International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

options
summer 2011

Food & water

Smarter management of global resources

Detlof von Winterfeldt
Director, IIASA

Smarter management of food & water

This issue of *Options* is devoted to IIASA's research in the area of food and water. Meeting the growing global demand for food and freshwater is a major global challenge and necessitates improved management of the world's land, water resources, and ecosystems. Over the next decade, IIASA's research will contribute to this global issue as part of a new strategy that focuses on three interlinked and complex global problem areas—Energy and Climate Change; Food and Water; and Poverty and Equity.

In 2010, 925 million people were undernourished (FAO) and 884 million people had inadequate access to safe freshwater (WHO & UNICEF). Yet demand for food and water is only set to increase, as the world's population continues to grow. According to IIASA's World Population Program, there will be an additional one billion people on this planet by 2030.

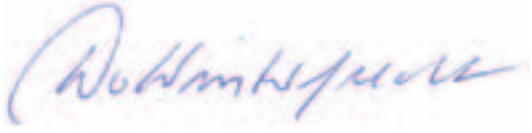
Food and water are intricately linked—agriculture accounts for 70 percent of freshwater withdrawals, according to UN-Water—and only research that is truly interdisciplinary and integrated will identify effective and efficient policy options. But just as food and water should not be studied in isolation, the world's food and water challenges cannot be researched without taking into account ecosystems, climate change, energy, economic and social systems, among others. Systems analysis is one of the few approaches that provide this integrated, long-term, and solution-oriented perspective; and systems analysis is central to IIASA's new strategy.

The complex trade-offs between energy, land, and water are shown in an analysis of the potential of bioenergy to provide huge amounts of clean renewable energy (page 8). The researcher argues for integrated land management and intensification of agricultural production. Other research pinpoints the land that offers the most potential for increasing crop yields (page 14). However, increasing the agricultural productivity of land can damage the environment if not carried out in a sustainable manner (pages 12, 21) or even significantly harm food resources—the dangers of overexploiting the world's fish stocks (page 16) being a case in point. Climate change will also bring new pressures to bear on the world's food and water systems, as shown by ongoing research into its impact on Russia's ecosystem (page 18).

IIASA's new strategy will build on the Institute's existing strengths, including its agricultural, land and forestry models (e.g., GAEZ, GLOBIOM, G4M); evolutionary approaches to studying fisheries; and a variety of innovative data and decision-support resources such as Geo-Wiki which uses volunteers to improve the accuracy of global land cover information (page 26).

Improving the skills and experience of young scientists is an integral part of IIASA's research agenda, and profiles of an Iranian PhD student and an Indian Postdoctoral fellow (pages 28–29) show the value to IIASA, the individual, and his/her home country of the Institute's capacity-building activities.

I hope you enjoy reading about IIASA's work in the new Food and Water research area. ■



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About *Options*

Options magazine features the activities of IIASA, the International Institute for Applied Systems Analysis, located near Vienna, Austria.

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Prepared by the IIASA Communications Department
Printed by *Rema*print, Vienna

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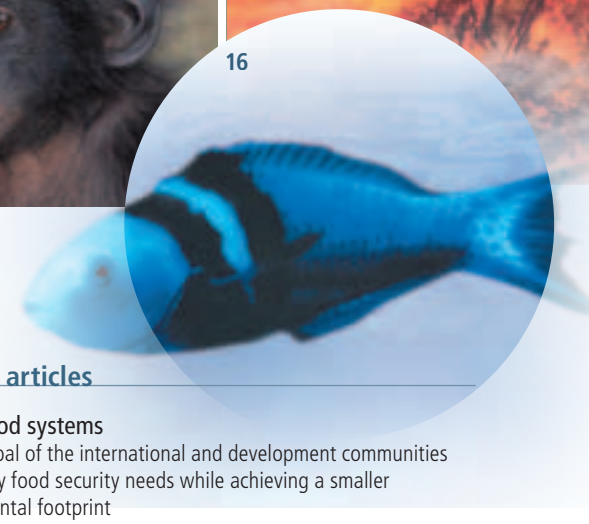
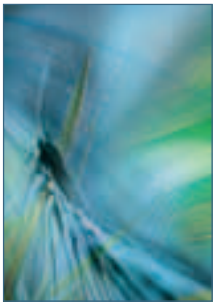




12 feature articles

research highlights

IIASA NATIONAL MEMBER ORGANIZATIONS

Brazil and Malaysia join IIASA

In February IIASA announced the accession of two new National Member Organizations (NMOs): the Center for Strategic Studies and Management in Science, Technology and Innovation (CGEE) of Brazil and the Academy of Sciences Malaysia.

IIASA's first Latin American NMO, CGEE supports the formulation of public policy on science, technology, and innovation and also works with science and technology actors in the productive sectors. Studies performed by CGEE are prospective, strategic, and also implementation-oriented over a wide range of topics, including water resources, biofuels, climate change, telecommunications, the Amazon Region, productive chains, human resources for innovation, biotechnology, nanotechnology, and information and communications technologies.

One of the main roles of the new Malaysian NMO is to provide independent unfettered advice to the Government on matters related to science, technology, and engineering. It also promotes public awareness of the central role which science and technology play in the nation's economic competitiveness and social wellbeing, taking an active role in education right from the primary school level. The Academy of Sciences Malaysia is committed to collaboration with "scientific fraternities" both regionally and internationally. ■

Brazil NMO: www.cgee.org.br/sobre/cgee_english.php
Malaysia NMO: www.akademisains.gov.my

CAPACITY BUILDING

New YSSP fellowships

IIASA's flagship capacity-building program, the Young Scientists Summer Program (YSSP), has received additional funding, due to the generosity of donors. Former YSSPer and IIASA colleague Petr Aven, who is now President of the Russian Alfa Bank, has established a fellowship to enable an advanced graduate student from Russia or from a developing country that is not a member of IIASA to participate in the YSSP. IIASA Annual Fund donors have also contributed to bringing two developing country researchers to IIASA for the summer to work on topics related to IIASA's research program.

Anastasia Emelyanova from Russia has been selected for the 2011 Petr Aven Fellowship. She is conducting a study within IIASA's World Population Program related to aging in the North, about which there is still a considerable gap in knowledge.

The two Annual Fund recipients are **Prestige Makanga** of Zimbabwe and **Shariar Rahman** of Bangladesh.

Makanga is working in IIASA's Exploratory and Special Projects Program, investigating how the concept of Volunteered Geographic Information (VGI)—where the general public contributes information voluntarily through Web interfaces—can be used to generate meaningful data on injury and its socioeconomic determinants.

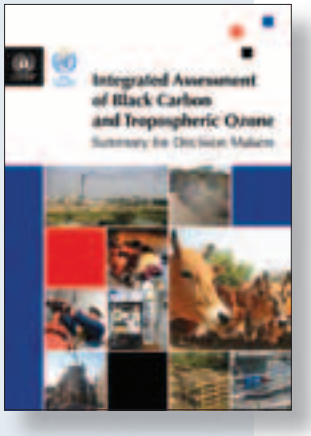
Rahman has joined IIASA's Advanced Systems Analysis Program to estimate water availability, demand, projection (2050–2100), impacts of natural (disaster, climate change), and anthropogenic disasters on water security and water governance in the southwestern region of Bangladesh. ■

YSSP www.iiasa.ac.at/yssp
Support IIASA www.iiasa.ac.at/donate

BLACK CARBON

GAINS model underpins new UN report

A recent scientific assessment sponsored by UNEP and WMO shows that it is possible to slow down the pace of global warming by reducing the concentrations of short-term climate forcers in the atmosphere. The assessment was based on results from the IIASA GAINS model.



Short-lived climate change forcers, such as methane, black carbon, tropospheric ozone, and many hydrofluorocarbons, have a significant impact on climate change, as well as a relatively short lifespan in the atmosphere compared to CO_2 and other longer-lived gases. Reducing these substances would enhance climate protection in the short term, buying time for longer-term measures against global warming to "kick in." Reductions would also have significant health, agricultural, and ecosystem benefits, by reducing air pollution.

The salient issues of the UNEP scientific assessment were announced on 23 February 2011 at a side event, "Quick Action on Climate Change: The Option of Reducing Short-lived Climate Forcers," at the 26th session of the Governing Council/Global Ministerial Environment Forum of UNEP in Nairobi, Kenya.

The main message of the side event was the need for awareness raising, especially among decision makers, regarding the potentials that already exist for reducing short-lived climate forcers. There was also a need to recognize that reducing short-lived climate forcers alone will not enable the below 2 °C temperature target to be met, UNEP said; hence, the importance of taking an integrated approach involving measures to reduce both short-lived forcers and CO_2. ■

Amann M, Klimont Z (contributors) (2011). Integrated Assessment of Black Carbon and Tropospheric Ozone. Summary for Decision Makers. UNEP and WMO.

DEMOGRAPHY

POP goes Wittgenstein

Wittgenstein Centre
FOR DEMOGRAPHY AND GLOBAL HUMAN CAPITAL

Wolfgang Lutz, Leader of IIASA's World Population Program (POP), has used the €1.5 million allocated for his use as winner of the 2010 Wittgenstein Award—also known as the "Austro-Nobel Prize"—to help fund the new Wittgenstein Centre for Demography and Global Human Capital.

The Centre aims to be the world's leading center on demographic analysis of the development of human resources and their impact on society and the economy within a few years. It is a partnership between IIASA, the Vienna Institute of Demography (VID), and the Vienna University of Economics and Business (WU) and includes research teams working on population development, health, education, politics, age, migration and education.

It has a global focus. In the next two years it will be working with Oxford University to create science-based population projections for all countries in the world where not only age and gender, but also education, employment and health status are taken into account.

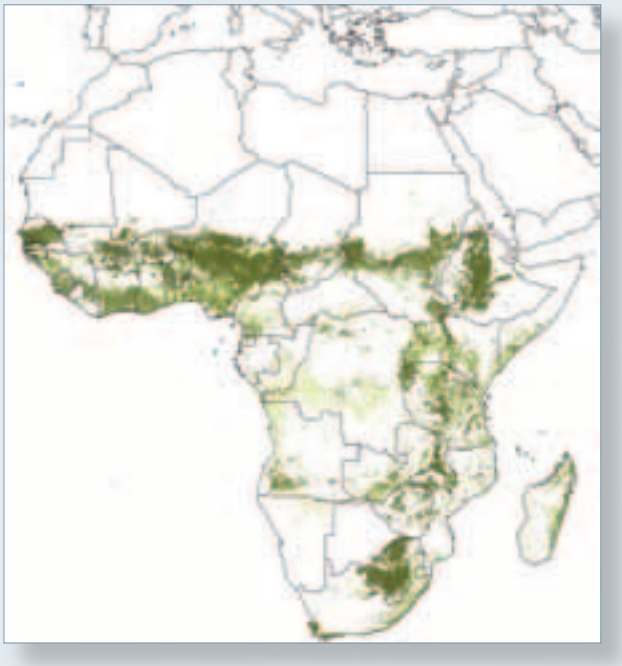
According to Lutz, "This important information allows for the prioritization of national social and economic policy and global development and environmental policies." ■

www.iiasa.ac.at/Admin/INF/PR/2011/2011-01-31.html

AGRICULTURE

New cropland map for Africa

Researchers at IIASA have combined five existing land cover datasets to create a cropland map for Africa. The five datasets—GLC-2000, MODIS Land Cover, GlobCover, MODIS Crop Likelihood and AfriCover—were first combined into a "synergy map" so that experts could scrutinize, compare, and rank each pixel to assess the likelihood or probability that it is cropland. The cropland map was then calibrated with national and sub-national crop statistics to validate the decisions made. The resulting cropland map was shown to have an accuracy of 83 percent, which is higher than the accuracy of any of the single individual maps. The cropland map is freely available at agriculture.geo-wiki.org (see page 26). It should reduce uncertainty and improve predictions in land use, vegetation, climate change, and Earth systems modeling. ■



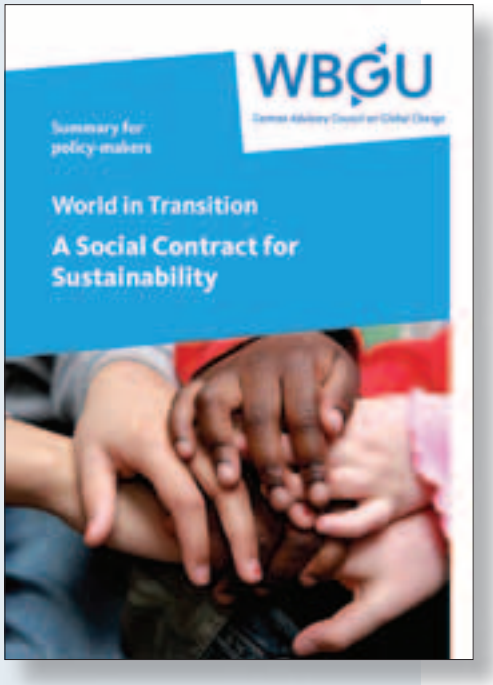
IMPROVING MAPS
IIASA researchers have developed a more accurate map showing where cropland currently exists in Africa.

Fritz S, You L, Bun A, See L, McCallum I, Schill C, Perger C, Liu J, Hansen M, Obersteiner M (2011). Cropland for sub-Saharan Africa: A synergistic approach using five land cover data sets. *Geophysical Research Letters*, 38:L04404.

ADVISING GERMANY

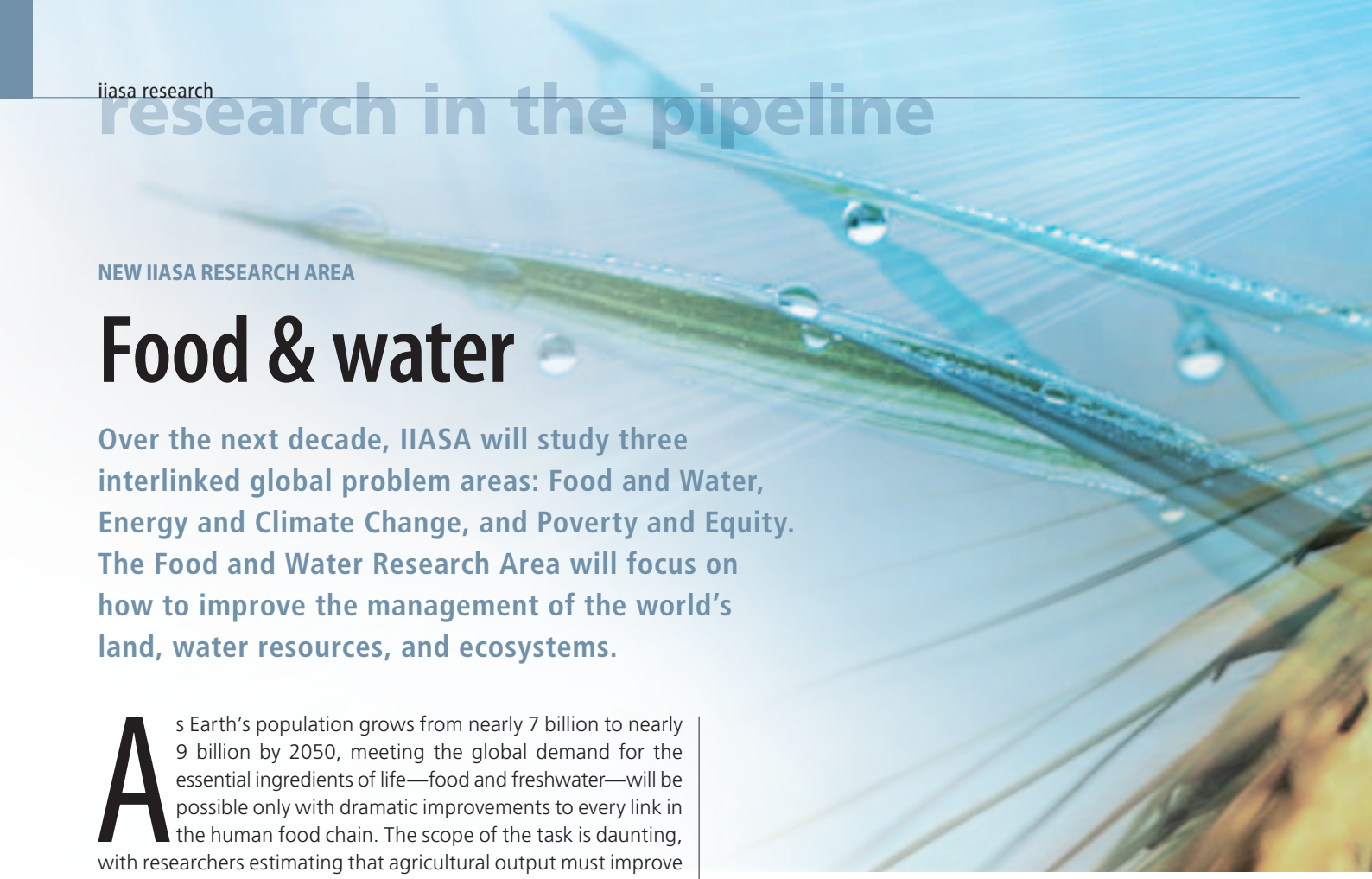
Transformation science

The German Advisory Council on Climate Change in April issued a new report to the German Federal Government "World in Transition—A Social Contract for Sustainability." IIASA's Nebojsa Nakicenovic and Niels B. Schulz were part of the writing team. The report delivered a number of recommendations. The main finding was that science and research should dedicate themselves even more



to the low-carbon transformation and that substantial funding for a new field of studies "transformation research" was needed, with particular emphasis on environment and energy research within a joint Germany–EU context. Such a research agenda should be backed by transformation education integrated into school, university, and vocational curricula. To achieve sustainability, there was a need for imaginative solutions that would seem daring in comparison with the status quo. "The fossil–nuclear metabolism of the industrialized society has no future," the report concludes. ■

Nakicenovic N, Schulz NB (contributors) (2011). World in Transition: A Social Contract for Sustainability. WBGU German Advisory Council on Climate Change. Summary for policy-makers.



NEW IIASA RESEARCH AREA

Food & water

Over the next decade, IIASA will study three interlinked global problem areas: Food and Water, Energy and Climate Change, and Poverty and Equity. The Food and Water Research Area will focus on how to improve the management of the world's land, water resources, and ecosystems.

As Earth's population grows from nearly 7 billion to nearly 9 billion by 2050, meeting the global demand for the essential ingredients of life—food and freshwater—will be possible only with dramatic improvements to every link in the human food chain. The scope of the task is daunting, with researchers estimating that agricultural output must improve by 70 percent globally and 100 percent in the least developed countries over the next 40 years.

Achieving that goal will require the use of improved breeding techniques for plants and livestock to foster greater environmental diversity and adaptation to climate change. Better land and water management systems are also needed, for, despite the land and water constraints, farmers will need to grow enough food to feed millions of additional people over the next 40 years.

The demand for freshwater is also increasing, with some experts predicting a gap of 40 percent between demand and supply in as little as 20 years. Agriculture already accounts for more than 70 percent of human water consumption, and several estimates indicate that by 2030 farmers will need 45 percent more water than they use now.

IIASA is pursuing a "systems approach" to the complex web of issues involved in providing sustenance to a burgeoning world population. The researchers approach the food and water problems in the broad context of land, ecosystems, and marine management, taking into account the availability of natural resources and the socioeconomic context in which those resources will be used.

IIASA is developing scientific models (see box) of these complex global problems in order to identify effective policy options. For example, researchers are using global land use models to look at the impacts of developing economies on forests and related ecosystems in Bangladesh, Brazil, China, the Congo Basin, India, the Koreas, and Russia in collaboration with the Food and Agriculture Organization of the UN, the UN Environment Programme, and the World Meteorological Organization, among other international organizations.

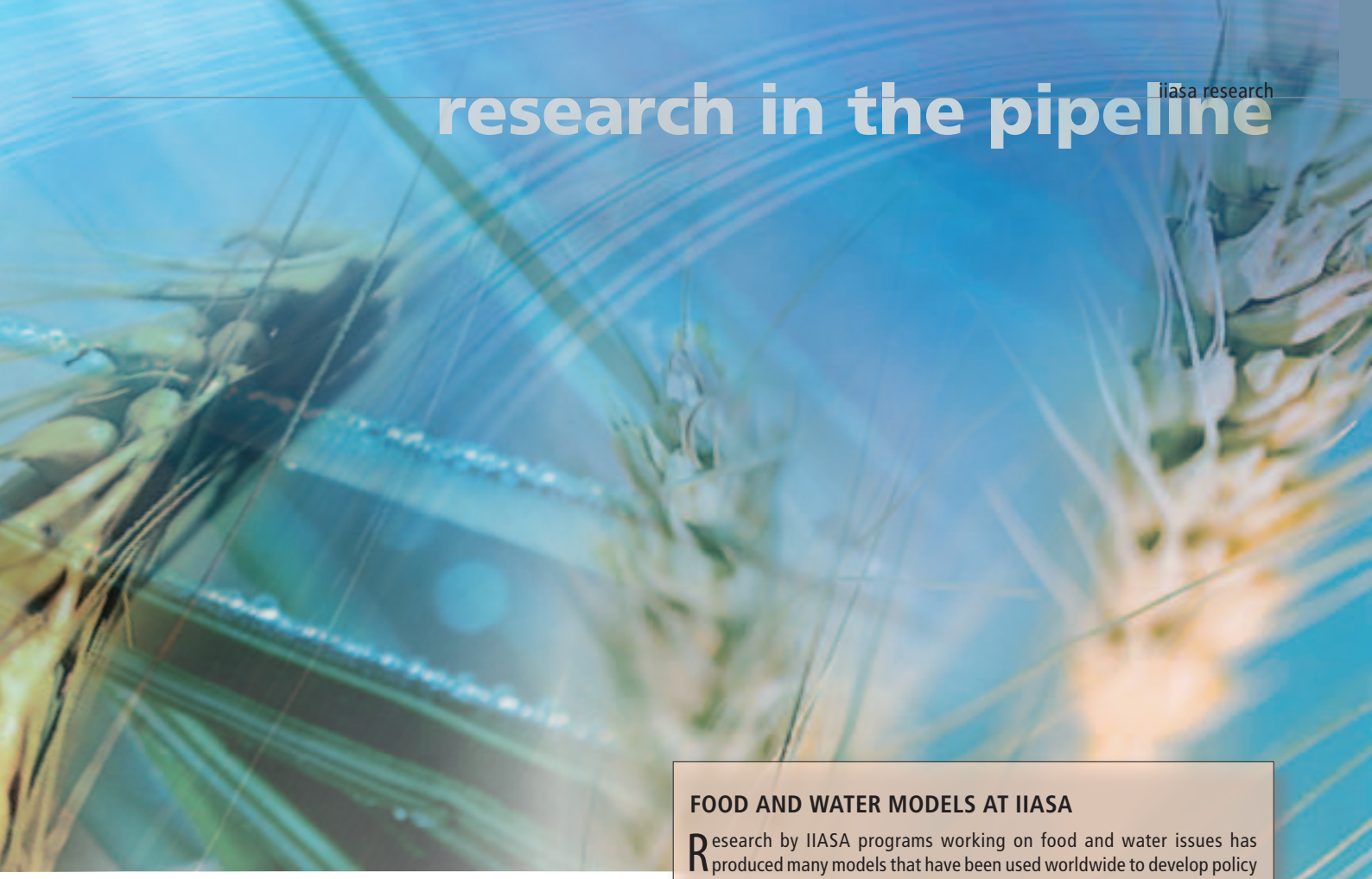
Researchers from across the Institute, but particularly from the Ecosystems Services and Management (ESM) and the Evolution and Ecology (EEP) programs, have defined the following food and water policy challenges as being of concern:

- Increasing competition for land and water resources from increasing industrialization and urbanization, particularly in developing countries. This demand for more land and water includes the potential threat to food crops from biofuels. Limited additional sources of freshwater and a decreasing quality of existing water supplies due to pollution. Freshwater resources are unevenly distributed, and the places where water is scarce are often the same places where hunger is worst.
- Forests, wetlands, and lakes play a major role in the subsistence of hundreds of millions of people and are critical in sustaining natural landscapes. These ecosystems are typically not managed in a sustainable way, with integrated management being rare.
- Seafood is the primary source of animal protein for more than one billion people; however, expanding food production from fisheries is hindered by rampant overfishing.

The Institute's areas of concern reflect integrated research that will be carried out over the next decade based on four integrative themes: food security, integrated water resource management, managing multiple ecosystems, and safeguarding sustainable seafood and aquatic ecosystems. Work within these themes will include the following:

FOOD SECURITY In addition to protecting productive land already in use, IIASA's Food and Water research plan shows that better management of marginal and degraded areas would help meet the increasing demand for food. For example, as competition for land and water from the energy sector increases, particularly for growing biofuel crops, IIASA researchers are looking for ways to enhance biofuel production without jeopardizing food crops or increasing deforestation. New databases and systems are being developed to better conceptualize economically viable, socially responsible, and environmentally beneficial uses of marginal land.

research in the pipeline



WATER RESOURCES Management of water resources in arid and semi-arid regions in order to avoid groundwater depletion is a particular problem, especially as these regions are expected to suffer disproportionately from climate change. IIASA is developing an approach that will enable these regions to create policies to better adapt to the stresses of climate change.

On the issue of water resources shared by a number of nations, IIASA expects to implement a model-based integrated watershed management analysis involving aspects of land use, agriculture, population, and poverty in a cross-border shared-resource context. This work will be driven by IIASA's new Water Program. Transboundary water issues will also be the focus of IIASA's Policy Forum, with Institute and NMO researchers working in collaboration.

MULTIPLE USES OF ECOSYSTEMS The task of providing sufficient food and water must be accomplished in the broader context of protecting ecosystems and the vital services these provide. Global challenges range from tackling food, water, and energy security to controlling multi-hazard disasters, existing and emerging infectious diseases, and basic nutrient cycles, as well as assessing their economic impacts. IIASA researchers are involved in complex planning, coordination, and international cooperation to deliver insights into managing and maintaining ecosystem services.

SUSTAINABLE SEAFOOD Safeguarding the marine environment as a food source is a critical part of this challenge, essential to feeding many millions of people. Yet overfishing in both the oceans and freshwater systems is already considered severe. IIASA's researchers are focusing on securing and expanding aquatic food resources through better fisheries management, without jeopardizing aquatic ecosystems. IIASA scientists have led international research demonstrating that pressure from overfishing can force fish to evolve rapidly, which may lead to the decline or even collapse of fisheries. Such human-induced evolutionary change must be accounted for in monitoring and management of aquatic systems in order to sustain fish populations.

The pressure on Earth's food and water systems comes from many sources, including the burgeoning human population, scarce and over-exploited natural resources resulting from inefficient resource management, and the adverse effects of climate change. Gaining a better understanding of how various ecosystems respond to these multiple stresses, so that they can be managed appropriately, is a key factor in moving toward global sustainability of food and water resources. In its new Food and Water Research Area, IIASA will be extending its systems analysis tools to bring new policy insights to longstanding challenges, many of which have so far proved resistant to traditional development approaches. ■

Further information IIASA's New Strategic Plan 2011–2020 at www.iiasa.ac.at/docs/strategic_plan.html.

Prof. Detlof von Winterfeldt is IIASA Director and **Prof. Nebojsa Nakicenovic** is IIASA Deputy Director.

FOOD AND WATER MODELS AT IIASA

Research by IIASA programs working on food and water issues has produced many models that have been used worldwide to develop policy strategies. They include:

BEWHERE Optimizing siting of bioenergy plants

BLS A tool to rationalize the world's food system

EPIC Environment Policy Impact model for soil productivity and management decisions with special emphasis on hydrology

G4M A global biophysical and economic forestry model addressing sustainable forest management

GAEZ Providing comprehensive information for national agricultural decision making

Geo-Wiki The global land cover validation tool

GLOBIOM Assessing competition between agriculture, bioenergy, and forestry for land use

HWSD A vast and growing database of global soil information

www.iiasa.ac.at/Research/Models

GLOBAL ENERGY ASSESSMENT

Feeding & fueling the 9 billion—sustainably

Food *versus* fuel isn't the answer. Integrated land management and sustainable intensification *are*.

Sustainably nourishing and fueling the nine billion people assumed to be living on Earth in 2050 is one of humanity's grand challenges. Today, about one billion people are malnourished globally—and around one billion, mainly in the industrial world, are obese.

According to estimates from the Food and Agriculture Organization of the United Nations, global food production will rise by 70 percent or more until 2050, mainly from increases in yields. Cropland expansion for food production is generally assumed to be modest, perhaps below 10 percent until 2050.

At the same time, there is the hope that bioenergy could provide huge amounts of clean, renewable energy, helping curb greenhouse gas (GHG) emissions from fossil fuel combustion. But, can we expect a strong growth in bioenergy production over current levels of ≈50 EJ per year, given the need to counteract further biodiversity loss and given, too, that food and bioenergy require the same limited resources, namely, fertile land and freshwater, and that even relatively small biofuel programs have recently contributed to food price surges?

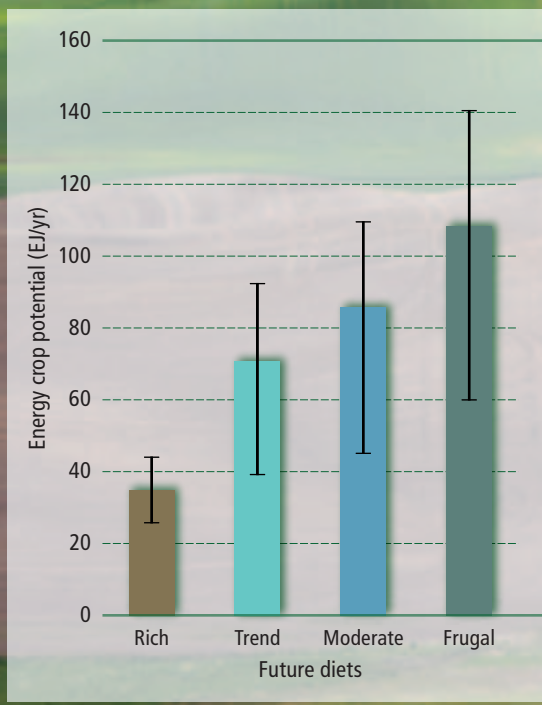
The answer is: yes, to a certain extent—if we do it right, which means abandoning the delusion of "silver bullets" and instead trying to better understand the dynamically interwoven social, economic, and ecological factors shaping the future global land system.

First, we need to acknowledge the enormous importance of future diets. To date, income growth has involved a transition from "poor" diets in which staple crops such as cereals or potatoes deliver most of the calories, to "rich" diets with an ample supply of animal-derived protein.

While our priority is reduced hunger and malnutrition, there are many dietary options. All diets depicted in the graph—from frugal to rich—supply sufficient calories and protein for a world population of nine billion in 2050. The "frugal diet" would require globally equal distribution of food containing a low level of animal products to abolish hunger. The "rich diet" would come closer to making the food supply levels currently enjoyed in the USA and Europe available worldwide. Hunger might still persist, even at that level of supply, however, if large inequalities in food distribution remain.

As the graph shows, the bioenergy potential in 2050 strongly depends on future diets: rich diets which need more cropland and rough grazing land for cattle leave little land for bioenergy crops. While people are unlikely to choose bioenergy over food, recognition of the adverse health effects of overconsumption, as well as promotion of vegetarian foods could persuade people to adopt environmentally less demanding diets, even in wealthy countries.

According to environmentalists, more widespread adoption of organic agriculture could reduce the adverse environmental effects associated with intensive agriculture. As organic yields are currently substantially lower than those of the most intensive conventional production methods, natural ecosystems, including forests, would have to be converted to crop and forage land if the aim should be to generate rich diets with organic agriculture. Thus, while agricultural intensification may increase some environmental pressures, it also helps to alleviate others such as deforestation. Foregoing yield gains from intensification therefore also has ecological costs,



LAND FOR FUEL
The global energy crop potential in 2050 depends on future diets (*left*) and yields of food crops (*right*). Moving toward a more modest diet always results in higher bioenergy potentials, while stronger agricultural intensification increases the energy crop potential only if we abstain from eating more animal products.

research in progress

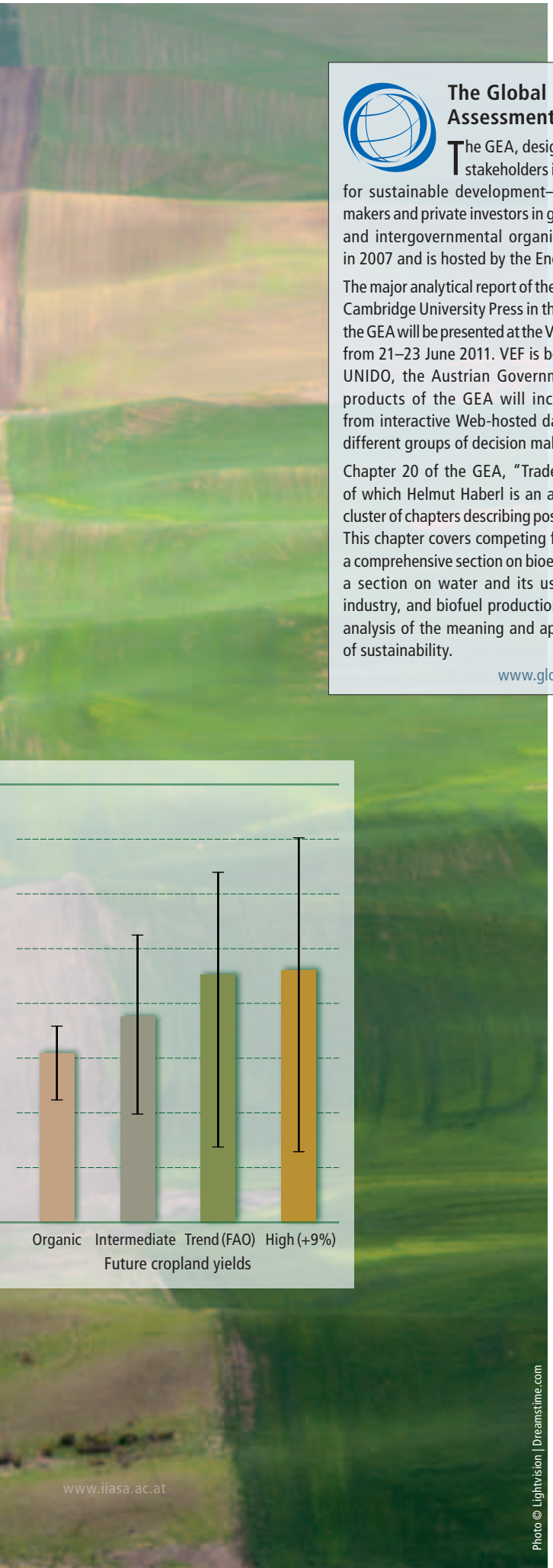


Photo © Lightvision | Dreamstime.com

The Global Energy Assessment (GEA)

The GEA, designed to provide advice to stakeholders in the transition to energy for sustainable development—for example, decision makers and private investors in governments, enterprises, and intergovernmental organizations—was launched in 2007 and is hosted by the Energy Program of IIASA.

The major analytical report of the GEA will be published by Cambridge University Press in the Fall of 2011. Work from the GEA will be presented at the Vienna Energy Forum (VEF) from 21–23 June 2011. VEF is being jointly organized by UNIDO, the Austrian Government, and IIASA. Other products of the GEA will include materials ranging from interactive Web-hosted databases to briefings for different groups of decision makers.

Chapter 20 of the GEA, "Trade-offs, land and water," of which Helmut Haberl is an author, forms part of the cluster of chapters describing possible sustainable futures. This chapter covers competing future demands for land, a comprehensive section on bioenergy use and potentials, a section on water and its use in cities, agriculture, industry, and biofuel production, as well as a thorough analysis of the meaning and application of the concept of sustainability. ■

www.globalenergyassessment.org

provided it does not go hand in hand with changes in consumption. These trade-offs need to be better understood.

Growth in yields need to be reconciled with a reduction in the adverse effects of agriculture—a strategy called "sustainable intensification." While formulating this goal is a useful first step, solutions are a long way off. Moreover, proper implementation of related technologies needs to be based on context-sensitive approaches that carefully consider local socio-cultural, economic, and ecological conditions. People living off subsistence agriculture must not be forced to accept development schemes imposed by others.

Addressing the food versus fuel dilemma goes beyond diets and agricultural technology. One strategy is the "cascade utilization" of biomass—reuse and recycling of biogenic wastes, by-flows, and residues. Recent studies suggest that the energy potential of agricultural residues, municipal solid wastes, and animal manure in the year 2050 may be approximately 100 EJ per year, about as much as the potential for dedicated energy crops. Many of these resources are sustainable and use synergies between food and fuel production, but some require careful scrutiny. For example, withdrawing organic matter such as straw from cropland may result in soil degradation and loss of soil organic carbon. This would jeopardize long-term sustainability of agriculture and result in higher agricultural GHG emissions. More evidence is needed to determine safe levels of use.

We also need to consider different land qualities. Approaches such as "environmental zoning" can usefully mitigate adverse effects and optimize outcomes by allocating to each region the most appropriate uses of the land. Of course, the need to reduce pressures on ecosystems and to reduce the rate of biodiversity loss must be integral to this approach.

Last but not least, we need an integrated approach to better understand the GHG emissions related to changes in land use. Currently there is a heated debate on the emissions of bioenergy related to "indirect land-use change" or iLUC. For example, if bioenergy is produced on land currently used for food crops, the production of food will move elsewhere. If it results in replacement of carbon-rich vegetation such as forests by cropland, iLUC implies a large "carbon debt," and bioenergy may even cause more GHG emissions than the fossil energy it replaces.

This problem can be avoided by taking an integrated view of the land, where all changes are taken into account and there are no "indirect effects." The goal must therefore be to manage the global land system in an integrated manner—to optimize outcomes in terms of food, feed, fiber, and energy supply and to maintain healthy, diverse ecosystems capable of supplying a large range of ecosystem services, including carbon storage. ■

Further information Haberl H, Beringer T, Bhattacharya SC, Erb K-H, Hoogwijk M (2010). The global technical potential of bio-energy in 2050 considering sustainability constraints. *Current Opinion in Environmental Sustainability* 2(6):394–403.

Helmut Haberl is at the Institute of Social Ecology Vienna, Alpen-Adria Universität Klagenfurt, Wien, Graz. He is a co-author of chapters 7 ("Energy resources") and 20 ("Trade-offs, land and water") of *Global Energy Assessment*, to be published in 2011.

getting research into practice

GAEZ
Global Agro-ecological Zones

AGRO-ECOLOGICAL ZONES

Bangladesh: Then and now

The Bangladesh Agricultural Research Council (BARC) this year published "Research Priorities in Bangladesh Agriculture" as part of its "Agricultural Research Vision 2030 and Beyond." Agriculture in Bangladesh plays a pivotal role in the national economy, food security, and labor force. Enhanced sustainable productivity is a necessity in all subsectors of agriculture to meet the needs of its fast-growing population.

Among the most densely populated countries in the world, Bangladesh was one of the first developing countries to carry out an appraisal of land resources for agricultural development in the late eighties. This assessment, which covered agro-ecological resources, land suitability, and the implications for development planning, was based on FAO/IIASA agro-ecological zones (AEZ) methodology and funded by UNDP and FAO.

This initial ground-laying has been of major importance for Bangladesh. Its Agricultural Research Institute is one of largest multi-crop research organizations in the world, with institutes devoted to research into rice, jute, nuclear agriculture, sugarcane, resource development, soils, fisheries, livestock, forests, tea, and sericulture.

According to BARC, there has been a commendable success in agricultural R&D, particularly in rice and vegetables over the last three decades. However, there is a growing concern among scientists and policy planners about how to meet the demands of the increasing population in the future, given that the country's natural resource base (land, soil, and water) is shrinking and degrading, and also deteriorating because of climate change. The BARC "Agricultural Vision Document 2030 and Beyond" identifies the main research areas needed—high population growth, declining and degrading land resources, decreasing water resources, increasing natural hazards, climate change vulnerability, wide yield gap, and an imperfect market.

To tackle one of those subjects, IIASA will be renewing its ties with Bangladesh as it welcomes Shahriar Rahman from the International Union for the Conservation of Nature in Bangladesh to conduct research funded by IIASA's Annual Fund. Mr. Rahman will join the Young Scientists Summer Program, working in the Advanced Systems Analysis Program, to estimate the household water availability and water demand for Bangladesh. ■

INCREASING RICE CULTIVATION

Grains of sense from Ghana scientists

In the West African state of Ivory Coast, rice is grown on both lowland and, provided rainfall is adequate, upland areas. In neighboring Ghana, however, rice cultivation is limited to inland valleys which form about 12 percent of total land area. Ghana's demand for rice currently stands at 700,000 mt, but local Ghanaian rice farmers can produce only 150,000, leaving a deficit of 550,000 mt.

The rice problem in Ghana is compounded by rampant smuggling of rice across the Ivory Coast—Ghana borders. An estimated 6 million bags of rice are smuggled each year into Ghana, representing an annual revenue loss of US$40 million to the Ghanaian government.

The Soil Institute of the Council for Scientific and Industrial Research (CSIR) of the Ministry of Environment, Science & Technology, in 2005 began a GIS-based assessment of land suitability in Ghana for rice production. It used the FAO/IIASA agro-ecological zones (AEZ) methodology to determine which areas have the potential to support rice cultivation in Ghana under rainfed conditions, as well as the extent and geographic positions within Ghana suitable for three particular rice cultivars—very early (<100 days), early (100–120 days), and medium (120–140 days).

The analysis, based on a national AEZ assessment and a similar study already carried out for Kenya, showed that areas potentially suitable for rice cultivation in Ghana ranged between two and four times more than land currently under rice cultivation, depending on the cultivar grown. A higher yield per hectare could also be targeted, says CSIR, going a long way toward reducing the shortfall, if not eliminating it entirely. ■

Further information

- IIASA's GAEZ Model at www.iiasa.ac.at/Research/LUC/Research-GAEZ_Workshop.
- BARC's "Research Priorities in Bangladesh Agriculture" at www.barc.gov.bd/documents/Research_Priorities_Bangladesh_Agriculture.pdf.
- Boateng E (2005). Geographic Information Systems (GIS) as a decision support tool for land suitability assessment for rice production in Ghana. *West African Journal of Applied Ecology*, 7:69–80.

Dipl. Ing. Günther Fischer and **Dr. Harrij van Velthuizen** are Senior Scientists in IIASA's Ecosystems Services and Management Program.

STOPPING DEFORESTATION

WWF's living forests challenge

A global analysis using IIASA models shows that more than 230 million hectares of forest will disappear by 2050 unless action is taken. A new WWF (World Wide Fund for Nature) report proposes that policymakers and businesses unite around a goal of zero net deforestation and forest degradation (ZNDD) by 2020 as a groundbreaking global benchmark to avoid dangerous climate change and curb biodiversity loss.

THE NEED FOR URGENT ACTION IIASA's Living Forests Model compares gross deforestation under the Do Nothing Scenario, Target Scenario, Target Delayed Scenario, and Half Measures Scenario. The numbers represent cumulative deforestation between 2010 and 2050. Under the Do Nothing Scenario, the area deforested is greater than the current total forest area of the Democratic Republic of Congo, Peru, and Papua New Guinea combined. (Source: *WWF Living Forests Report*, Chapter 1)

The highly proactive and interactive WWF went to Indonesia in April to launch the first chapter of its *Living Forests Report*, Forests for a Living Planet, at the Business 4 Environment Global Summit (B4E), co-sponsored by the company Global Initiatives and the Government of Indonesia. It was a bold move to bring home to business and government leaders the folly of squandering forests for short-term profit taking, when governance and economic incentives could keep forests standing with longer-term benefits for the whole global community.

The vision advocated by the WWF at B4E was equally bold: "Zero Net Deforestation and Forest Degradation (ZNDD) by 2020." ZNND, says WWF, would not only stem the depletion of forest-based biodiversity and ecosystem services and associated (GHG) emissions, but also address the many targets of the Millennium Goals and the UN conventions on biodiversity and climate change.

Perhaps the boldest step of all was to highlight the "Living Forests Model," developed by the WWF with IIASA. Outside the research world, models are frequently unsung workhorses, producing results that give insights into the world's most complex and apparently intractable problems. WWF judges that the time is now right to visibly demonstrate *one*, that effective environmental policies are based on serious scientific data and the sophisticated methodologies developed to interpret them, and *two*, that these policies need urgent implementation. "'The Living Forests Model' shows that conserving our forests is possible—and urgent. But it won't be easy," said Rod Taylor, WWF International Forests Director.

The first chapter of the report introduces the "Living Forests Model"—an integrated version of IIASA's tested G4M and GLOBIOM models—and shows how models, rather than making exact predictions, inform the policy debate with respect to the important issues of population rises, food prices, pollution, biodiversity, and livelihoods. It also shows geographically explicit land-use change under different scenarios. It features a reference "Do Nothing Scenario" and demonstrates how this would change if measures were introduced to rein in deforestation and forest degradation. It also features other scenarios that change key assumptions in the Do Nothing Scenario.

The WWF plans a year-long conversation on the options and opportunities for achieving the Living Forests Vision. WWF and IIASA will use the "Living Forests Model" to explore current and potential future land-use trends, including how growing global consumer demands affect what we produce, the knock-on effects on GHG emissions, and the impacts of these trends on resources and prices. More chapters will be released throughout 2011. ■

Further Information *WWF Living Forests Report* at www.panda.org/livingforests.

Dr. Michael Obersteiner led IIASA's modeling team for the WWF Report with **Dr. Petr Havlik** providing the calculations from IIASA's GLOBIOM model and **Dr. Mykola Gusti** from IIASA's G4M model. All are Researchers in IIASA's Ecosystems Services and Management Program (ESM) along with **Mr. Florian Kraxner**, Deputy Program Leader of ESM.

Green food systems for the 9 billion

A major goal of the international and development communities is to satisfy food security needs while achieving a smaller environmental footprint. This is becoming harder to reach by the day. In 2050 there will be an estimated 9 billion mouths to feed, compared to almost 7 billion today. Without timely solutions, this will necessitate a 50 percent increase in food production and, of course, all the damage that present-day agricultural practices imply for the environment.

Matching food to hunger is a persistent problem. Historically there has always been more than enough food to provide adequate nutrition for the global population. Hunger is patchy, with excess and insufficiency in every country. While globally one billion people suffer food insecurity, health problems due to overeating abound. Obesity in North America is well documented. Less known is that children's average life expectancy in the USA is expected to fall below that of their parents for the first time in modern history. Tastes are shifting, too. As economies expand, Asian palates are demanding more livestock-based products like red meat, which is closely aligned to methane emissions and the relatively inefficient use of land for feed-lotting.

Human activities to date have already adversely affected 60 percent of ecosystems, pushing the functioning of some key Earth systems beyond planetary boundaries. Several international environmental agreements are in place that seek to reclaim "lost ground." And although schemes like lowering the carbon footprint of agriculture, the "100-mile diet," and other food system activities—often alluded to in the rhetoric of global agendas—show considerable unrealized promise, there are no quick fixes.

NO UNIVERSAL FIXES

Some components of the food system have the potential to deliver both sustainability and a reduced footprint, for example, intensive organic farming systems which can maintain high production levels with fewer pesticides and artificial fertilizers. Many, however, do not; and some achieve one and not the other. For instance, intensive shrimp production in Asia enhances local incomes and hence food security. However, fish farming harms the environment and, being subject to global economic fluctuations, could cause even greater damage if producers cannot afford their upkeep. There are no universal fixes either. The contribution of different food system activities to food and environmental outcomes must be analyzed in terms of "where," "when," "how" contextually speaking, as well as taking human livelihoods, equity, energy, water, and other multiple interconnected questions into account. Achieving this dual goal is an enterprise of immense complexity, with cascading sets of interactions, trade-offs, and synergies that, for decision makers, make the problem seem intractable.

"Where" is a problem, as many current adaptations in food systems that look environmentally beneficial at the local level could prove disadvantageous for food security and environmental performance in a wider landscape or globally. Furthermore, while deintensification of agricultural production may reduce harmful environmental effects *locally*, it could—if applied as a global strategy—lead to more deforestation and agricultural expansion into higher risk areas, if yields decline. This would mean a heavier environmental impact and reduction of food security.

Naturally, this logic also applies to the controversial issue of biofuels and biomass use. Integrated biomass systems, which include renewable energy systems, increase the level of economic activity in rural areas and diversify the economy, increasing overall resilience and income levels. Smallholder grower schemes are more likely to lead to better integration of biofuel cash crops into a wider spectrum of cropping systems, whereas large-scale monoculture biofuel production is more likely to have negative impacts on food and environmental security.

TRANSIENT SOLUTIONS

"When" is another important factor. While a switch to high-yield organic farming is desirable, it is not possible until four factors are in place: knowledge, technological resources, nutrient supply, and markets for premium products. This means that an intermediate stage is needed that might be environmentally less benign and during which we need to learn and to build human capital. Scientists are confident that the recognition of the potential in this type of farming will generate the answers needed. In the meantime, an interim strategy based, for example, on biochar (a form of charcoal, from agricultural waste, that helps soils retain nutrients and water) and similar transient "solutions" would buy time for new technology development.

Clarity on these heavily interlocking issues can only come from a systems perspective. One research insight is that the links between food security and environmental agendas are weak, probably because of the many legitimately competing issues concerning food, environment, social, and economic outcomes at local and regional levels. The links between the two need strengthening, with agriculturalists and environmentalists joining forces much more to work toward common goals. Another insight is that there is no point in local food and environmental initiatives that do not mesh with overall global actions—a consistency of approach can be assured by a good governance scheme, either self-regulatory or externally imposed. The third insight is some actions can identify lessons now for future approaches to research and decision making.

LESSONS LEARNED

A major lesson to be learned comes from the international climate negotiations which are heavily dominated by developing regulations, markets, and incentives to reduce net CO_2 emissions globally and nationally. While, if successful, these arrangements will slow climate change, potential negative implications for food security are frequently not considered. Large areas of monoculture forest plantation, for example, may be effective carbon sinks, but they may also displace food production—as may a major move to biofuel production on high-quality agricultural land. In the future, mitigation instruments should explicitly consider synergies and trade-offs with food security and strive for multiple benefits, for instance, by devising markets that incorporate the effects of large-scale mitigation on food system resilience.

LEAPFROGGING

In developed countries, the first transition to the green revolution to increase food production had several unintended and undesirable impacts, like overused water cycles and nitrogen leakage. Now various forms of more efficient agriculture have emerged that aim to maintain, or even increase productivity at the same time as reducing environmental impacts. The problem is the risk that, to meet food security goals, large areas of developing-world agriculture will make only the first transition. There is an urgent need for processes that encourage these regions to skip the first transition and go, as much as possible, to the second. Research should identify the forms of efficient agriculture that would be most appropriate in different regions, and ensure that locally appropriate technologies and cultivars are available at reasonable cost to meet local food preferences.

Post-obesity diets are another emerging trend resulting from public-awareness campaigns for healthy diets, which lower total food demand and reduce processing, packaging, and transportation. Transition countries are already rapidly developing health problems linked to overconsumption, even among the poorest and particularly in cities. The challenge for policymakers is to promote awareness by providing better information on the impacts of "bad" diets on personal and public health locally, and about environmental impacts and food shortages elsewhere in the world. These lessons must be transferred as fast as possible to developing communities so that they can avoid the worst health and environmental impacts of food system transition.

ENCOURAGING BIODIVERSITY

To improve joint food and environmental outcomes, there needs to be a shift away from large-scale monocultures which facilitate the spread of pests and diseases to more diverse integrated biomass systems with a wider and more precise genetic fit to local environmental conditions. By encouraging cooperative ventures among smallholders, economies of scale can be realized to stay attractive for badly needed investments along the entire food supply chain.

There must be integration of the different global, national, and even local institutions in charge of the food security and environmental agenda through appropriate interorganizational arrangements. At the national level this should be required by government and internationally; treaty making processes on sustainable food systems for the nine billion in coordination with other land-based conventions should be explored, with a possible mechanism to transfer carbon financing and other forms of Payments for Ecosystem Services (PES) to promote food security and environmental outcomes.

There still needs to be continued delivery of technical and institutional solutions for running efficient and effective food systems, both by spreading existing technologies wider and innovation along supply chains and ecosystem service creation. Research needs to place these technologies firmly in the food system and ecosystem services context to identify the synergies and trade-offs between them and the risks they may involve. ■

Further information Obersteiner M, Stafford-Smith M, Hiepe C, Brklacich M, Rudder W (2010). Green food systems for 9 billion. In: J Ingram, P Ericksen, D Liverman (eds), *Food Systems in a Changing World*. Earthscan, London, pp. 301–316.

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IIASA GAEZ MODEL

Political will is the only way to end hunger

INCREASING AGRICULTURAL PRODUCTION
The map shows the different potential of land to increase crop production. Red and brown areas show land with the most potential to increase productivity and green areas the least. The map presents apparent yield gap ratios (actual/potential production) comparing high input level potentials with actual yields. (Source: GAEZ v3.0)

To feed an estimated world population of 9 billion in 2050, agricultural production would need to rise by almost 1.4 percent per year from the year 2000 baseline. This may seem small, but in fact it will take an enormous effort to achieve on the part of farmers, researchers, and agricultural extension workers. Indeed, given all the pressures involved in some regions in making the swift improvements needed in, for example, irrigation, transport infrastructure, and fertilizers, it is uncertain whether such output growth per unit of land can be achieved and sustained to 2050.

The paradox of food insecurity and hunger is that, globally, there is sufficient production to provide food for everyone at a satisfactory level of nutrition, and yet 1 in 7 people in the world face daily hunger. People in countries with persistent food insecurity problems do not have opportunities to access the actual or potential global plenty. Lacking income-earning alternatives outside agriculture, they are dependent on the performance of local agricultural production.

In the past, the answer was often simply to expand the amount of cultivated land and pastures. We now know that expansion usually occurs at the expense of forests and has adverse knock-on effects for the environment, ranging from increased greenhouse gas concentrations in the atmosphere to disturbance of the hydrological cycle. Any decision to increase agricultural production has to take into account multiple factors: likely environmental damage, climate change impacts as well as water availability, given that around 70 percent—and up to 90 percent in some countries—of the world's freshwater ends up in agricultural uses.

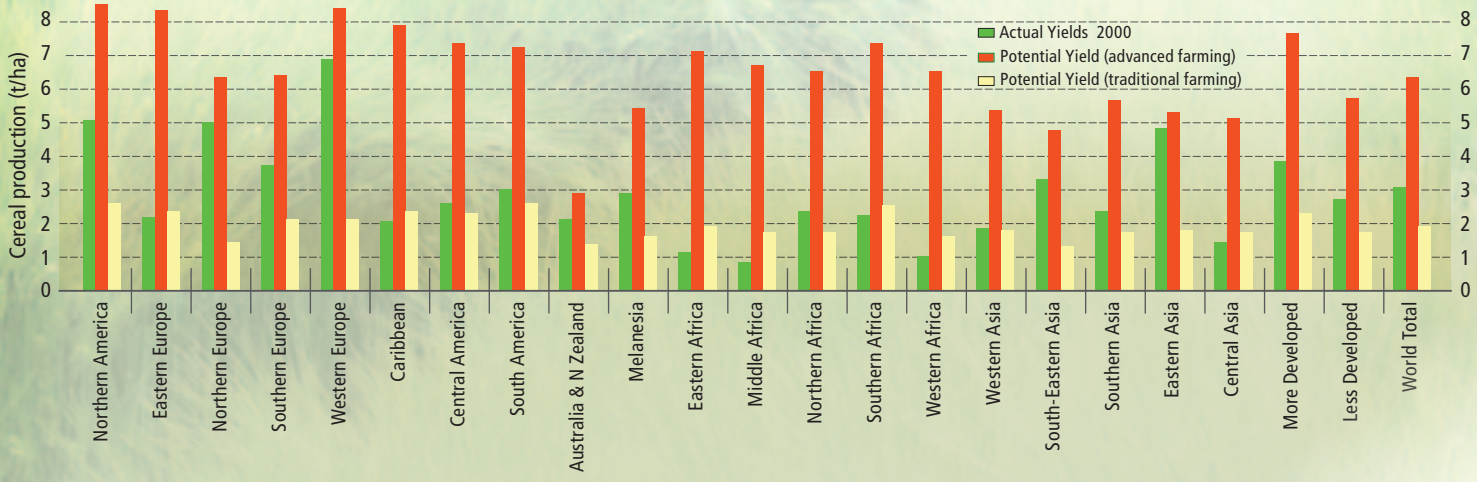
GAEZ MODELS YIELD GAPS IIASA and the Food and Agriculture Organization (FAO) of the UN began developing methodology a couple of decades ago to better understand the interactions of the many complexities of the world agricultural system. The latest version, Global Agro-ecological Zones (GAEZ v3.0), uses crop modeling and environmental matching procedures to identify crop-specific limitations of prevailing climate, soil, and terrain resources under assumed input levels and management conditions. The most recent model runs show that much of the land most suitable for food and feed crops is already in use or is not available for crop production because it is under legal protection, has carbon and biodiversity value (i.e., forests), or feeds most of the world's 3.5 billion ruminant livestock. GAEZ shows that, on a per capita basis, "prime" and "good" resources for agriculture are plentiful in only a few regions, mainly Australia, South America, North America, Eastern Europe, and Russia. There is little availability in northern Africa and Asia, where technological improvements, efficiency gains, and yield gap reductions will be needed to overcome resource scarcities. Perhaps most worrisome, a substantial decline in per capita availability of food is foreseen in the sub-Saharan African region, where although land is still plentiful, population growth will be largest. Unless these

countries can quickly and successfully turn their agricultural system performance around, today's relative abundance will turn into scarcity, putting a noose round the neck of development in the region.

From a resource point of view, even if farmers do chop trees down to make room for growing staple crops, the potential productivity in currently unprotected grass/woodland and forest ecosystems is less than on current cultivated and pasture land. But there is a much wider issue here. Land and water use for food production regularly compete with other uses and ecosystem services. The conflicts and the trade-offs in rational food production must be understood from the governmental to the farmer level. Coping with these competing demands requires better understanding and management of land, water, and ecosystem services. Using GAEZ can show decision makers at national and regional level how to carry out a robust expansion of food and bioenergy production, while sustaining ecosystem functions, preserving global gene pools, and enhancing terrestrial carbon pools.

available grassland, woodland, and forest ecosystems, which, as mentioned, would carry undesirable environmental costs.

In the context of such land transactions, FAO and other multilateral institutions have been busy on the governance and capacity-building side—see the recent World Bank Report, "Rising Global Interest in Farmland—Can it Yield Sustainable and Equitable Benefits?" The most critical need is for credible and scientific information, to enable, for instance, an estimation of fair rental or sale value for farmland and to convince governments to provide adequate rights of access to land and other natural resources to local food producers, plus secure tenure of those rights. Farmers will invest in improving their land through soil protection measures, planting trees, and improving pastures if they have secure tenure and can benefit from their investments. Reducing rural poverty and hunger cannot be achieved without political and resource commitment to sustainable agricultural development.



ACTUAL YIELDS VERSUS POTENTIAL YIELDS
In 2000 some regions, such as Western Europe and Eastern Asia, cultivated quantities of cereals (green) only a little below the full potential (red) of the land using advanced farming (e.g., adequate fertilizers, pesticides, etc.). Conversely, cultivation of cereals in other regions such as Western and Central Africa, were even lower than the land's potential yield using traditional farming (e.g., no fertilizer or chemical crop protection measures) (yellow). The chart compares the actual average cereal cultivation in 2000 with the potential yields of advanced and traditional farming. (Source: GAEZ v3.0)

LOCAL PRODUCTION VITAL Farmers have more than yield gaps to contend with. The expansion of urban areas and land required for infrastructure and other non-agricultural purposes is expected to greatly outpace population growth. Projections with IIASA's world food system model indicate that some 80 million hectares will need to be converted for residential, industrial, and infrastructure use from 2000 to 2050, over 90 percent of this in developing countries.

The recent surges in food and fuel prices have driven countries with a high dependence on food imports to seek assured food supplies through a rush of agricultural investment in land in other countries. The Gulf Cooperation Council Countries, China, India, South Africa, South Korea, and others have been buying and leasing farmland, often in food-insecure countries, especially in sub-Saharan Africa. Although such investments could catalyze access to technology, skills, capital, and employment, they also carry considerable risks. There have been several examples in the recent past where investments have threatened local resources and marginalized small producers. They also raise the risk of increased expansion of cultivated land by local farmers into

AGRICULTURE MUST BE PRIORITIZED Trends over the last 30 years show a reduced allocation of national development budgets to agriculture in developing countries, a setback that has coincided with declining multilateral lending and bilateral aid for the sector. Agriculture has been regarded as backward by national governments and their international partners, was thus given low priority. The latest developments in biotechnology, such as nutritionally enhanced and productive germplasms, are bypassing poor farmers. Privatization and patenting of agricultural research findings are taking place on an unprecedented scale. When profits are at stake, there is hardly likely to be a focus on the needs of the poor.

Equally worrying is that agricultural extension and marketing services are deteriorating in many developing countries because of low political support for agriculture. Many farmers cannot access their required agricultural inputs or get their goods to market because there is no transport infrastructure.

Overarching all these concerns is that there are a number of regions where climate change poses a significant threat to food production and food security. Some farmers may be able to adapt to climate change and benefit from CO_2 fertilization, but the risks they face from increased climate variability and extreme weather events may outweigh the as yet uncertain potential for increased crop production. ■

Further information Global Agro-ecological Zones (GAEZ) Model at www.iiasa.ac.at/Research/LUC/Research-GAEZ_Workshop.

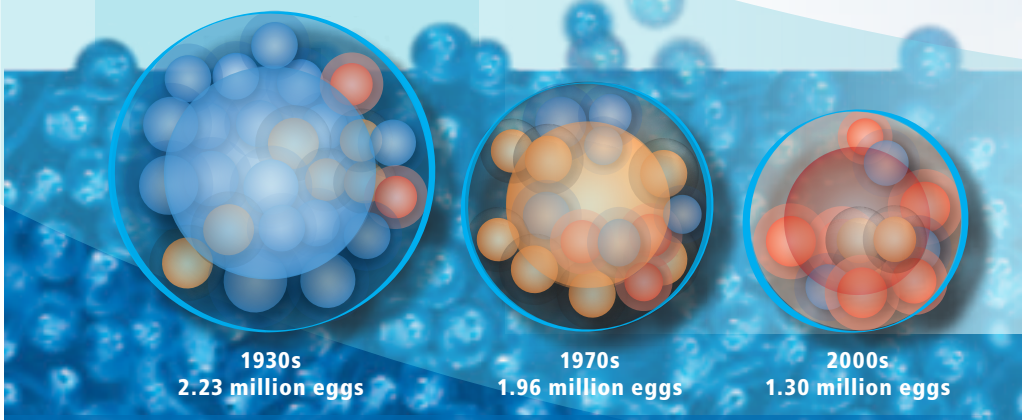
Dipl. Ing. Günther Fischer and **Dr. Harrij van Velthuizen** are Senior Scientists in IIASA's Ecosystems Services and Management Program.

Assessing the impacts of Fisheries-induced Evolution

FinE

A Specific Targeted Research Project with 18 international partners funded by the European Commission 2007–2010

Pressure from large-scale commercial fishing, as well as intense recreational and sport fishing, is accelerating evolution in some fish populations and threatening the sustainability of fisheries. Scientists are responding with tools to conduct evolutionary impact assessments that can lead to better management of fisheries.



FIRST-TIME SPAWNERS PRODUCE FEWER OFFSPRING When females of Northeast Arctic cod spawn for the first time today, they produce fewer eggs than they did decades ago.

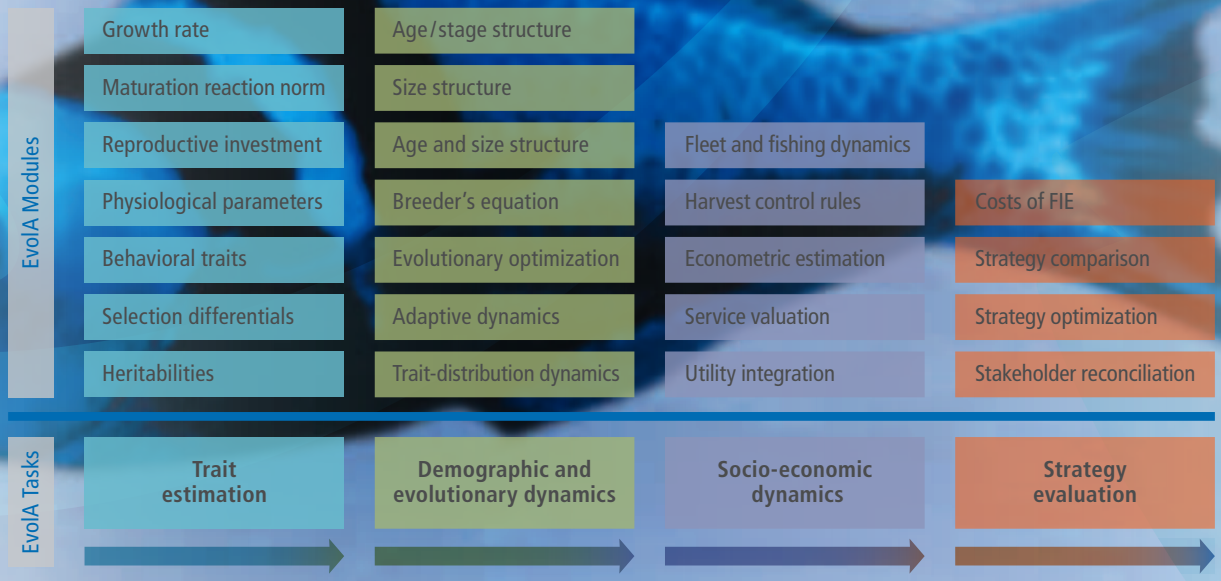
For more than a decade, IIASA's Ulf Dieckmann has recognized that the natural pace of Darwinian evolution was being accelerated in oceans and lakes by large-scale commercial fishing operations and individual anglers. And although most fisheries scientists and managers thought of evolutionary change as a centuries-long process, Dieckmann and his colleagues in the Evolution and Ecology Program (EEP) noted in their research that it could happen within decades, through a phenomenon called rapid contemporary evolution, or more specifically, fisheries-induced evolution (FIE).

At its core, FIE is driven by reproductive success—fishing alters which fish can reproduce most successfully. Fish with suitable genetic programs tend to thrive, while those not adapted to the conditions created by fishing, don't. "What fisheries are really affecting most is the longevity of fish," Dieckmann says. "Anything that is programmed to happen late in life is less likely to happen if there is heavy fishing. The advantage of reproducing at an older age is lost when there is no old age."

The mechanism of fisheries-induced evolution is fairly straightforward: remove the bigger and older fish from a population through fishing and, from a Darwinian perspective, the evolutionary balance shifts toward fish that reproduce earlier. This promotes, as Dieckmann puts it, a "live fast, die young" approach to life.

Theoretical biologist Dieckmann and an international group of collaborators have accumulated the scientific evidence necessary to convince many in the fishing-management profession that fisheries-induced evolution is real. As a result, the focus of scientists in national fisheries research agencies is shifting toward a serious examination of how important evolutionary impacts are to maintaining sustainable fisheries. Instead of balking at the idea of rapid induced evolution, they are now engaging in conversations about "the utility of doing this, about the costs and benefits of making evolutionary impact assessment part of the system," Dieckmann says.

The next step for researchers is quantifying the potential ecological and economic damage rapid evolution can cause, and providing managers with the tools needed to integrate the impacts of FIE



BUILDING BLOCKS IN AN EVOLUTIONARY IMPACT ASSESSMENT (EvoIA) When devising a specific EvoIA, practitioners can go through up to four tasks. For carrying out each task, different modules are available. While the tasks are usually carried out in the order indicated by the arrows, not every EvoIA will necessarily cover all tasks. Also the shown modules can be flexibly combined according to needs and data availability.

into their standard assessment practices. To that end, an international expert group of IIASA scientists and collaborators, working under the auspices of the International Council for the Exploration of the Sea (ICES), has developed a framework that provides the building blocks fisheries managers need to conduct evolutionary impact assessments (EvoIA) for the fish populations they oversee (see figure, *page top*).

The EvoIA framework is based on four modules that enable managers to estimate changes in the genetic traits of fish stocks, study the resultant effects on stock dynamics, account for the socioeconomic implications for stakeholders, and finally, use those insights to identify alternative management strategies that best achieve evolutionarily sustainable fisheries.

The first module, trait estimation, allows fisheries managers to examine patterns of growth, maturation, and reproduction and to evaluate whether observed phenotypic changes have an evolutionary basis. This is necessary since phenotypic changes typically also include non-genetic responses to environmental change, which cannot be passed on from one generation to the next. By analyzing correlations with environmental variables and by estimating selection pressures, managers can get a sense of which changes are likely to have been caused by FIE. Genetic changes, which are not only cumulative over the years but also very difficult to reverse, can thus be singled out for managerial attention.

The population-dynamics module enables flexible examinations of the demography and evolution of fish stocks. The module provides models that make it easy to "switch off" evolution, so as to compare the impacts of a management measure between a real evolving fish population and the hypothetical case of a non-evolving stock. In conjunction with the socioeconomic module described below, this enables quantifying the ecological and economic costs (or, sometimes, benefits) of FIE.

The socioeconomic module looks at the implications of the evolutionary impacts of fishing on the services provided by an ecosystem, quantifying their socioeconomic utility. By coupling a biological model of a fish stock to a socioeconomic model describing what different stakeholders—be they individual anglers, commercial fishing enterprises, coastal communities, consumers, or conservation groups—derive from that stock, managers can investigate how alternative management strategies translate into societal costs and benefits.

Finally, management-strategy evaluation allows fisheries managers to consider what they should do about FIE and make that a part of their overall management objectives. Such evaluations take the biological and socioeconomic consequences of alternative management strategies as inputs, and return the strategy that best agrees with given objectives.

"We have developed the EvoIA approach to enable fisheries scientists and managers to integrate evolutionary assessments into their standard routines for stock assessment," Dieckmann says of the framework that, for the first time, allows a structured approach for assessing the evolutionary consequences of fishing.

In stressing the importance of EvoIAs, Dieckmann says, "the particularly insidious feature of FIE is that genetic changes accumulate. They build up and get worse over time. As fish in a population mature at younger and younger ages, they often reproduce less efficiently." (See diagram, *left*.)

That is bad for the sustainability of both the fish population and the fishery. And once FIE has occurred, it is hard to reverse. "There is an asymmetry in the evolutionary response," Dieckmann says. "FIE may cause genetic change within just a few decades, but even if fishing is stopped, the genetic recovery will usually occur only at a snail's pace."

Detecting FIE and using the framework for quantifying its ecological and economic impacts currently requires relatively advanced tools and research skills. "What we would like to do next is to make EvoIAs more accessible," says Dieckmann. To do that the researchers are creating a "model in a box" that will be simple enough for non-experts to use, yet sophisticated enough to give useful information about FIE in a particular fishery. ■

Further information *Brief overview of EvoIAs*: Jørgensen C, Enberg K, Dunlop ES, Arlinghaus R, Boukal DS, Brander K, Ernande B, Gårdmark A, Johnston F, Matsumura S, Pardoe H, Raab K, Silva A, Vainikka A, Dieckmann U, Heino M, Rijnsdorp AD (2007). Managing evolving fish stocks. *Science*, 318:1247–1248. ▪ *Information about the ICES expert group*: www.ices.dk/reports/SSGSUE/2010/wgevo10.pdf.

Dr. Ulf Dieckmann is Program Leader of IIASA's Evolution and Ecology Program.

Russia faces tough climate change challenges

Melting permafrost, dying forests, and fragile ecosystems, combined with poor resource management, means climate change could hit the Russian people especially hard

With its millions of hectares of boreal forests, vast supplies of fresh water, and rich stores of gas, oil, and other natural resources, Russia is a study in complex and fragile ecosystems. And with more than two-thirds of those ecosystems based on frozen ground, or permafrost, Russia is expected to experience some of the earliest and most dramatic effects of climate change—almost all of them bad.

Many of the changes, such as melting permafrost in Siberia and dying forests across Russia's northern tier, will be caused directly by the warming and instability of the climate. Other changes, including increasing industrial contamination of soil and water with toxins, destruction of the environment in regions with intensive gas and oil extraction, and loss of forests to encroaching grasslands, are being caused by poor resource management that will accelerate the negative impacts of climate change.

That bleak portrait comes from the research of IIASA's Environmental Services and Management (ESM) team, headed by Anatoly Shvidenko, a modeler and forestry expert who has studied Russian forests and ecosystems for decades. His concern over the future of the Russian land has grown as he and an international team of experts have studied the ecological changes expected from climate change and the increasing exploitation of Russia's natural resources.

In the past year, thanks to a collaboration with scientists from Japan's GOSAT (Greenhouse Gases Observing Satellite), the ESM team has developed a "reality-based" assessment of the carbon exchange between the land and atmosphere over Russia. This greenhouse gas accounting system, more accurate than past tools, has allowed researchers to use several models to check their results against data already gathered on the Russian environment and to assess how the future is likely to affect water supplies, agriculture, forests, and fauna across the country.

Called the Integrated Land Information System (ILIS), this information base combines data from eight satellites with a myriad of ground-based measurements. While information about Russian ecosystems has been available for years, Shvidenko says much of it, particularly official data from the Russian public administration, is obsolete or unreliable.

To create the up-to-date view of Russian ecosystems, IIASA researchers used the best current information from an array of reliable sources and can now provide accurate answers to many questions about Russia's ecosystems and their carbon budgets. But even using multiple models and several databases, understanding the dynamics and evolution of Russia's vast ecosystems under the stress of climate change is difficult.

"The complexities of a changing world cannot be understood using a simple cause and effect approach," Shvidenko says. "Integrated modeling and systems analysis remains one of the few tools able to provide answers."

East Siberia, as well as other regions in Russia's northern tier, is particularly susceptible to climate change and, according to the current scenarios of the Intergovernmental Panel on Climate Change (IPCC), is likely to experience the most dramatic climate change on the globe. While the IPCC is hoping to limit the Earth's average warming to 2 °C by mid-century, the ESM models predict a 6–10 °C increase for vast territories of Northern Eurasia, including much of Siberia, by the end of this century.

Concurrent with that increase, water supplies in vast areas of the region may decrease substantially. The ESM research shows that the climate warming will negatively impact the vitality and productivity of ecosystems and likely lead to an explosive acceleration of natural disturbances, particularly wildfires and outbreaks of insect infestation.

IIASA modeling indicates that as the permafrost melts and the already severe forest fire problem gets worse, agricultural lands in river valleys will face increased flooding. The flooding will result from rains that are more intense, but less frequent as climate warming increases the length of hot, dry periods during the summer.

Photo: Dr. L. Vaschuk

Climate change will also shift Russia's climatic zones, according to a number of models, and that, in turn, will cause a redistribution of vegetation. Some modeling shows a two-fold decrease in forested areas by the end of the century, and a significant increase in "desertified steppes."

Such changes will affect biodiversity and ecosystems productivity, including plants, forests, wild animals and—not least of all—people. The wellbeing and standards of life of local populations in the affected areas could be hit hard, particularly through the loss of stable crops in agriculture, hunting, and other means of subsistence, Shvidenko says.

The risks for terrestrial ecosystems, particularly agriculture and forestry, from climate change and anthropogenic pressure can be categorized as the following:

- Loss of soil fertility due to water erosion, soil compaction, lack of nutrients, changing water tables, and soil contamination.
- Impoverishment of soil biota causing a decline in productivity of land.
- Lack of water resources in expanding arid regions in the south.
- Increased periodic flooding of agricultural lands, particularly in river valleys.
- Outbreaks of pests, such as the Siberian silk moth, and harmful microorganisms.
- Green desertification in areas where forests are lost to unproductive grasslands.
- Increasing air pollution, as well as soil and water contamination.

What is under way in Russia in terms of ecological changes due to climate change combined with poor management of natural resources is a "crisis," Shvidenko says. ESM researchers note that the development of an advanced unified ecological management policy, especially for Russia's northern regions, is critical. Given the rapid changes anticipated because of climate change, integrated observation systems that cover the entire circumpolar boreal forest biome should be developed to provide early warning of changes, and the researchers recommend the establishment of a system of protected territories, based on their fragile and vulnerable ecology, needs to be developed for high latitude territories.

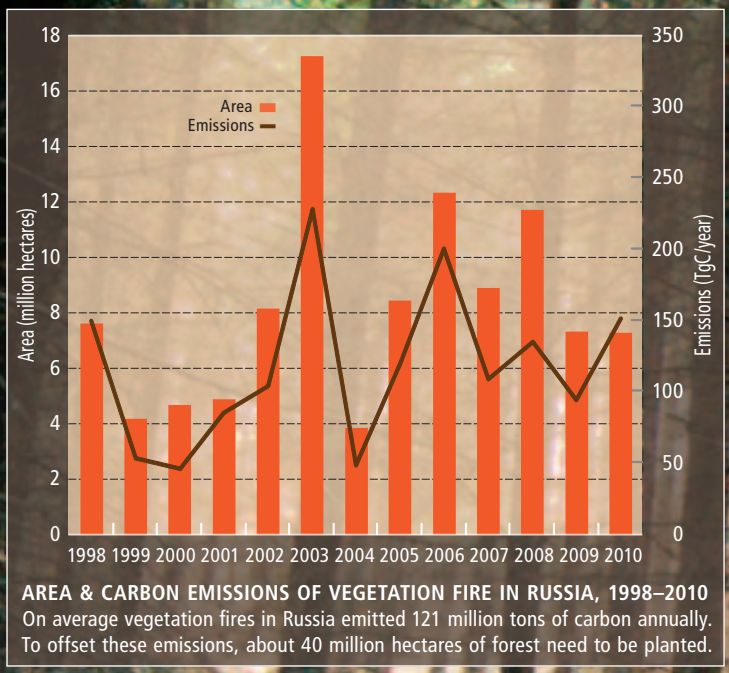
The ESM assessment shows that wild fires burned an average of 8.23 million hectares of Russian land and released 121 million tons of carbon to the atmosphere annually during the past 12 years, and the problem is expected to worsen over the next few decades. The Russian government needs to develop policies that have a clear emphasis on protecting the natural landscapes, particularly forests. The exploitation of forests and other natural resources in environmentally sensitive regions of Russia must be brought under control through a policy-based approach that recognizes the challenges caused by climate change.

Finally, the assessment notes, although there is widespread scientific agreement on the overall impacts of climate change, the uncertainties of estimates and predictions are high. Those uncertainties must be dealt with through better observation and data gathering, continued in-depth analyses, and recognition by policymakers that, despite the uncertainties, the need to set policies for biophysical, ecological, social, and economic issues arising out of climate change is urgent. ■

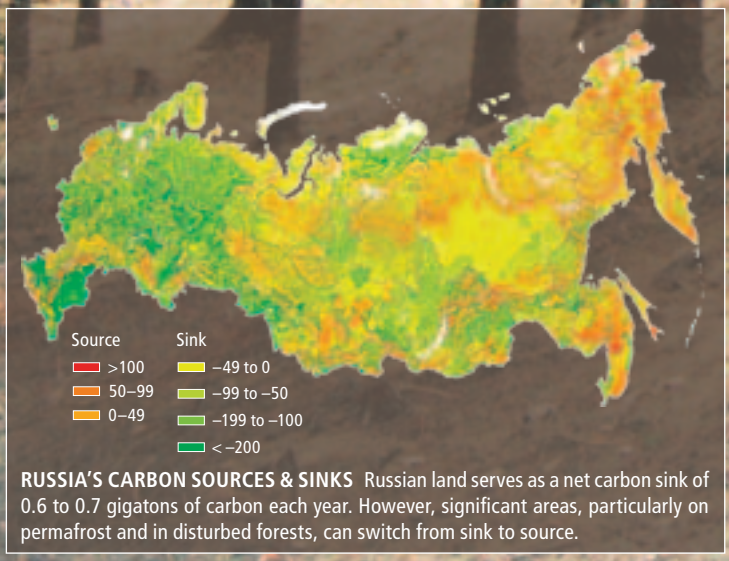
Further information Shvidenko A (2009). Terrestrial ecosystems in Northern Asia, global change and post Kyoto developments. In: *Resource Economics, Environmental Economics and Climate Change—2009*. Proceedings of International Conference, 1–7 July 2009, Siberian Federal University, Krasnoyarsk, Russia, pp. 665–678. Available at www.iiasa.ac.at/Research/FOR/forest_cdrom/Articles/Shvidenko_2009_Kyoto.pdf.

▪ Shvidenko A, Schepaschenko D, et al. (2011). Carbon Emissions from Forest Fires in Boreal Eurasia between 1998–2010. Conference Paper, The 5th International Wildland Fire Conference, 9–13 May 2011, Sun City, South Africa. Available at www.iiasa.ac.at/Research/FOR/forest_cdrom/Articles/Shvidenko_et_al_2011_Wildfire.pdf.

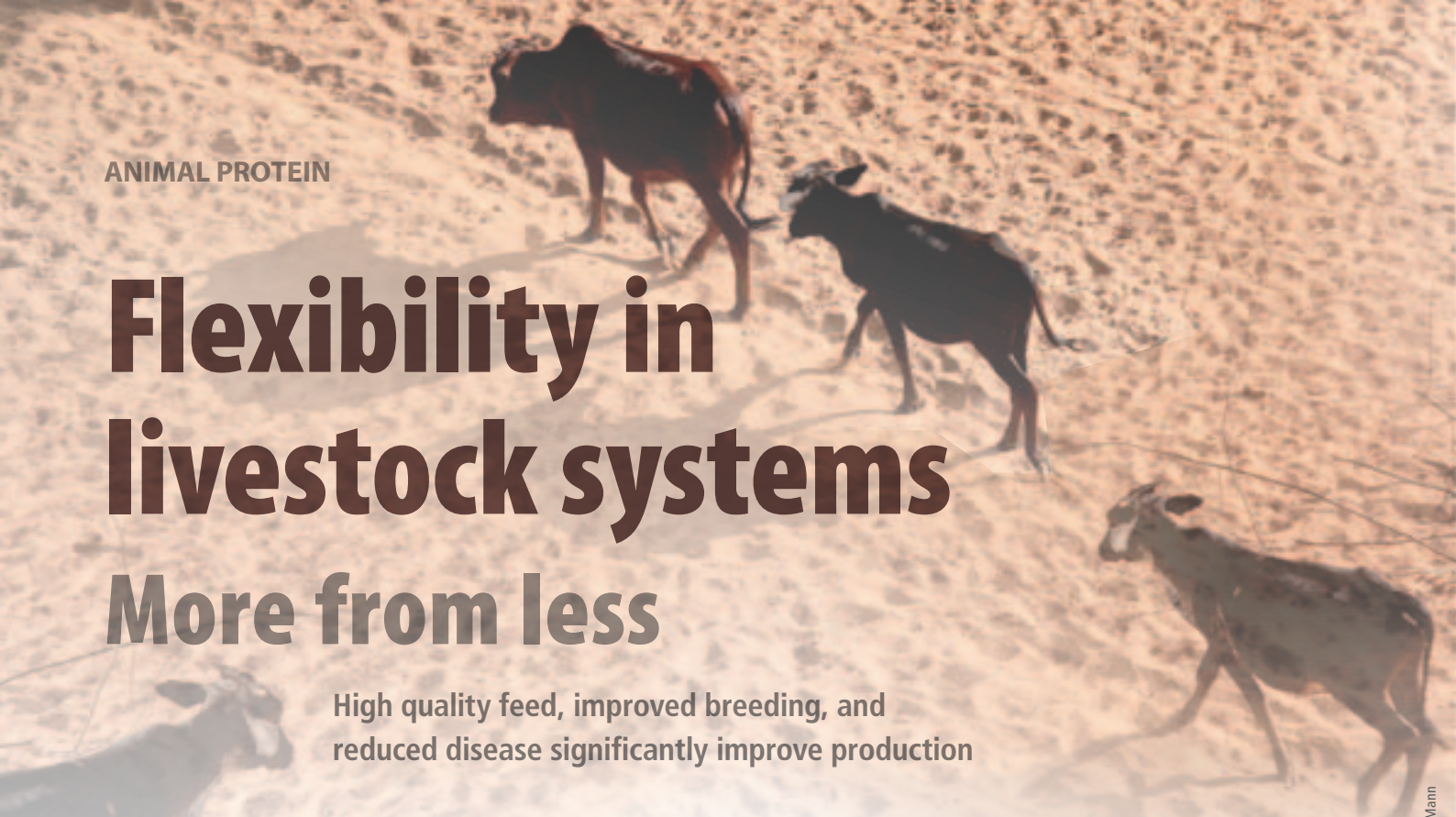
Prof. Anatoly Shvidenko is Acting Leader of IIASA's Ecosystems Services and Management Program. **Dr. Dmitry Shchepashchenko** is a Research Scholar with the same Program.



AREA & CARBON EMISSIONS OF VEGETATION FIRE IN RUSSIA, 1998–2010 On average vegetation fires in Russia emitted 121 million tons of carbon annually. To offset these emissions, about 40 million hectares of forest need to be planted.



RUSSIA'S CARBON SOURCES & SINKS Russian land serves as a net carbon sink of 0.6 to 0.7 gigatons of carbon each year. However, significant areas, particularly on permafrost and in disturbed forests, can switch from sink to source.



Flexibility in livestock systems

More from less

High quality feed, improved breeding, and reduced disease significantly improve production

With the demand for meat and other livestock-related food expected to grow by more than 50 percent over the next 20 years, finding the land and other resources to support additional animals in an increasingly crowded world will, under current production practices, mean more deforestation and higher prices both for livestock and crops.

But it is possible, according to new research based on IIASA's GLOBIOM model, to increase the amount of animal protein available for consumption while at the same time limiting the amount of land needed to raise more livestock and slowing the expected price increases.

In a partnership with the **Sustainable Livestock Futures Programme** at the International Livestock Research Institute (ILRI) in Nairobi, Kenya, IIASA researchers with the Ecosystems Services and Management Program found that allowing livestock production systems to freely adapt to future conditions by making investment capital more accessible can result in a 57 percent increase in livestock protein production with only 10 percent more animals. And this can be done on 1.3 percent less land than was being used for livestock production in 2000, the baseline year for the study.

That increased efficiency results from improvements in the way much livestock production is currently done, says IIASA agricultural economist Petr Havlik. Getting more productivity out of less land comes from using higher quality feeds, improving the breeding of the animals, and doing more to limit disease, he says. "One of the key factors in the productivity of any animal is disease," Havlik said. "In the developing world it is a serious problem because imagine what it means if you lose half of your herd every season. It means you have to double the size of your herd and feed twice as many animals because you know you're going to lose so many of them."

Livestock operations take up about 30 percent of land globally, and much agricultural land expansion, particularly land for pasture and for growing soybeans for livestock, comes at the expense of forests. That is especially true in tropical regions, Havlik said, and as a result livestock is a substantial contributor to climate change and biodiversity losses.

To understand the impact of future livestock production, IIASA researchers used GLOBIOM, a bottom-up model of the global agriculture and forest sectors. The researchers expanded the standard model with a module containing livestock production data, much of it provided by ILRI. Two scenarios were fed into the GLOBIOM; one allowing production systems to shift and adapt to future economic drivers, and the second locking livestock production into the systems as they were in 2000.

The model looked at different livestock production systems, including rangeland-based, mixed land fed by rain, mixed land irrigated, and urban. The land types were also categorized by climate, including arid, semi-arid, humid, temperate, and tropical. Feed types, such as crop residues, grains, and grass from grazing, were also entered. The livestock included buffalo, cattle, sheep, goats, pigs, and poultry.

"We developed a matrix of input and output parameters to define correctly every production system for every species involved in every region," Havlik said. "For the output we looked at the different productivities and feed ratios for each system."

The model found that in many regions if livestock production systems are allowed to switch to more intensive mixed production systems, as researchers describe them, then as breeding and feed types improve, the world's protein demands can be met with significantly fewer livestock resources. But the model also shows that some regions, such as many grass lands in Africa, won't sustain more efficient crops like soybeans and corn, so should be simply left for livestock grazing.

Although the research shows there is an efficient, resource-conserving path to high livestock production, following that path will be difficult, Havlik said. Beyond getting livestock producers to change practices that have been used for decades, changing production systems typically costs money.

"So if you look at the model and see that it is more efficient to be flexible in your production system, then you face the barrier of investment," Havlik said. "You realize it will be profitable in the long run, but if you don't have the money for the initial investment, or the payback is 10 or 20 years away, then it will never happen," he said.

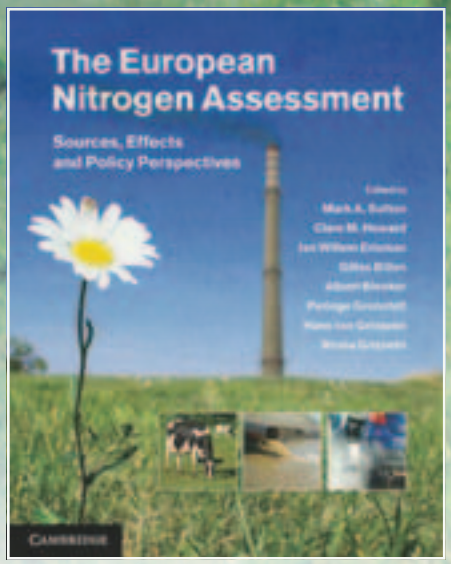
The research, he said, shows there is a way to move forward, "so now we're interested in the policies and how to overcome these barriers." That will require a study all of its own, he concluded. ■

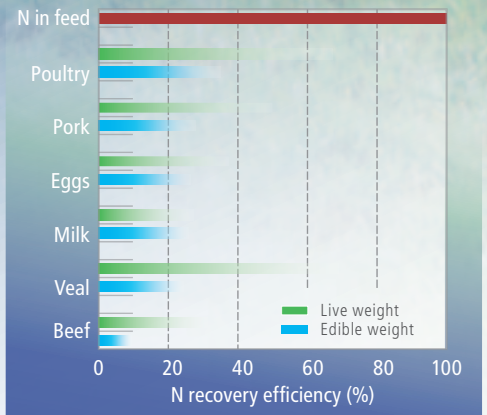
Further information Details on the GLOBIOM model and its use in the livestock research are available at www.iiasa.ac.at/Research/FOR/globiom/livestock.html.

Dr. Petr Havlik, an agricultural economist, is a Research Scholar with IIASA's Ecosystems Services and Management Program.

IIASA looks to the future in European Nitrogen Assessment

GAINS model shows rise in damaging agricultural nitrogen





RETAINED REACTIVE NITROGEN Fraction of reactive nitrogen in animal feed which is retained in animal tissue or edible animal products. Data from the European Nitrogen Assessment.

IIASA chemical engineer Wilfried Winiwarter received a call in the fall of 2008 inviting him to bring his expertise in atmospheric modeling to the European Nitrogen Assessment project. Three years later, he has just completed, as lead author, the assessment's chapter on future scenarios of nitrogen in Europe.

The landmark 600-page study, based on research by 200 European scientists, found that reactive nitrogen damages water, air and soil quality, causes harm to ecosystems and is a significant health threat to millions of people in Western Europe. Reactive nitrogen, a scarce resource in the natural environment, has been greatly increased by human activity, primarily the use of nitrogen-based fertilizer in agriculture.

The European Nitrogen Assessment found that excess nitrogen in the environment costs the European Union between €70 billion and €320 billion per year, more than double the value that nitrogen fertilizer use adds to European farm income.

Using IIASA's GAINS model in concert with other models, Winiwarter found that although reactive nitrogen emissions—mostly in the form of nitrogen oxides—from the transportation and industrial sectors can be reduced over the next few decades, the levels of damaging nitrogen being released by agriculture will continue to rise. Reactive nitrogen from agriculture includes ammonia, nitrate, and nitrous oxides.

"With agriculture there are always a large number of people who need to have their concerns addressed," Winiwarter says. "Efforts to change farming practices and reduce emissions will have to start with the large agro-industry farms where controls can have a substantial impact. Then you need to turn to the smaller farms." It may not be necessary to change practices for individuals operating small hobby or subsistence farms, he said.

Agricultural practices differ from country to country, as do environmental conditions, which makes controlling reactive nitrogen emissions even more challenging, Winiwarter maintains. "It matters," he says "whether you operate under summer temperatures of 30 or 20 °C (86 or 68 °F), and whether you have humid conditions or dry conditions. Temperature also affects soil chemistry and the evaporation of ammonia from manure and fertilizer."

According to Winiwarter's assessment, "agricultural nitrogen use is expected to remain the leading cause of nitrogen release to the environment, as options to reduce emissions are limited." Major changes in the use of nitrogen in agriculture will occur, he adds, only if the extent of agricultural production changes. This could be triggered by decreasing population numbers in Europe, but also requires agriculture to put less emphasis on maximizing output.

Because animal production and the cultivation of animal feed crops are responsible for high overall losses of nitrogen, Winiwarter says, changes in Europeans' dietary habits could be an alternative path to reducing reactive nitrogen. "Agricultural activity may decrease strongly if the European population adopts a healthier 'low meat' diet leading to lower nitrogen losses related to animal husbandry," he writes in the assessment. However, if agricultural land previously used for animal feed production is used to grow biofuel crops, nitrogen fertilizer may still be required, which means that the problem of reactive nitrogen emissions may continue.

For the immediate future, he says, "the nitrogen community is quite active in policy processes and there are many (involved in the assessment report) who will continue to work on the issue." The next revisions for the 1999 United Nations Gothenburg Protocol, which sets emission ceilings for nitrogen oxides, ammonia and several other pollutants "should take account of the nitrogen assessment work when defining measures to be taken in the future," he concludes. ■

Further information *The European Nitrogen Assessment*, published by Cambridge University Press, is available at www.nine-esf.org/ENA-Book. The assessment is the topic of a recent comment published in *Nature*; see www.nature.com/nature/journal/v472/n7342/abs/472159a.html.

Dr. Wilfried Winiwarter is a Research Scholar in IIASA's Mitigation of Air Pollution and Greenhouse Gases Program.

DEFORESTATION

Challenges for the Congo Basin forest

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Avoiding deforestation and forest degradation has an important role to play in strategies for reducing greenhouse gas emissions. As a result, the future of the Congo Basin rainforest—the second largest rainforest in the world—is of major concern. To date, the Congo Basin rainforest has experienced little of the large scale deforestation phenomenon experienced in other tropical regions. But population growth, increasing demands for food and energy, improving transport infrastructure, and greater exposure to international markets are likely to place greater pressure on this region's rainforest over the coming decades.

Under the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) launched in 2008, the international community commits to the transfer of money to developing countries which make efforts to reduce deforestation and improve forest management. Congo Basin countries have expressed a strong interest in REDD. Hence, in a recent project, IIASA researchers used GLOBIOM (Global Biomass Optimization Model) to explore some likely future deforestation scenarios and the potential impact of REDD on the region.

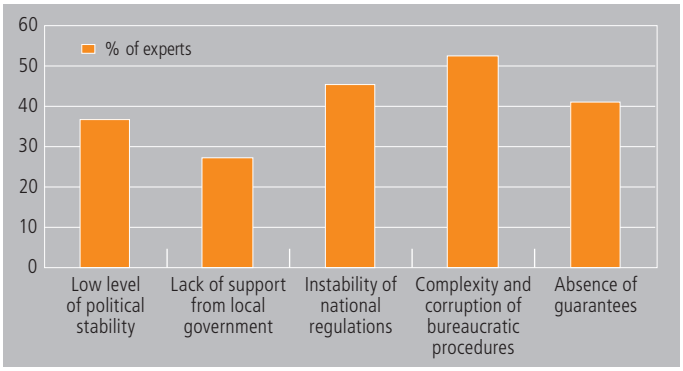
Findings show that the scenarios with the highest negative impact on forest cover in Congo Basin result from improvements in transport infrastructure—a scenario which could lead to a three-fold increase in deforestation. While a cap-and-trade approach has the potential to reduce significantly deforestation in the Congo basin, researchers warn that adopting this course would constrain the development of the country's agricultural sector, leading to increases in local food prices. Agricultural productivity growth would therefore be crucial to avoid the potentially adverse effects of limiting deforestation on Congo Basin development. ■

Further information Mosnier et al. (forthcoming). Modeling impacts of development trajectories on forest cover in the Congo Basin. Submitted to *Environmental and Resource Economics.*

Ms. Aline Mosnier is a Research Assistant in IIASA's Ecosystems Services and Management Program.

ENERGY

Barriers to renewable energy investment



BARRIERS TO INVESTMENT Experts were asked to identify what was preventing investment in renewable energy projects in North Africa.

While North Africa is a very promising location for the development of renewable energy sources (RES), especially for solar and off-shore wind, according to new IIASA research North African governments must take steps to reduce corruption and streamline bureaucratic procedures if they wish to attract foreign direct investment (FDI) to develop the region's renewable energy potential.

Scientific studies have demonstrated the technical feasibility of developing large-scale renewable energy projects in the Sahara Desert for import to Europe and local consumption. Estimates suggest that installations of concentrated solar power covering an insignificant part of the desert could meet all of Europe's and North Africa's power needs. Yet, while the involvement of private capital in RES projects at such scale is crucial to success, European FDI into the renewable energy sector in North Africa remains minimal compared to other regions.

Researchers set out to identify the barriers to private investment and the costs of these barriers in terms of investment volumes. In a survey of concentrated solar power experts, over half (52 percent) named complexity and corruption of bureaucratic procedures as a significant barrier to deployment of RES in North Africa (see figure). By corruption, experts mean nepotism, the expectation of hidden payments or gifts to officials, or long delays in bureaucratic procedures unless bribes are given. In a further survey, more than three-quarters of participants identified regulatory risk—defined as complexity or corruption relating to bureaucratic procedures—as a high level concern. The modeling of investment volumes showed that investors perceive bureaucratic corruption as a significant risk and therefore require much higher risk premiums for their capital.

Findings suggest that unless such barriers are addressed, investors may simply seek other regions for investment or the volumes of investment will be higher because of the costs of capital. "Given the region's singular potential for solar and wind development, this must be avoided," says IIASA's Nadejda Komendantova. ■

Further information Komendantova N & Patt A (2011). Could corruption pose a barrier to roll-out of renewable energy in North Africa? In: Transparency International, *Global Corruption Report: Climate Change*, Earthscan, London, UK.

Dr. Nadejda Komendantova is a Research Scholar and **Dr. Anthony Patt** is a Senior Research Scholar in IIASA's Risk, Policy and Vulnerability Program.

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BIOMASS

Making more of forest biomass

Interest in the utilization of forest biomass for energy production has grown rapidly because of its potential to mitigate increases in greenhouse gases and reduce dependence on fossil fuels. In British Columbia, the abundance of suitable biomass, especially from trees damaged by mountain pine beetle infestation, has highlighted the value of finding efficient ways to use biomass.

During current tree felling operations in British Columbia, branches and tree tops (known as "slash") are discarded in piles and burnt as waste, thus increasing CO_2 emissions to the atmosphere. In a recent project, IIASA researchers set out to evaluate the costs, CO_2 emissions, and energy balances associated with three potential systems for recovering and burning slash for energy purposes, for example, in combined heat and power stations.

Researchers based their study on the following three Nordic systems for slash recovery which, with adaptations, could suit conditions in British Columbia. In the *slash* system, unprocessed (loose) slash is transported by trucks to industrial sites, where it is pulverized into coarse chips of bark and wood, known as hog fuel. In the *hog fuel* system, the pounding and crushing takes place at the roadside near the logging site, and trucks then transport the hog fuel to industrial sites. In the *bundle* system, slash is compressed near the logging site, and the resulting bundles are transported by trucks to industrial sites, where they are pulverized into hog fuel.

"Findings indicate that the hog fuel system is the cheapest, per unit of delivered biomass, whereas the bundle system is the most expensive system when transportation distances are short (less than 100 km). The slash system is the most expensive when transportation distances exceed 100 km," concludes IIASA's Ola Lindroos. ■

Further information Lindroos O, Nilsson B, Sowlati T (2011). Costs, CO_2 emissions, and energy balances of applying Nordic slash recovery methods in British Columbia. *Western Journal of Applied Forestry*, 26(1):30–36.

Dr. Ola Lindroos is Research Scholar in IIASA's Ecosystems Services and Management Program.

Photo © Diego Vito Cervo | Dreamstime.com

POPULATION STATISTICS

Stereotyping underlies statistics

While the accuracy of official data on birth and death rates is often taken for granted, stereotypes regarding who is likely to die a particular kind of death are coloring U.S. official statistics, a new IIASA study suggests.

"While previous research has demonstrated inconsistencies in racial vital statistics, the processes creating these discrepancies are not well understood," explains IIASA's Andrew Noymer. "We investigated whether seemingly non-racial characteristics of individuals, such as their cause of death, affect how they are perceived racially by others."

Findings demonstrate that otherwise similar Americans whose underlying cause of death was chronic liver disease or cirrhosis were more likely to be classified on their death certificate as American Indian than Americans who died of other causes—even if they were not classified as American Indian by their next of kin in a subsequent survey. A similar pattern exists between dying of homicide and the likelihood of being classified as Black.

"Our findings suggest that the racial information recorded in vital statistics may be affected by the same kinds of social processes that shape racial classification more broadly," Noymer points out. "Research shows that changes in how people are racially classified over their lifetime are related to changes in social status that conform to widely held racial stereotypes. Just as Americans are less likely to be seen as white by a survey interviewer after they have been incarcerated, unemployed, or fallen into poverty, we conclude that stereotypes about who is likely to die a particular kind of death may shape U.S. official vital statistics." ■

Further information Noymer A, Penner AM, Saperstein A (2011). Cause of death affects racial classification on death certificates. *PLoS ONE* 6(1).

Dr. Andrew Noymer is a Research Scholar in IIASA's World Population Program.

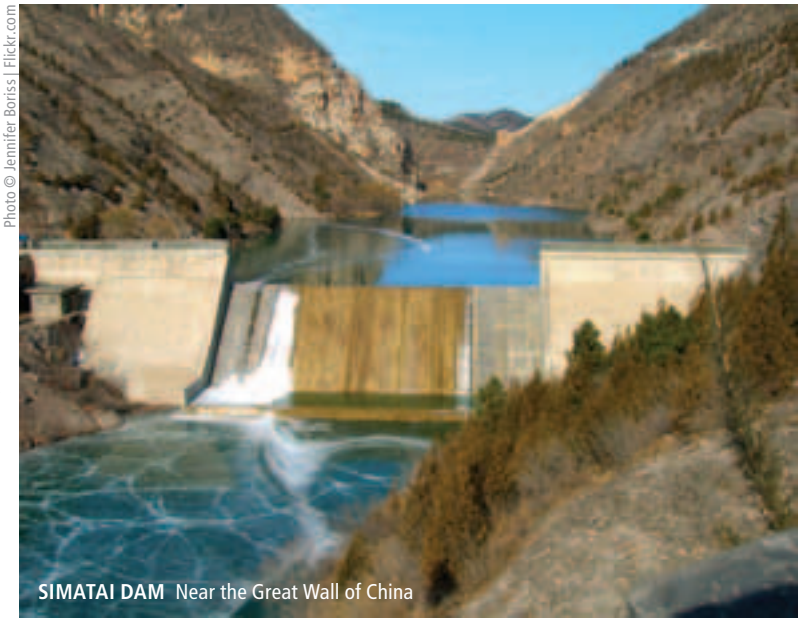


Photo © Jennifer Boriss | Flickr.com

SIMATAI DAM Near the Great Wall of China

WATER MANAGEMENT

New methods for managing water resources

Beijing is one of the world's ten largest cities and faces serious water shortages. Despite declining industrial, agricultural, domestic, and ecological water consumption, Beijing's water use still greatly exceeds the available water resources.

Based on a method known as ecological network analysis, IIASA ecologist Brian Fath collaborated with researchers from Beijing Normal University's School of the Environment to explore Beijing's urban water metabolic system. The objective was to solve the serious water shortage problem and relieve conflicts between development of the urban economy and the available water resource. As Fath explains, "We analyzed the supply and demand components of urban water metabolism as a means to identify bottlenecks in the ability of the available water resources to support urban development, and to reveal possible ways to rationalize the utilization of Beijing's water resources."

The comprehensive analysis highlights possibilities for improvement. "To ensure that water supplies stabilize or increase, the rainwater collection and recycling components of the system must continue to improve, and water consumption by the industrial, agricultural, and domestic sectors must continue to decrease, perhaps by increasing reuse and recycling of water," argues Fath. Simply stabilizing water consumption will not be enough, as the declining water table in the study area suggests that water continues to be used unsustainably and that measures must be taken to allow the recharge of this water resource.

"This model provides a useful means of analyzing the main components of the system and their functional relationships," Fath points out. "In the future, the model should be further improved to provide a more precise simulation of the complexity of real urban water systems." ■

Further information Zhang Y, Yang Z, Fath BD (2010). Ecological network analysis of an urban water metabolic system: Model development, and a case study for Beijing. *Science of the Total Environment*, 408(20):4702–4711.

Prof. Brian Fath is a Research Scholar in IIASA's Dynamic Systems Program, Associate Professor at Towson University, USA, and Deputy Director of the Low Carbon Research Center in the Beijing Development Area.


Photo © Jialiang Gao | www.peace-on-earth.org

AGRICULTURE

Changing climate for Chinese agriculture

How can agricultural productivity in China be increased without damaging the environment? This is one of the questions addressed in the European Commission's recent Chinese Agricultural Transition: Trade, Social and Environmental Impacts (CATSEI) project. Contributing to this project, IIASA researchers explored how climate change may affect agriculture in China for two different time periods, the 2050s and 2080s, as well as the implications of attempts to boost agricultural productivity for the environment.

Researchers developed climate change scenarios to estimate potential effects on crop yields, land cultivation potential, and the number and type of crop combinations that can be cultivated. Findings indicate that climate change will require a substantial adaptation of cropping systems in China, with crop production potential likely to shift to China's northern regions. Crop water requirements are projected to increase 10 percent or more by 2050 although, as researchers point out, there is already a high risk of increasing water scarcity due to climate change.

Overall, the demands of a growing population, rapid urbanization, rising incomes, and changing consumption preferences will, researchers argue, stimulate the intensification of agricultural land use and livestock production. Pollution of the atmosphere, water, and soil resources by residues of intensive crop and livestock production is already a serious environmental issue in China. Researchers conclude that without appropriate measures—such as steps to reduce ammonia emissions resulting from livestock production—the severity of the trend will only continue and may even become irreversible in some areas. ■

Further information Fischer G et al. (2011). Agriculture, Food and Water: Environmental Impacts and Linkages. Report for the Chinese Agricultural Transition: Trade, Social and Environmental Impacts (CATSEI) Project.

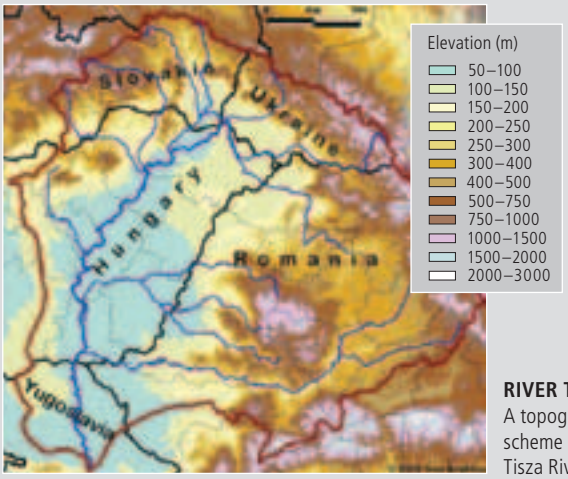
Dipl. Ing. Günther Fischer is a Senior Scientist in IIASA's Ecosystems Services and Management Program.

ECOLOGY

Lessons for river management policy

Repeated failures of conventional management policies to handle a series of recent floods on Hungary's Tisza River have brought calls for changes to the river management policy. New IIASA research examines why the transition to a better management policy for the Tisza River has currently stalled.

Hungary's Tisza River experiences some of the most sudden and extreme (up to 12 m) water level fluctuations in Europe (see map). The urgency of this situation has led to increased public participation in the water policy debate, including demands for more experimentation with alternative river management policies. But, as IIASA's Jan Sendzimir points out: "In river basins, transformation from traditions of reactive flood defense to more adaptive management regimes is difficult. Transformation may require profound shifts in the institutions, technologies, and personnel as well as the ecological, economic, and social processes they influence in setting the basin's trajectory."



Map © 2002 Ivan Kruhlov

RIVER TISZA
A topographic scheme of the Tisza River basin

After exploring the bridges and barriers to the formulation and sustained implementation of adaptive policies for the Tisza River, researchers conclude that governance, learning, and information management are important bridging factors. "Governance and learning opened the door to new ideas, but neither was sustained sufficiently by consistent leadership to secure transformation," Sendzimir concludes. "Ultimately, we found that new ideas may become established, but sometimes the older ideas reestablish their previous dominance. This illustrates how policy and ideas can evolve more in a spiral than a straight line as they focus and refocus among contending paradigms championed by different coalitions through formal and informal processes." ■

Further information Sendzimir J, Flachner Z, Pahl-Wostl C & Knieper C (2010). Stalled regime transition in the upper Tisza River Basin: The dynamics of linked action situations. *Environmental Science and Policy*, 13: 604–619.

Dr. Jan Sendzimir is a Research Scholar in IIASA's Risk, Policy and Vulnerability Program.

CLIMATE CHANGE

Finland to feel climate benefits

Climate change is likely to have a more favorable impact on Finland than on other countries that border the Arctic, according to IIASA research.

Far-reaching and multi-faceted changes are taking place in the Arctic region. In a recent review commissioned by the Prime Minister's Office of Finland, researchers set out to investigate these changes including the effects of climate change and likely climate abatement policies on Northern Europe and the Arctic Sea area, with a special emphasis on Finland.

Findings reveal several positive opportunities of climate change for Finland, albeit with some potentially adverse consequences. For example, climate change will open new opportunities for Finnish agriculture. A warmer climate will extend the thermal growing season and allow for a substantial expansion of cultivable areas to include commonly grown major and minor crops, as well as increasing the yield of major field crops.

Evidence further suggests that the growth and productivity of forests will accelerate. Climate change and optimal forest management could increase the amount of carbon in Finnish forests by up to one-third, as growing conditions will be more favorable, particularly for deciduous trees. However, forest damage caused by insects is expected to spread further northward; timber felling conditions will become more hazardous; and the forest fire potential is expected to increase.

Researchers conclude that future socioeconomic developments in the Arctic region will depend on the effectiveness of state policies and on adaptation and mitigation programs. In Finland, however, sustainable development policies and programs are already well developed and being successfully implemented. ■

Further information Shvidenko A et al. (2011). The effects of climate change and abatement policies on the value of natural resources in Northern Europe and in the Arctic Sea area. *Finland Prime Minister's Office Reports* 1/2011 (18 January 2011).

Prof. Anatoly Shvidenko is Acting Leader of IIASA's Ecosystems Services and Management Program.

The reliability of land cover information derived from satellite-based Earth observation can now be compared and validated with the help of the global community and a new Web tool:

Geo-Wiki

Satellite-based Earth observation is an important source of baseline information when developing global models of land-use and land use change. The accuracy of these models and the outputs generated from them are coming under increasing scrutiny as nations commit to specific land cover related targets, such as those for food production, biodiversity protection, or carbon storage potential.

The past 10 years have seen a growth in the number and sophistication of satellite-based Earth observation tools designed specifically to classify land cover. Chief among these are GlobCover (European Space Agency), GLC-2000 (the Joint Research Center of the European Commission—JRC EC), and MODIS (NASA). However, while the amount of data collected has grown and the spatial resolution of the information has improved, when comparisons are made across these datasets there is a significant amount of "disagreement," in either the individual land classes or in the spatial distribution of the land cover. These disagreements can be caused by the different methodologies used to classify land cover, the type of satellite sensors used, or geo-referencing errors.

One option for improving the accuracy of the data is through the use of crowd-sourcing—the collection of land cover information by people on the ground or through the internet, via a Web-based tool called Geo-Wiki.org. Developed by IIASA, the University of Applied Sciences Wiener Neustadt, and the University of Freiburg, Geo-Wiki.org uses Google Earth as the delivery platform and crowd-sourcing as the mechanism for collecting and verifying land cover data. Crowd-sourcing leverages the immense power of Web technologies to capture data from a large and undefined group of people.

"In the case of Geo-Wiki, when a volunteer registers, information is collected on where they live, their local knowledge and education level. They are asked to review locations—or "hotspots"—where data are missing or where there is disagreement over the land cover," explains IIASA's Steffen Fritz, team leader of the Geo-Wiki project. "The data they input are then checked by the Geo-Wiki development team to ensure they meet certain standards. Volunteers can also submit photographs of the location to help in the validation of the land cover."

"After a process of data validation the information recorded in Geo-Wiki.org is freely available for researchers, decision makers, or land managers anywhere in the world to access and create their own land cover maps."

Geo-Wiki can also bring information from multiple sources together into one hybrid global land cover map, making it easier to compare information and enabling, for the first time, coordinated validation of land cover information. The result is more accurate land cover information than any current individual product can provide. The Geo-Wiki team estimates that the accuracy of land cover maps can be increased by up to 20 percent compared to current sources. Importantly, Geo-Wiki can be used to identify inconsistencies between satellite data and critical data such as those reported by member countries to the Food and Agriculture Organization of the United Nations.

Application

- The JRC EC is using Geo-Wiki to produce maps of cropland in Africa.
- The National Oceanic and Atmospheric Administration are also encouraging the use of Geo-Wiki among school age groups by using the Globe network as a mechanism for learning about the environment.
- IIASA hosted a workshop in June 2011 with 60 technical experts from Africa using Geo-Wiki.org to visualize cropland maps in Africa and estimate uncertainties in the current data.

All validation points are freely available to the research community for use in the validation and calibration of their own data.

Involving the community

Interest in Geo-Wiki.org is growing and the number of volunteers has grown, with over 12,000 validations now complete. To maximize the value of Geo-Wiki the developers are encouraging people to get involved, one novel approach is the development of games, or 'gamification' of Geo-Wiki, as undertaken by IIASA and the Technical University of Vienna.

In a similar way to the bird-watching "ebird project" which has some 48 million records of bird sightings across the globe, the value of Geo-Wiki will be realized through the involvement of the global community. ■

Further information Geo-Wiki Web site at www.geo-wiki.org ▪ The Globe Program and Geo-Wiki at globe.gov/events/climate-land-cover

Dr. Steffen Fritz is a Research Scholar in IIASA's Ecosystems Services and Management Program.

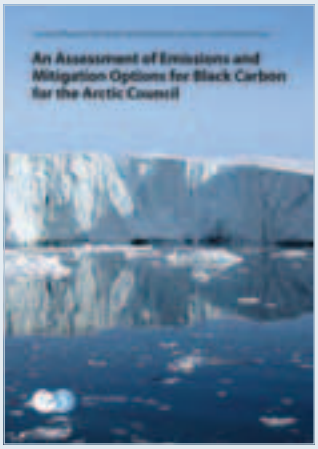
publications

IIASA's online publications catalog is available at www.iiasa.ac.at/Publications

The emissions gap report

Climate change represents one of the greatest challenges, as well as a major opportunity to catalyze the transition to a low-carbon, resource-efficient green economy. Taking as its point of departure the pledges associated with the Copenhagen Accord of 2009, this report informs governments and the wider community as to how much we have progressed over the past 12 months in our response to climate change. It poses questions such as: What might be achieved in terms of limiting a global temperature rise to 2°C or less in the 21st century? And what remains to be done—what is the gap between scientific reality and nations' current level of ambition?

Riahi K, Wagner F (Contributors) (2010). *The Emissions Gap Report: Are the Copenhagen Accord Pledges Sufficient to Limit Global Warming to 2°C or 1.5°C?* UNEP.



Black carbon in the Arctic

An Assessment of Emissions and Mitigation Options for Black Carbon (BC) estimates BC emissions, trends, and mitigation potential to 2030 from all Arctic Council Nations. The new report was presented at the Arctic Council Ministerial Meeting in May 2011. IIASA GAINS is one of two models underpinning the study.

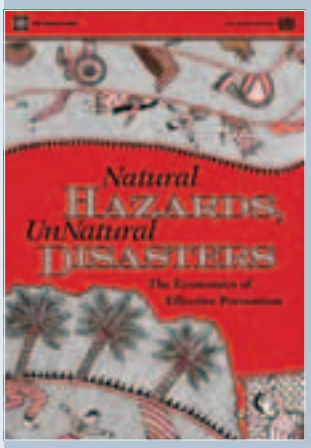
Klimont Z, Kupiainen K (Contributors) (2011). *An Assessment of Emissions and Mitigation Options for Black Carbon for the Arctic Council.* Technical Report of the Arctic Council Task Force on Short-Lived Climate Forcers.

IPCC special report on renewable energy

Over 120 researchers working with the Intergovernmental Panel on Climate Change (IPCC) demonstrate the potential of renewable energy in this new special report. Close to 80 percent of the world's energy supply could be met by renewables by mid-century if backed by the right enabling public policies the report shows.

Krey V, Riahi K, Nagai Y (Contributors) (2011). Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Forthcoming



Natural hazards, unnatural disasters

Earthquakes, droughts, floods, and storms are natural hazards. Unnatural disasters are the deaths and damages that result from human acts of omission and commission. Every disaster is unique, but each exposes actions by individuals and different levels of governments that, had they been different, could have resulted in fewer deaths and less damage. Prevention is possible, but this book examines what it takes to do it cost-effectively. IIASA researchers contributed three background papers to this World Bank report that has been described as "remarkable," "fascinating," and "excellent" by six Economics Nobel Prize winners.

Bayer J, Hochrainer S, Mechler R (Contributors) (2010). *Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention.* The World Bank.

Energy security

At the regional or national level, energy security is often viewed from a political or economic perspective. In a chapter in this new handbook on energy security, IIASA's Shonali Pachauri argues for the need to view it from the household perspective as well. She puts forward a range of indicators from access to modern energy to multiple fuel use by households as a means of measuring and monitoring energy security for households in India. The handbook aims to broaden discussions of energy security, including its definition, dimensions, ways of measuring and indexing it, and the complicating factors that are often overlooked.

Pachauri S (2011). The energy poverty dimension of energy security. In: B.K. Sovacool (ed.), *The Routledge Handbook of Energy Security.* Taylor & Francis Group, London, UK, pp. 191–204.

greening

2,800 trees offset IIASA's business travel emissions

IIASA is offsetting the carbon emissions from travel of staff and associates. Last year, our 650 business trips amounted to 645 tons CO_2, more than one-fifth of IIASA's annual total emissions. These travel emissions are offset by certified carbon credits: The Kikonda Forestation Project in Uganda won prizes for its high positive impact on ecology and the local community. About 2,800 trees will now be taken care of on behalf of IIASA, adding to the 25 hectares of rainforest bought the year before. As a rule of thumb, for every trip from Vienna to nearby cities such as Berlin one tree is planted. Trips to Washington DC or Delhi are offset by 10 trees, and travel to Japan, Australia, or South America requires 20 each.

IIASA's Carbon Footprint Initiative | Jens Borken-Kleefeld

Plugging communication gaps

According to IIASA postdoctoral fellow Upasna Sharma, improving adaptive capacity to climate change in India is a priority

Upasna Sharma received her PhD from the School of Management at the Indian Institute of Technology, Bombay. Her thesis was on 'Enhancing adaptive capacity to climate risk'. Since 2002, she has worked on issues related to impacts, vulnerability, and adaptation to climate change and natural hazards, as well as on key issues in climate change negotiations under the United Nations Framework Convention on Climate Change. She joined IIASA as a postdoctoral researcher in 2009.

- Sharma U, Scolobig A (forthcoming). The interplay of science and policy in landslide risk assessment: Insights from India and Italy.
- Sharma U, Patt A (forthcoming). Disaster warning response: The effects of different types of personal experience.

The challenges that India and many other developing nations face will be a big part of my research agenda, wherever I may be based. For some years, this has centered on "adaptive capacity"—the ability to respond positively to climate hazards. While at IIASA, I will be producing three scientific papers on related topics.

The first one on hazard early-warning systems, aims to enhance understanding from a policy perspective, of specific factors that affect the warning-response process in the context of tropical cyclone warnings in India. Some of the important factors included are communication of the uncertainty in the forecast, hazard experience, and levels of decision making. This is an important issue, as warning systems can affect risk perception and hence how people respond to the climate hazard.

My IIASA research is a natural extension of my PhD work at the Indian Institute of Technology, Bombay. This research used both qualitative and qualitative methods: the former for an exploratory case-study in the context of a cyclone that had crossed the coast of Krishna district in Andhra Pradesh in 2003; the latter for large sample survey in the context of cyclones "Fanoos" and "Ogni" that crossed the Indian east coast in 2005 and 2006, respectively. Many new factors emerged from the research; at IIASA I continue to work on refining understanding and learning about some of the most important.

My second IIASA paper is on the role of targeted human and social development—an important approach to adaptation to climate change in the academic discourse—in enhancing adaptive capacity to climate risk. I am researching whether the level of education has a bearing on an improved ability to respond to current climate risks, for example, tropical cyclone hazard.

The link between human and social development and reduction of vulnerability to climate risk is not as linear and simple as it first would seem. For example, while the goal of universal education may lead to enhancing capacity in a generic sense, it may be simplistic to assume that achievement of this goal would automatically lead to enhanced ability to respond to climate risk in a specific manner, for example, by taking appropriate action to avoid the risk of tropical cyclones. Thus, this topic is important not only in terms of scholarship, but also because it has practical implications for allocation of financial resources across the many adaptation activities.

The third paper is based on my contribution to the EU FP7-funded project on "SafeLand—Living with landslide risk in Europe: Assessment: Effects of global change, and risk management strategies." For this project I conducted a case-study on "Landslide risk management in India: Interfaces between legislation, policy, and science" which is one of the five national case-studies (France, India, Italy, Norway, Romania) studied by this project.

In January this year I organized and coordinated a workshop in collaboration with Technology Information Forecasting and Assessment Council (TIFAC) and Sardar Patel Institute of Economic and Social Research (SPIESR), which aimed to enhance interaction and collaboration between relevant Indian scientists and IIASA researchers. I am also coordinating and contributing to a project on disaster micro-insurance in South Asia, in collaboration with an Indian partner, that grew out of this workshop. The workshop and follow-ups have enhanced interaction and collaboration between Indian scientists and IIASA researchers working in this field. ■

capacity building

Bridging troubled waters

IIASA guest research scholar Masoud Yazdanpanah says a new framework for water management is needed in Iran

For over a decade, Iran has been faced with a water crisis so severe that the government has been forced to accept foreign aid for only the second time since the 1979 revolution. The crisis, exacerbated by severe droughts in 2008 and 2009 and high population growth rates, has resulted in much of Iran's land ceasing to be productive. Though a wide range of potential solutions have been implemented, there has been no conceptual framework in place to guide them toward fruition; and subsequent policies have at best been passive and haphazard.

In 2010 I spent six months at IIASA analyzing the concepts of "reflexive modernization" and "cultural theory" put forward, respectively, by German sociologist Ulrich Beck and British anthropologist, Mary Douglas. Second modernity and cultural theory are now well established internationally as a systematic way of dealing with the hazards and insecurities caused by modernization itself. As my own research focus is on environmental sociology and socio-political theory at the policymaking and individual levels, I found a great deal to commend "second modernity," and "cultural theory," with their emphasis on multiple stakeholders and multiple perspectives in decision making, and thus on participatory rather than just hierarchical action. I concluded that it could well provide the conceptual framework needed for water management not just in Iran, but in other countries faced with water crisis and drought.

"First modernity" dates back to the 1962 "White Revolution" with its Western-style goals of industrialization, urbanization, and mastery of nature. The arid regions of Iran, it was assumed, could be industrialized by building dams, pumping out groundwater, and constructing canals to bring water from remote sources to "make the desert bloom." However, over the past four decades, Iranian farmers and others close to the land have watched water tables drop, as one well after another has dried up and formerly fertile lands have become unproductive. Compare this with pre-modernity days, when water management was hard-wired into the socio-ethical-cultural system of Iran. The Persians invented the *qanat* or chain-well system, an engineering wonder through which the inhabitants "sustainably" managed their water resources for millennia, enabling them to survive and prosper without taking more water each year than they received. Traditionally, a least, nature was not the neutral and infinite provider that first modernity believed it to be.

Espousing second modernity, in Iran or elsewhere, would mean increasing the potential of local people to influence and control their future on a long-term basis. Being empowered to participate in so-called sub-political activities, would enhance stakeholders' capacity to conserve the ecological functions of water, increase value generation in terms of goods and services, and attain sustainable development, particularly in rural areas.

The government of Iran has attached the highest priority to its participatory water management program, launched with the goal of involving local communities in the management of water resources. However, the lack of a suitable framework has been a serious constraint to success, which I believe the values enshrined in second modernity and cultural theory could do much to address. ■

Masoud Yazdanpanah

is a PhD student of agricultural extension and education at Shiraz University in Iran. He works on projects related to drought management, rural development, and sustainable fisheries, and teaches courses on agricultural extension, environmental sociology, and qualitative and quantitative research methods. He joined IIASA's Risk and Vulnerability (RAV) Program in June 2010 as a Guest Research Scholar.

Yazdanpanah M, Hayati, D, Zamani H, Karbalaee, F (forthcoming). Exploring reflexive modernity as the basis of a new sustainable water management paradigm.


Dr. Arkady Kryazhimskiy

The Russian Academy of Sciences, its Steklov Mathematical Institute, IIASA, and Lomonosov Moscow State University partnered to host

EGMD 2011

"Economic Growth: Mathematical Dimensions" — the international winter school for graduate students in economics and applied mathematics


Dr. Sergey Aseev

Russian novelist and essayist Leo Tolstoy wrote that mathematicians find pleasure not in discovering truth but in seeking it. The 50 international students who traveled to Moscow in January–February to attend the International Winter School on "Economic Growth: Mathematical Dimensions—2011" (EGMD) at Lomonosov Moscow State University definitely seemed to agree with the great man. Studying the phenomenon of endogenous economic growth from the perspective of formal mathematical analysis made for an exciting week for the graduate students. Exciting, because a course with such renowned speakers handling such significant subject matter is a rarity on the international academic circuit.

According to IIASA's Arkady Kryazhimskiy who was scientific supervisor of the Winter School, you could feel the enthusiasm in the air. It was a "meeting of like-minded people," he says. "The students were thrilled to meet each other, especially because international links in this field are still undeveloped. Plus, most of the non-Russian students—from Germany, Italy, Singapore, Romania, Kazakhstan, Azerbaijan, Serbia, and others—were in Moscow for the first time and enjoyed learning about the city."

IIASA's Russian National Member Organization, the Russian Academy of Sciences, through its Steklov Institute of Mathematics, helped fund and organize the event, with more financial support coming from the Russian Foundation for Basic Research, the philanthropic organization "Volnoe Delo," and students' fees. The organizational linchpin was Arkady Kryazhimskiy himself. Leader of the Advanced Systems Analysis Program at IIASA, Dr. Kryazhimskiy has been Principal Research Scholar at the Steklov Institute since 1996 and in the following year was elected to the Russian Academy of Sciences.

IIASA scholar, Elena Rovenskaya, who teaches econometrics at Lomonosov and is Executive Director of EGMD, carried out coordination activities between the Moscow University and IIASA. She says the course topics were partially based on scientific research activities conducted within the Advanced Systems Analysis Program at IIASA. For instance, IIASA's Sergey Aseev, who divides his time between IIASA and the Steklov Institute, lectured on the application of Pontryagin's maximum principle in growth theory. Brian Fath of Towson University, USA, who visits IIASA each summer for three months and works both in the Advanced Systems Analysis Program and Young Scientists Summer Program (YSSP), lectured on Economic Dynamics of the Complex System Cycle. Thomas Weber of Stanford University (YSSP 2001) taught Dynamic Games and Economic Growth

The timetable was strenuous with eight hours of work each day: four hours of lectures and four of discussions. Yet there was still time for cultural events. A three-hour sightseeing bus tour to see Red Square, the Kremlin, Arbat Street, Novodevichiy monastery, Vorobievy Gory, and Viktory Park was somehow slotted into the academic agenda; students and professors were invited for dinner by the Steklov Institute to a typically Russian-cuisine restaurant, and there was always Moscow's vibrant night life to enjoy, as long as you could get into the lecture theater by 9 a.m. the morning after.

Students also found time to get together to make a short animated film, complete with equations, of their studies in Moscow. It can be seen on YouTube: www.youtube.com/watch?v=MSdynp2PIEc.

This was the summer school for graduate students in economics and applied mathematics, the first having taken place at Moscow State University 5–26 July 2009. With over 9,300 hits to IIASA's EGMD page, there may well have to be a third. ■

Further information See IIASA's EGMD Web site at: www.iiasa.ac.at/Research/DYN/indexcapacitybldg_feb11.html.

Dr. Arkady Kryazhimskiy, Leader of IIASA's Advanced Systems Analysis Program, was scientific supervisor of EGMD.

Dorsamy (Gansen) Pillay

**Vice President and Managing Director,
Research and Innovation Support and Advancement (RISA),
National Research Foundation (NRF) of South Africa (SA)**

"Researchers by their very nature are passionate and demanding and need to be heard," says Dorsamy (Gansen) Pillay, the member of IIASA's Governing Council representing South Africa (SA).

As Pillay's daily routine shows, the demands of his position as Vice President and Managing Director of the South African National Research Foundation (NRF) draw on every fiber of his being. Formerly a university research professor in microbiology and molecular biology, he now "vigorously champions" the cause of researchers at national level. "I take comfort," he says, "from the fact that our Corporate Executive team contributes to strategically shaping the research agenda of SA."

To refer to what he does as work, however, is a misnomer. "I have never 'worked' in my life!" he jokes. "I go to work each day to enjoy myself and to be driven by the multiplicity of challenges facing our country."

South Africa decided to join IIASA, he says, to ensure that developing countries are consulted and included in shaping the global agendas related to IIASA's research. Having witnessed for himself the benefits of internationalization, membership of IIASA was a natural evolution. "SA has the largest, most diverse economy on the African continent and a lot to offer the IIASA family," states Pillay.

The scope and depth of IIASA's South African National Member Organization is impressive, as shown by the seven directorates that Pillay leads, supported by Executive Directors: (i) Knowledge Fields Development; (ii) Human and Institutional Capacity Development; (iii) Knowledge Management and Evaluation; (iv) International Relations and Cooperation; (v) Applied Research and Innovation; (vi) Grants Management and Systems Administration; and (vii) the South African Agency for Science and Technology Advancement. "More than enough to keep anyone busy!" he says.

A critical component of his task is human capital development—training the next generation of researchers for SA and the African continent with a focus on developing research funding at SA's 23 universities plus its Science Councils and National Research facilities. Not surprisingly, SA lobbies hard for the expansion of human capacity development programs at IIASA.

Pillay is also charged with ensuring the integrity and robustness of the peer-review systems used to assess research proposals, as well as for the evaluation and rating of individual researchers. There are 2,145 NRF-rated researchers in the country.

However, Pillay's greatest passion is the training of students—"fresh minds which challenge you, bring to the table new and different ideas, and keep you honest. It is something that keeps my sanity, and I take every opportunity to address and motivate students. After all, research is the quest for truth. IIASA is attractive to me because of the excellent research that lies at its heart." ■

A day in the life of the Vice President and MD

04h30 Wake up, if not earlier (sleep apnea problem).

05h00 Gymnasium for stretching and aerobic exercise.

06h15 Shower, read world news on *News24.com*, light breakfast.

07h15 At work respond to E-mails, finalize programme for the day.

08h15 Briefing with PA and signing of documents (requisitions, financial authorizations, etc.).

08h30 No two days are the same! The day could revolve around Board, Corporate Executive, Executive Evaluation Committee or RISA Executive meetings; meetings with the Department of Science and Technology, workshop openings, keynote addresses, appointments with various external stakeholders (e.g., embassies), universities…

16h30 Meet PA for document signature, review the diary for the next day and rest of the week.

18h30 Return home. Watch the news on TV, listen to music, dinner, and entertain friends.

21h30 Prepare for meetings, respond to E-mails, read documentation, etc.

23h30 Sleep.

Save the Date

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