forest management to show forest managers the economic benefits of managing the forest compared with the ecological cost of different economic measures. A single model would not be able to capture this kind of information.

At IIASA, integration has been done in different ways. One method is to use the best approximation of past history as a basis for integration and to extrapolate this approximation into the future. Another methodology can be applied when the model’s output is random. The joint distribution of two models can be compared, and by combining the results of the two models uncertainty can be reduced in many cases. This approach was applied by a participant of the Young Scientists Summer Program under the supervision of the Advanced Systems Analysis Program, in which models to generate the net primary production of the Russian forest-tundra were developed that had decreased uncertainty compared with previous attempts.

“While it is often believed that curbing greenhouse gas emissions reduces growth, integrated modeling shows that pollution controls feed back into economic growth through improvement of health, well-being, and thus productivity.”

IIASA’s Mitigation of Air Pollution and Greenhouse Gases (MAG) Program and its World Population (POP) Program have recently collaborated to gain insights into the argument that environmental investments divert investments that could lead to economic growth. This is currently the position of the Indian Government, which has its own program for pollution and greenhouse gas (GHG) control by 2030. IIASA modeling sought to compare the scenario of this current legislation with a scenario under which India would adopt the very stringent European Union (EU) air pollution legislation and targets to 2030 and maintain it thereafter. Two models were used: the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model, developed by MAG, which provides a consistent framework for the analysis of the co-benefits arising from air pollution and greenhouse gas reduction strategies; and the SEDIM model (Simple Economic Demographic Interaction Model) of IIASA’s World Population Program (POP).

The results showed that air pollution investments in developing countries have only a small impact on growth and increase the Human Development Index. The impacts would be even more positive if mitigation focused on productive investments like energy efficiency improvements for climate change.
“There is no fundamental trade-off between poverty reduction and environmental protection: access to modern energy will not make climate change worse.”

A team from the Netherlands Environmental Assessment Agency (PBL), which cooperated with IIASA on the Global Energy Assessment, has conducted and published a model analysis (Roads from Rio) to see where it is possible to achieve multiple sustainable development goals at the same time.

Using the IMAGE (Integrated Model to Assess the Global Environment) model, the team focused on building a vision for 2050 of full access for the poor to modern energy, and food, together with achievement of the 2°C temperature target. The two key sectors of food and biodiversity and energy and climate change were modeled for the analysis. Using IMAGE for a trend projection, the team found that with a continuation of current policies there will be no breakthrough, and that the situation will drift on as it is. However, there are ways to address this successfully, using three main pathways: (i) global technology with large-scale technologically optimal solutions, intensive agriculture, and international coordination; (ii) decentralized options with local energy production, multi-functional agriculture, and local policies; and (iii) consumption changes with dietary changes, a less energy-intensive lifestyle, and technology releasing other pressures.

All pathways could halt biodiversity loss, especially increased agricultural productivity. To achieve sustainability goals, there needs to be transformative action. This can be achieved bottom-up through societal and business efforts, backed by government regulations and incentives.
RESEARCH FOR A CHANGING WORLD
Synergies and Trade-offs among Multiple Sustainable Development Objectives

Parallel Session 3 presented some of the strong interactions (trade-offs and co-benefits) between long-term GHG mitigation and human development, and discussed how these two strands can be reconciled.

“There are other challenges than just climate change when it comes to future energy strategies. We will therefore need to think more holistically and keep looking beyond our own noses to make real progress.”

Policies to protect the global climate and limit global temperature rise offer the most effective entry point for achieving energy sustainability, reducing air pollution, and improving energy security. By adopting an integrated perspective on energy and climate policy, one that simultaneously addresses three of the key objectives for energy sustainability, major synergies and cost co-benefits can be realized.

The practice of integrating sustainable energy policies within a holistic framework offers marked advantages over traditional approaches, which, because they are typically more fragmented, often ignore important policy synergies.

VOLKER KREY
Deputy Leader, Energy (ENE) Program, IIASA
Moderator

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Voices 67
“There needs to be coherence and universality as we move from the Millennium Development Goals to the Sustainable Development Goals.”

The United Nations has set two processes in motion: the Sustainable Development Goals (SDGs) and the Post-2015 Development Agenda. These processes are “messy, politicized, and unpredictable”—characteristics that are anathema to scientists. The Stockholm Environment Institute (SEI) uses a simple and understandable model, known as “the cake,” to drill down from universal to specific goals. People’s wellbeing forms a core at the center of the cake, surrounded by an enabling context and finally by international public goods.

The horizontal layers represent the drivers that make it possible to achieve development goals. The top layer represents stakeholder engagement, accountability, and responsibility; the next layer down represents technological and innovation; and the bottom layer represents social trust, empowerment, and cohesion. Thus, the “energy” wedge of the cake would include all layers, rather than separating economic and environmental goals, as usually occurs. It is essential to combine needs with resource constraints to achieve global balances.

Obtaining a global balance depends on combining development needs with resource constraints. The goals and commitments by and for all nations are “universal.” However, universality does not mean that the same solutions would apply to all problems or communities. Policymakers must resist the current tendencies to treat environment and development as separate goals, to reject universality, and to put societies and people against each other. Instead, the world must approach the topics of environment and development from a systems perspective.

“Risk really matters for private investors in sustainable development projects.”

IIASA has been providing scientific inputs to the DESERTEC concept, which was developed by a network of politicians, scientists, and economists from around the Mediterranean and North African (MENA) region. From this arose the DESERTEC Foundation which demonstrates a way of using concentrating solar-thermal power plants in North African deserts to satisfy renewable energy demands. The energy is for use locally and export to Europe.

Investment goes to regions where risk is perceived as lower. Perceived risk drives the cost of investment, as risk premiums are higher. This is reflected in the cost of renewable energy itself in terms of eurocent/kW hour, delaying the cost parity with energy forms like coal. Shareholders and stakeholders have been interviewed extensively about what type of risk is seen as most serious. Top of the list is regulatory risk in the guise of the bureaucratic complexity and non-transparency of local procedures. Regulatory instability, insecure property rights, and insufficient financial support for business are other risks seen by potential investors in such investments.

Risk really matters for MENA, and for renewable energy investment. The risk patterns seen in MENA are part of a larger pattern of risk importance for sustainable development.
“Policymakers and scientists have found it difficult to work together. Bridging this gap could be a key role for IIASA.”

When Russian President Alexei Kosygin and U.S. President Lyndon Johnson met in June 1967 at Glassboro in New Jersey, they managed to agree that their two nations needed to: (i) Do everything possible to avoid unintentional war; (ii) Slow the arms race; (iii) Establish a code of conduct that would define acceptable and unacceptable behavior for the two superpowers; and (iv) Address global problems. At the time, although this issue was not regarded as particularly important, the two leaders discussed the possibility of establishing a joint Soviet–American research center—later to be IIASA. Eventually, IIASA became known as one of the 30 most important think tanks in the world because it was able to “think about the unthinkable.”

Leaders recognize that they cannot carry out successful negotiations without incorporating scientific knowledge into negotiations and decision making. However, policymakers and scientists have found it difficult to work together. Bridging this gap could be a key role for IIASA. Many international negotiations have produced no results because diplomats were not prepared to deal with issues driven by scientific and technical realities; the scientists had no mechanism for making their voices heard or for influencing the content of discussions. To achieve meaningful results, negotiators must identify the problem, propose desirable solutions, calculate the resources available, work out a strategy, and specify an outcome. Scientists are very good at identifying problems; they can alert decision makers that a problem exists, and may suggest possible solutions. However, different nations favor different solutions. International negotiators must then harmonize their approaches and determine the resources needed to work toward a solution.

VICTOR KREMENYUK
Deputy Director, Institute of U.S. and Canadian Studies of the Russian Academy of Sciences
Panel Presentation
Building Bridges through Negotiations
Parallel Session 4 presented research by IIASA scientists and external researchers who seek to enhance the analysis of differential vulnerability of heterogeneous populations by taking education and human capital explicitly into account.

“Not every human being is the same, so just counting the people in demography is not good enough.”

Science simplifies, whether through the modeling process or providing options for policymakers. Many macro-economic models have carried simplification too far in assuming that all humans are the same and that counting people is enough. It is not. Demographers have given people a sex and age group, and more recently at IIASA other human aspects, like education, on-the-job training, health, cognitive functioning, attitudes to risk, and access to savings and credit. Together, these data allow the characteristics and amount of human capital to be assessed, as well as the process that leads to human capital accumulation. Like other kinds of capital, human capital is produced at a cost, and produces a stream of benefits over time. Thus the relatively simple approach employed in many macro-economic models has been complicated and opened up to produce more insights into population dynamics.
“Nowhere are the impacts of disaster greater than on the poor, who are generally found to be most vulnerable to natural hazards.”

The impacts of disasters have increased over the last decades: losses in 2011 being the biggest ever at nearly $400 billion over 800 events. The only bright spot is that loss of life is decreasing. Climate change adds to the picture, with the increases in air temperature and sea level and an increasing frequency, intensity, and duration of extreme events such as droughts, heat waves, and heavy precipitation.

Although extreme events are frequently called natural disasters, they are, in fact, unnatural, being caused by the actions of humans rather than natural forces. Key drivers of risk are exposure of people and capital as well as vulnerability—the predisposition to damage.

According to the recent IPCC Special Report on “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX),” to which IIASA staff contributed, vulnerability is a key determinant of risk. Even non-extreme weather and climate events can lead to extreme impacts if vulnerability is high.

While poverty is not equal to vulnerability, it shapes the ability to cope with disasters. Lack of savings and an inability to raise credit to rebuild livelihoods explains why coping capacities are limited for the poor. Low-quality housing heights poor people’s physical vulnerability, exposing them to the elements or forcing them to use temporary shelters. Lack of formal education and vocational training explains inefficient farming practices in the face of systemic drought risk.

There is growing awareness of the relevance and need to tackle these indirect, long-term effects. IIASA is working in many locations and contexts toward a more comprehensive understanding and quantification of vulnerability, given the many gaps in assessing vulnerability (measurement, time-series data, and integration with an estimate of risk).

“The evidence suggests that the more education, the greater the cognitive performance, and the lower the burden of aging to society.”

The rise in median ages across most parts of the world has changed the relative age-ranking of countries. In the 1980s Western countries with a relatively high median age were overtaken by Japan. Parts of Asia, for example, Indonesia and China, are undergoing more rapid aging than Europe. According to UN median population projections, China will overtake the Nordic countries in the 2020s.

Do countries with an older median age face a larger problem with respect to productivity than those with a younger median age? Aging poses many challenges to budgets and fiscal sustainability. A key policy response has been to increase the length of the working life. However, over recent decades, the importance of cognitive functioning in the workplace, which partly determines how long people can work, is likely to have increased. The standard Old Age Dependency Ratio (OADR) divides people into the 15–64 (working/productive) age group and the 65+ (retired/unproductive) age group. IIASA has proposed an objective and harmonized measure of cognitive functioning to provide a better indication than chronological age for when people become dependent on others.

The measure, the cognition-adjusted dependency ratio (CADR), takes the observed differences in cognitive functioning of seniors into account when comparing aging across countries. In the CADR, the denominator is composed of everyone aged 15 to 49 and the 50+ population (no upper age bound) with good cognitive functioning (approximated by those who are able to recall at least half of the words in the test). The numerator consists of the number of persons aged 50+ who recall fewer than one-half the words in the test.

Using the standard OADR, India is the youngest country; Mexico, China, the United States, northern Europe, continental Europe, China, and southern Europe follow. Using the CADR, the United States is the youngest, followed by Northern Europe. Education is the key.
"Female and male education plays a central role in triggering democratization processes.”

How the accumulation of human capital (and in particular formal education) across age groups affects economic growth has been the subject of multidisciplinary work at the World Population Program (POP) at IIASA for over five years. The basic research paradigm is that by monitoring changes in the composition of populations in terms of age, gender, and education we can explain differences in economic outcomes across countries and over time. In particular, we can gain better insights into the ways economies adopt technologies and grow in income per capita.

The data being used to analyze this issue were not optimal until a few years ago, when POP completed its back-projections of population by age, gender, and education to the 1970s. Looking at the full range of population by age, gender, and educational attainment from the past to the present can give a much greater understanding of why and how populations are able to grow. By feeding these extra dimensions into economic growth models we have been able to understand, through the evolution of age/education dynamics, how economic growth takes place and also to create projections of future economic growth.

We have moved further to social and political outcomes, in general finding strong correlations between education dynamics and political change at the country level. The more educated are on average more willing to participate in political processes and our research has given robust evidence that female and male education plays a central role in triggering democratization processes.
Roundtable Seminar 1 focused on where social and technological solutions intersect. Given that technological solutions alone will most likely not be enough to achieve targets, changes in consumer preferences and lifestyles are also needed. How can we best assess and pursue the need for such changes?

“Should we develop new technologies or should we change behavior?”

A great deal of technology has been developed at Sweden’s Royal Institute of Technology (KTH), including Electrolux products; Skype was coded in part by KTH, and Spotify was developed there. We value consumption, and our human footprint is growing along with the exponential growth of the human population. There are many questions to ask, such as if the development of bio- and other materials can compensate for the fact that we are using materials up faster than ever to the point of irreversibility. Should we invent new technology to change our development path or should we change our behavior and start rationing carbon? My slide of an old lady doing knitting digitally on a Playstation [below] is a good illustration of the tensions—even the confusion—that currently exist about our possible behavioral and/or technological futures.
“If systems thinking cannot engage with the economic discourse, this will limit its policy impact.”

The question is not one of social versus technological solutions. Most scientists believe that a combination of social and technological solutions is required, given that technological development throughout history has involved or affected societal change, and vice versa.

In the short term, people either ignore their energy use or are satisfied by it. Most people don’t think deeply about energy when they turn their kettle on. At longer time scales and with bigger decisions, costs and impacts may be tangible and people will optimize and think about trade-offs, say between cleaner choices and between price levels.

In long-term transformational change, neither of the above apply. What will be done regarding transport and what is emitted in 2050 have very little to do with existing behavioral patterns or markets/prices. They are driven by infrastructure investments like roads and the co-evolution of systems and technologies associated with them, for example, distribution networks. Thus, there are processes that work over a few years based on the behavioral and organizational structure that exist today; and there is governmental decision making over bigger time horizons and scales within a pre-established jurisdiction which defines the rules of investment.

Risk and uncertainty are relevant in all these domains but take different forms. There is a need to integrate thinking with respect to social and technological scales and time frames with different types of economic thinking. One barrier within the systems transformation field is the dearth of economics. Given that most of the world still operates around the economic discourse, if systems thinking cannot engage with the economic discourse, this will limit its policy impact.

“There has been a dramatic increase in emissions in transport.”

Over the last ten years, Austria has reduced greenhouse gases (GHGs) through reducing domestic consumption of fossil fuels. The share of solar and biomass technologies in new buildings is now 70%, compared with 10% in the mid-90s, and this has brought GHGs down.

While European Union (EU) data show the same trend, one sector that has shown a dramatic increase in emissions is transport. While technological progress in new buildings has outbalanced the per capita increase in dwelling area, the efficiency increase in vehicles has not outbalanced the growth in mileage traveled.

New technologies are needed, but modeling has shown that technology changes and behavioral changes cannot taken alone do as much as the two types of change combined.

Another problem is that the current EU greenhouse gas accounting system looks only at production emissions. These emissions are going down in Europe, but this is because emission-intensive production is taking place elsewhere on the planet and we are simply importing those goods to Europe.

Stakeholder dialog has taken place in Styria through Austria’s Climate Action Strategy. It has been found that stakeholders prefer to use cleaner alternative fuels rather than change their own habits. The dialog continues, but scientists should have an internal dialog with themselves as people and consumers and use that dialog to frame their own research questions.
Roundtable Seminar 2 enabled participants to delve more deeply into issues of preserving biodiversity and other ecosystem services, while ensuring attainment of the UN Millennium Development Goals.

“Nothing is more controversial than the trade-off between water and ecological services.”

The trade-off between water and ecological services raises many questions regarding the potential decline in biodiversity due to an increased rate in water withdrawal from rivers, lakes, and reservoirs. It is clear that the 70% increase in food production needed to feed 9 billion people on the planet by 2050 must come from some form of agricultural intensification, which will mean increased water withdrawal. Unless these developments can be reconciled with sustainable ecosystem functioning, ecosystems in developing countries, in particular in sub-Saharan Africa, will suffer the most. It is in these areas where current rates of population growth are the highest and that this intensification will most likely occur.

STEFFEN FRITZ
Research Scholar, Ecosystems Services and Management (ESM) Program, IIASA
Moderator

LINDA SEE
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Rapporteur
“IIASA has initiated a global water project, one of the outputs of which will be a new generation of integrated global water scenarios.”

The objective of water studies is human welfare. There have been some achievements, but considering the explosive growth in the world’s population, there is much more to be done. Billions of people are at the mercy of their variable climate and are living in absolute poverty, condemned to be poor because of climate variability. The North could not have developed without learning to overcome this variability. Under global warming, that variability is going to increase and become more intense.

All ecosystem services are water-related. On the one hand, waste and wastewater go back to the environment untreated, and on the other hand, more water is used than is available. The areas with water scarcity are exactly the areas that have the highest loss in biodiversity. Water is the essential element needed for food, energy, and the maintenance of ecosystems, and it will need to provide for an additional two billion people in the future.

As major studies have shown, the solutions are not just global options, but can be implemented at the local level. Much is already being done at the local level to overcome water problems, and we can borrow from these ideas.

IIASA has initiated a new Water Project, one of the outputs of which will be a new generation of integrated global water scenarios which should be consistent with other global scenarios. The global water scenarios will look at the various ways in which the world might evolve to find robust and adaptable solutions for water and ecosystem protection in which people can invest now and that also take account of the different ways the world may evolve in the future.

“If we are to make truly sustainable progress towards the UN Millennium Development Goals and the post-2015 development agenda, then a transformation is required—underpinned by science—in how we manage the world’s natural resources.”

Degradation of the world’s ecosystems is undermining the ability to provide livelihoods. The Millennium Ecosystem Assessment in 2005 came to the conclusion that 60% of ecosystem services are being used unsustainably. There must be a transformation towards sustainable use to meet aims in the future. Are we producing policy-relevant science? The science–policy interface has been strengthened by the establishment of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) in April 2012 which will assess the state of the planet’s biodiversity, its ecosystems, and the essential services they provide to society. The IPCC was formed for the same kind of function with respect to making climate change information available. How can we, as a science community, assure strong participation so that it is credible, legitimate, and relevant?
In recent years the concept of green growth has emerged with its focus on the economic co-benefits of establishing new industries based on clean technologies. Many definitions and concepts have been surfacing. In Roundtable Seminar 3 the implications of these were discussed.

“I think we need to ask ourselves whether we are ready for inner green growth.”

The panel created some research questions in advance of the Roundtable Seminar:

- What is new in the concept of green growth—does it offer anything that is different from “sustainable development”? Is it meant to replace the term?
- Does green growth really address all the three pillars of sustainability: the economic, the social, and the environmental?
- What are some examples of green growth and how is it measured? How is it operationalized?
- Does the green growth concept take into account the plight of the poor, who depend so much on natural resources for their livelihood?
- What are the factors that influence the diffusion of the green growth idea?
- How and to what extent are policies, and political and cultural networks that address issues of climate change and sustainability, advancing green growth?
“From Science to Policy is very important but even more so is From Policy to Action.”

Our over-use of natural resources is serious. Many say that the problem can be solved through policy and investment, but nothing is happening. A new science that is holistic, integrated and solution-oriented is needed, but it is also necessary to motivate action.

Natural resources are needed to drive the global economy and to take up waste outputs. Will the green economy work? The United Nations Environment Program (UNEP), among others, has come up with definitions for the green economy, but the true meaning of the green economy goes beyond these: it has to be shown that the green economy can demonstrate new and higher values for the consumer. Thus, the focus should be on values not volumes. The total economy and not just a subset of the economy must be considered. This means a fundamental change in production and consumption. One barrier to the green economy is that consumers give more weight to short-termism. This will be difficult to get around. Industry itself is a bottleneck. For instance, in the Swedish forest sector, although there is a full recognition of what needs to be done to be competitive and survive in the future, the same type of measures are being adopted as in the past, like cost-cutting.

As far as the financial community is concerned, UNEP estimates that it will cost 2% of GDP to transform to the green economy, and that the money will mainly come from private capital. It is hard to be optimistic about private investment, as investors are more interested in derisking than going into greening issues.

There are plenty of areas where the forestry sector can take advantage of opportunities in a greening world. A Canadian analysis estimates the green market potential at $200 billion, but in non-conventional forest product areas, like nutrients, biochemicals, and carbon fibers. Materials like cellulose-based plastics can currently replace 15% of the global consumption of plastics, for example, in car components.

Another green growth area is housing, with an estimated 100,000 new housing units per day being needed by 2030 to meet growing living standards and rising population. India, for example, will need “one new Chicago” per year. This too can be met partly from natural fibers.
“Any development that can help achieve the necessary shift to higher efficiency and renewable energies—and the slogan of green growth might be such a concept—is welcome.”

Climate change is well understood, and what needs to be done is known, namely, reduce or avoid greenhouse gases (GHGs) in the longer run. But can green growth help? Practically all nations have increased their GHG emissions. The amount of GHG reductions needed is obscured by looking at the problem in a global manner. A reduction of 30–50% by 2030–2050 sounds feasible. These percentages are based on not exceeding a 2°C increase in the global temperature.

Kevin Anderson, Deputy Director of the Tyndall Centre for Climate Change Research, calculated that for non-Annex 1 countries to stay within a 2°C limit, a 3% growth in GHGs needs to be negotiated—which is less than half the growth rate of China at present—with a peak in 2025, and after that a 7% decrease per year. A 7% decrease is more than any mature nation has ever achieved; for instance, when the Soviet Union collapsed, its GHGs went down by 5%.

According to Anderson’s calculations, the industrial countries would have had to stop emitting GHGs by 2010. Since they did not, there are major implications for the emissions from developing countries and countries in transition. This is a very different message from a 30–50% reduction by 2030–2050 and it is not feasible, either economically or ethically.

Dennis Meadows, who authored The Limits to Growth, has been saying for years that if we cannot solve the problems abiding by the rules, then we need to change the rules. As the two degree limit is based on the law of physics, it cannot be changed. However, human-made economic systems can be changed.

Is green growth the new rule we need? To some extent, depending on how broadly one defines green economy. The new rules must make it possible to accept de-growth. There are many things that are not needed and that it is not necessary to produce. The term green economy might cover the transition needed, but the term green growth does not. The new rules must reward longer-term thinking and sustainable actions which our economy does not embrace, and they must be part of a more general transition. Transformation involves a change of values. A shift in emphasis is needed from extrinsic (money, status, competition) to intrinsic values (sense of community, cooperation), otherwise these problems cannot be addressed. The message needed is that a change in values can lead to more satisfying lives.
Roundtable Seminar 4 targeted one of the most difficult questions for scientists: how to get the scientific message across in order to shape policy. The discussions not only covered advice for scientists and policymakers on how to interact efficiently, but also pursued the debate of policy relevance versus policy impact.

"IIASA's vast experience and global scientific outlook on the problems confronting humanity today is more needed than ever. Yet, more is to be done. Let us celebrate and follow up."

The science–policy interface is a complex and messy entanglement. One of the polarizations that comes up in this debate is facts, which are on the side of science, versus values, which are on the side of society. Facts become facts through a long and arduous scientific process. They can be overtaken by new facts. However, there are always uncertainties, and one of the biggest misconceptions of the public and policymakers is that they can get a clear-cut yes or no from scientists.

Of crucial importance is the timing of policy action for the best impact. Sometimes we cannot time events, for example, when a catastrophe strikes. However, such events are an opportunity for learning and also bring the public into the debate. The unintended consequences of actions that affect the scale and breadth of future actions also need to be taken into account.
“Evidence-based policy is a necessary, but not a sufficient condition for tackling global challenges.”

In 1984–1987 when IIASA was doing its first work on RAINS, a Dutch diplomat to the Montreal Protocol told me: “What I need from you guys is not a recipe but a menu to choose from.” Norman Neureiter also addressed the policy process when he told a packed auditorium at ISPR A recently: “Science is only one input into the policy process, and it’s a minor one.” Through many years of working on science for policymakers, I have found that this kind of approach is the right one for policymakers. In the 1980s the playing field was the United Nations Economic Council for Europe, based in Geneva and this was where the first negotiation on acid rain took place. Now, the stakes in different countries are not homogeneous; the general issue of the environment is presided over by different ministries (energy, environment), there are many more players, and there are frequently controversies about policy within nations. The role of science will be disputed more and more. “Climategate” was not the first time science results have been disputed. Perceptions about the environment are very different in the United States and Europe, as well as among different countries in Europe.

“Humans are now largest force in movement of sediment on Earth, greater than all rivers, and ice, wind, and water together.”

Twenty-six gigatons of sediment a year are moved for pleasure, needs, and convenience. In addition to moving sediment, it is being put in places it normally does not go. One very large dam is built every year, and this has been done for 130 years. Dams intercept sediment and affect the coastal zones where the sediment used to go, clogging up flood plains. Oil gas and water are mined. While there are concerns about a global sea-level rise of three millimeters per year, there is also considerable subsidence due to human activities. In the Yellow River delta, 240 millimeters depth of sediment a year is being removed, which represents one meter over four years. Jakarta is already four meters below sea level. Another problem is that half a billion people live on river deltas, and they have had no say in why the cities or the sediment got there. Valuing these problems is largely missing from the debate. How much is a delta worth? The Mississippi Delta is expected to disappear by 2100 with a loss of $100 billion in ecosystem services. This delta, moreover, did not have that many people living on it. Why is a delta not valued? The people who build dams are upstream and the decisions they take influence the downstream, but different states and jurisdictions fail to talk to each other. Policies are only as good as their ability to be implemented and upheld. And another reason why deltas are not prioritized is that a lot of poor people are living on them.
To contain the associated risks to the climate, we have to exploit the most effective, fastest, and least expensive potential solution: energy efficiency."

There is an urgent pressure on science and policies to speed up and scale up. Global knowledge networks are needed on renewables, and especially on efficiency in buildings.

The Energiewende means the transformation of the energy system. What kind of knowledge of science and research is needed to foster social transformation processes and lifestyle shifts? The Energiewende not only means phasing out nuclear energy, but reducing non-renewable primary energy by 50% by 2050 alongside a slow increase in GDP. This could be possible and would be an encouraging impulse of science for policies to reach what Angela Merkel has called “revolutionary targets.” By reaching these, Germany would be the first country to demonstrate that highly developed countries can decouple energy consumption from GDP growth.

To make the Energiewende a success integration of policy realms is needed, for example, through ecological–industrial policy to support green technology that is “Made in Germany” and to support resource efficiency programs. There is much evidence that the macro-economic effects of climate protection policy can be amplified through the integration of resource productivity strategies. The competitive position of German industry could be increased through these policies: they could bring about a 20% reduction in the total material requirements, new employment, new business fields, and even a reduction in the public budget.

Energy efficiency has been improved by 25% but, as this has been evened out by growth, we need to know how to reduce the rebound effect in both developed and developing countries. This will be important in India and China where by 2050, 50% more energy consumers will be added.
Recent criticism of modeling and optimization has resulted in suggestions that many of the challenges identified during the Conference should be addressed with different tools, such as simulation. Roundtable Seminar 5 picked up the debate and explored the scope of optimal versus “suboptimal” solutions.

“What do we do if we have insufficient information to find the optimal strategy? Are a lack of information or inadequate modeling tools an excuse for inaction?”

It is important to consider what we want to know about a system before deciding how to model it. Finding the optimal strategy may give us a solution, provided that we have enough data. However, it neglects to tell us how the system works as a whole. Alternatively systems interactions can be modeled using a simulation model with programmed rules describing the system’s behavior.

RESEARCH FOR A CHANGING WORLD
Optimal versus Suboptimal Solutions
“Clumsy solutions only emerge in rich argumentative institutional settings pioneered at IIASA, where each of four voices—individualist, hierarchist, egalitarian and fatalist—enjoys access and is responsive to, not dismissive of, the others.”

Keynes was not famous for his politeness. Once, when a Treasury paper was passed to him for comment, he wrote on it, “I would be in full agreement with this if the word ‘not’ was inserted in every sentence.” The same, proponents of clumsy solutions maintain, holds for the precepts of policy analysis, which are: (i) ensure you have a single and agreed definition of the problem; (ii) clearly distinguish between facts and values; (iii) establish a single metric (e.g., dollars or lives saved) so as to be able to compare and assess options; (iv) optimize. All four need “not” (or “do not”) inserting.

But there is a proviso. These rewritten precepts apply only to wicked problems: problems, that is, that are characterized by contending and mutually incompatible definitions of what the problem is, and where those definitions do not converge as the policy process progresses. Climate change, for instance, is a wicked problem; the ozone hole, and its solution by way of the Montreal Protocol, is a tame problem.

Most of the problems IIASA addresses are wicked problems, but they tend to be treated as tame ones. So a markedly different approach is needed: an approach that can be summarized in the mantra: “Wicked Problems, Uncomfortable Knowledge, Clumsy Solutions.”

The basic idea—pioneered at IIASA in the 1980s—is that there are four ways of organizing—individualist, hierarchist, egalitarian and fatalist—each of which is, at the same time, a way of disorganizing the other three.

The normative implication of this fourfold plurality is this: Since each is capturing elements of experience and wisdom that are missed by the others, and since each provides a clear expression of how a sizeable proportion of the populace feels that we should live with nature and with one another, it is important that all be taken account of in the policy process. Solutions can only emerge in those argumentative and deliberation-rich institutional settings where each of the four voices (a) enjoys access and (b) is then responsive to, rather than dismissive of, the others.

“Prioritizing between several goals at the same time is a problem.”

Goals can be split into short-term and long-term goals. If I have a long-term goal, I can plan my actions today so that it optimizes my goal in the long run. If I have a short-term goal, the short-term actions might not contribute to achieving the long-term goal.

There are some exceptional situations where there is no visible conflict between short-term and long-term actions and systems analysis should pay serious attention to these, as they show the world in harmony.

In mathematics, although multi-optimality is very rare, there are some situations where multi-optimality, in which short-term and long-term goals coincide, occurs quite naturally. One famous example comes from the theory of evolutionary games: the so-called fictitious play dynamics. Another comes from the theory of optimal economic growth, where a trade-off can be made between short-term term goals and long-term decisions in response to a practical situation. An instrument called “shadow prices” allows a resolution to that problem to be found. A way to estimate shadow prices at every point in time is key to finding harmony between short- and long-term actions in economic development.
WORLDS WITHIN REACH—FROM SCIENCE TO POLICY
Closing Plenary

This session was the final one of the conference and drew business to a close. It included a summarized overview of the conference by former IIASA Deputy Director Jill Jäger, awards to the winners of the poster session, and closing remarks on the part of IIASA’s Director and Chief Executive Officer.

“What do we do if we have insufficient information to find the optimal strategy? Are a lack of information or inadequate modeling tools an excuse for inaction?”

It is important to consider what we want to know about a system before deciding how to model it. Finding the optimal strategy may give us a solution, provided that we have enough data. However, it neglects to tell us how the system works as a whole. Alternatively, systems interactions can be modeled using a simulation model with programmed rules describing the system’s behavior.

PAVEL KABAT
Director and Chief Executive Officer, IIASA
Moderator
“Listening to all of the presentations, I did have this great sense of urgency to start and continue the transformational change that are under way. But I also saw signs of optimism that the knowledge that we have accumulated over 40+ years will help, and a sense of excitement coming out, not a sense of desperation, that we can meet the challenges we face.”

Jill Jäger’s summary forms the basis of her detailed scientific summary, which will be published separately to coincide with the publication of this brochure. The conference will also generate two journal Special Issues as well as a prospective article on potential research issues of the future.

“The posters are an integrative part of this IIASA jubilee; they mirror the efforts of a fast-growing new generation of high competence scientists.”

With around 132 posters addressing all the main themes of the conference, the poster session was a further opportunity for knowledge exchange and discussion. They were also an exceptionally important part of the conference, as they reflected a great interest in IIASA’s work as well as innovative approaches to coping with transformational challenges. A great deal of work and effort has gone into the production of these posters and we would like to thank those who participated.
‘Thanks are due to the poster committee and to conference participants who voted on the third of our awards.’

The Poster Review Committee selected the poster by Yu Nagai, PhD student at the Vienna Institute of Technology and Research Assistant in the Energy Program at IIASA, on “Policy Scenarios for Achieving Universal Modern Energy Access in 2030” as the Best Poster.

Aline Mosnier, PhD candidate at the Life Sciences Institute in Vienna and Research Assistant in the Ecosystems Services and Management Program at IIASA, was awarded the Best Poster by an Early Career Scientist by the Committee for her poster entitled “The global impact of U.S. biofuel on GHG emissions.”

The winner of the vote by conference participants for the Best Poster was Sujata Dutta Hazari, Northeast Centre for Research and Development, Guwahati, India, for her poster on “Deconstructing Sustainability: Rethinking Ideas of Growth and Consciousness through Education.”

NARASIMHA RAO
Postdoctoral Research Scholar, Energy (ENE) Program, IIASA; Chair, Poster Review Committee
Poster Awards

Poster Awards

Deconstructing Sustainability: Rethinking Ideas of Growth and Consciousness through Education

Policy Scenarios for Achieving Universal Modern Energy Access by 2030

Day 3: Closing Plenary

Voices 87
WORLDS WITHIN REACH—FROM SCIENCE TO POLICY
Closing Plenary

“IIASA is helping to put the pieces of the puzzle together.”

If the IIASA 40th Anniversary Conference has shown one thing, it is the importance of the tightly knit networks of people and research on which the success of the International Institute for Applied Systems Analysis is based—and on which it depends. IIASA has 20 National Member Organizations (NMOs); the 20 member countries represent nearly 60% of the world population; 850 researchers are connected in one way or another to IIASA’s core business; 3,000 scholars have spent part of their career at IIASA and are talking the language of systems analysis to their colleagues and students around the world; and 1,500 alumni have graduated from our Young Scientists Summer Program since it began in 1978.

Our network of people and their own networks of partners in the scientific, academic, institutional, and policy domains are helping us fulfill our vision of systems science for policy support.

I use the word “fulfill” advisedly. In 2005 we saw the momentous publication of the Millennium Ecosystem Assessment (MEA) which considered how we might best protect our planet’s dwindling resources. As we have heard at our conference, we are now at the stage of discussing sustainable resource use, which is an enormous step forward.

Sustainable development is a far more complex arena for science. IIASA, over the foreseeable future, will look at the many interconnected processes that make up our world—the co-benefits, feedbacks, cross-sectors, and trade-offs that occur at the intersections of our main research subjects, which we call the nexus areas.

In doing this, we will be building on the many theoretical approaches developed in systems analysis research at IIASA over the last 40 years and combining our efforts with those of the social sciences, business, and civil society.

Nations, people, partners, sectors, methodologies, policy advice: these are all part of the vast and complex puzzle that IIASA is helping to put together.

We cannot aim for show-stopping solutions. We can, however, carefully assemble the emerging pieces of the intricate mosaic of our world and build a rational and consistent response to the challenges that we perceive.

In those terms alone, the conference has shown how bright and hopeful the future is, not just for IIASA, but for the whole scientific community.
PRESENTATION OF THE AUSTRIAN CROSS OF HONOUR

On 23 October 2012 Professor Dr. Norman P. Neureiter was awarded the Austrian Cross of Honour for Science and Art 1st Class by the Austrian Federal Minister for Science and Research on behalf of the Federal President of the Republic of Austria, for his services and contributions to Austrian science and research. The award ceremony took place at the Hofburg Palace in Vienna at the gala dinner on the eve of IIASA’s 40th Anniversary Conference. Professor Neureiter is Acting Director of the Center for Science, Technology & Security Policy of the American Association for the Advancement of Science (AAAS).

TIPPING THE SCALES TOWARDS GLOBAL SUSTAINABILITY

On 24 October 2012 at a cocktail reception at the Festsaal of the Vienna City Hall as part of the IIASA Conference activities, Professor Dr. Johan Rockström spoke on “Tipping the Scales Towards Global Sustainability.” Professor Rockström led the team that developed the Planetary Boundaries framework for nine “planetary life support systems” that are essential for human survival and offer a safe operating space for human activities at a time when the planet is undergoing rapid change and Earth systems are being pushed toward their limits. Dr. Rockström is Professor of Water Systems and Global Sustainability at Stockholm University and Director of the Stockholm Resilience Centre.

IIASA/OeAW PUBLIC LECTURE SERIES

On 25 October 2012 at the Festsaal of the Austrian Academy of Sciences (OeAW), IIASA and the Austrian Academy of Sciences established a joint public lecture series on scientific topics of mutual interest, aimed at a broad academic audience, decision makers, and the public. The first lecture in the series, held in conjunction with IIASA’s 40th Anniversary Conference, comprised two presentations by speakers at the conference:

Dr. William Nordhaus
Professor of Economics, Yale University, USA
“Maastricht and Kyoto: A Tale of Two Treaties”

Professor Carlo Rubbia
Nobel Prize, Physics; Scientific Director, Institute for Advanced Sustainability Studies e.V., Potsdam, Germany
“Can We Maintain Sustainability for the Future of Humankind?”
IIASA would like to thank all those organizations that gave their financial support to the IIASA 40th Anniversary Conference.

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ABOUT THE CONFERENCE

Today’s world is undergoing major transformations, characterized by increased globalization, fundamental shifts in economic and political power, escalating environmental challenges, and unpredictable social conflict. IIASA’s 40th Anniversary Conference examined the many sustainability and development challenges such transformations impose and explored options for resolving these challenges. It explored new “future worlds” that accommodate our collective needs and aspirations, while living within, and respecting, planetary boundaries.

ABOUT IIASA

IIASA is an international scientific institute that conducts research into the critical issues of global environmental, economic, technological, and social change that we face in the twenty-first century. Our findings provide valuable options to policy makers to shape the future of our changing world.

IIASA is independent and funded by its National Member Organizations. In June 2013, these were:

AUSTRALIA The Commonwealth Scientific and Industrial Research Organisation (CSIRO)
AUSTRIA The Austrian Academy of Sciences
BRAZIL Center for Strategic Studies and Management in Science, Technology and Innovation (CGEE)
CHINA The National Natural Science Foundation of China
EGYPT The Academy of Scientific Research and Technology (ASRT)
FINLAND The Finnish Committee for IIASA
GERMANY The Association for the Advancement of IIASA
INDIA The Technology Information, Forecasting and Assessment Council (TIFAC)
INDONESIA The Indonesian National Committee for IIASA
JAPAN The Japan Committee for IIASA
MALAYSIA Academy of Sciences Malaysia
NETHERLANDS The Netherlands Organization for Scientific Research (NWO)
NORWAY The Research Council of Norway
PAKISTAN The Pakistan Academy of Sciences
REPUBLIC OF KOREA National Research Foundation of Korea (NRF)
RUSSIA The Russian Academy of Sciences
SOUTH AFRICA The National Research Foundation
SWEDEN The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS)
UKRAINE The Ukrainian Academy of Sciences
UNITED STATES OF AMERICA The National Academy of Sciences

RELIVE THE CONFERENCE ONLINE

View conference photos, scientific posters, video recordings of speeches and presentations, and more, on the conference Web site: conference2012.iiasa.ac.at