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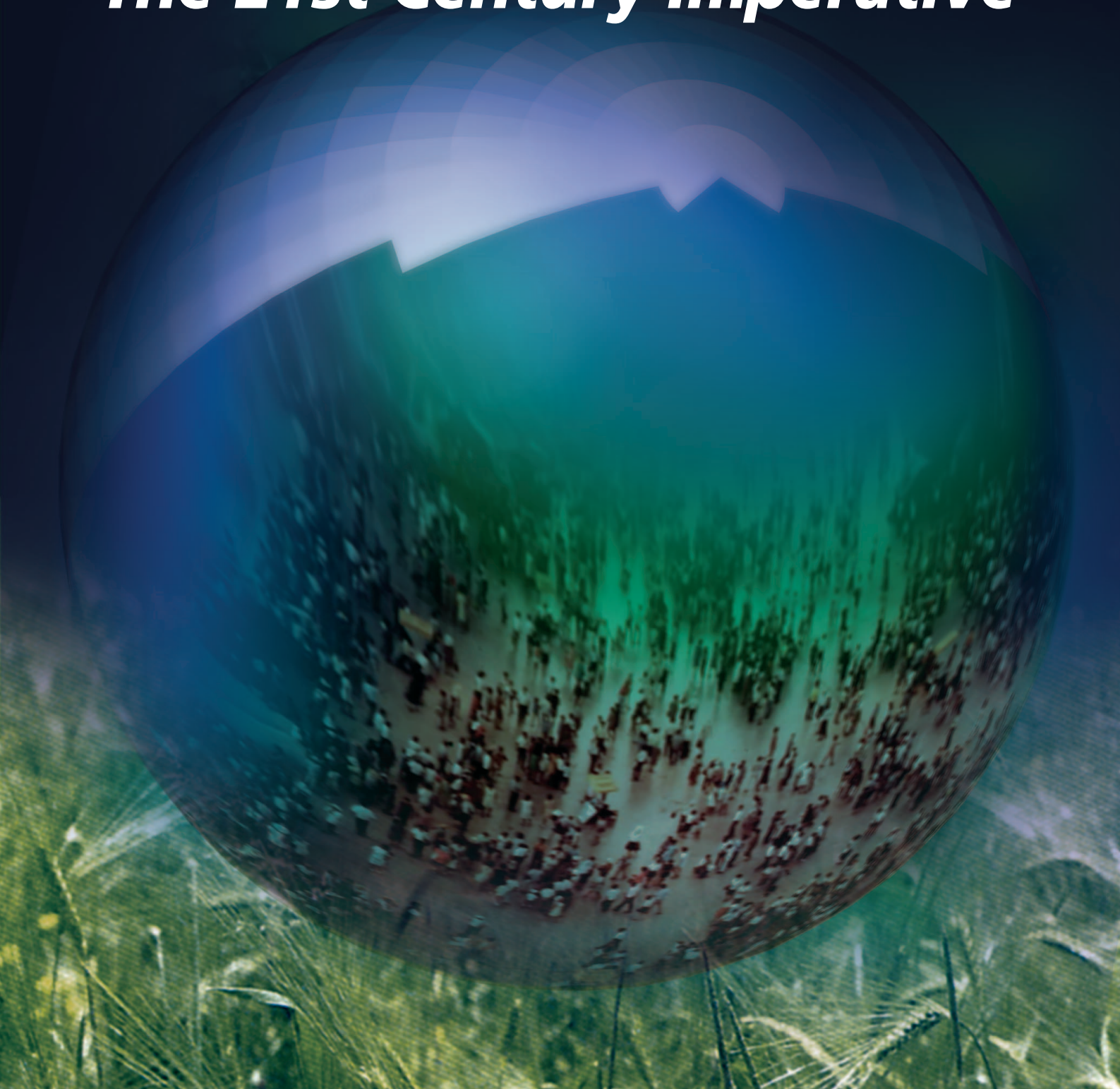
options

spring 2002

Achieving Sustainable Development

The 21st Century Imperative



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Options magazine features the activities of the International Institute for Applied Systems Analysis (IIASA), located in Laxenburg, Austria. IIASA is an interdisciplinary, nongovernmental research institution sponsored by a consortium of National Member Organizations in Asia, Europe, and North America. The Institute's research focuses on sustainability and the human dimensions of global change. IIASA's studies are international and interdisciplinary, providing timely and relevant insights for the scientific community, policymakers, and the public.

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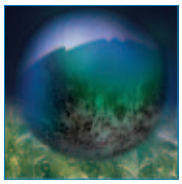

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by Anka James

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IIASA was created 30 years ago as part of a bridge-building initiative between the two then superpowers with the aim of enhancing security and building confidence. In 1972 this initiative brought together the scientific communities of 12 national member organizations to create a collaborative international research institute. During the past three decades, IIASA has accumulated vast experience in applying integrated scientific analysis to understand and design policy response to major environmental, social, and economic problems in a holistic, multidimensional, and interdisciplinary systemic approach.

The Institute is a pioneer in the study of human dimensions of environmental, technological, and economic change. Human security issues relating, for example, to the supply of water, food, and energy, and the protection of the earth's life support systems have been high on the list of IIASA's priorities since its creation. Today, under US leadership, the world community of nations has been mobilized to confront the threat of terrorism to ensure fundamental human security for everyone everywhere. However, the plight of the poor and vulnerable must not be forgotten.

This issue of *Options* highlights the human dimensions of IIASA's work by looking at ongoing research in selected projects, including population (demography, education, and aging); land-use change (hunger and food security, climate change, and ecological and economic integration for agricultural development); energy strategies (integrated energy–economic–environmental scenarios for the future); risk and society (sustainability and justice); economies in transition (social and development challenges in these countries); and international negotiations (the techniques of conflict resolution). All articles analyze the pressures on human populations and assess policy options and outcomes.

The end of the cold war marked the start of a new era for IIASA. In 1994, the Institute was given a new mandate agreed upon by the member countries at a ministerial meeting. The new mandate emphasizes *science*, reiterates *policy relevance* and makes *global* a key word. Thus, during the last decade, the trend has been for IIASA to expand the East-West perspective and to add a North-South one. This has resulted in an increasing collaboration with major developing countries such as India, and in January 2002 led to China becoming the second Asian country to join IIASA.

China's membership strengthens the Institute's position as a global "science for policy" institution that provides an international setting to facilitate scientific cooperation, to better address regional and global challenges, and to inform policy makers. IIASA is continuing its efforts to expand membership to include other developed and developing countries.

In the context of 21st-century challenges, IIASA has both a responsibility and an opportunity to make a scientific contribution to the human dimension issues facing the world. IIASA has the necessary scientific credibility and analytical experience, and with the support and commitment of its member countries, it can truly rise to this challenge.

Arne Jernelöv
Acting Director

Achieving Sustainable Development

The 21st Century Imperative

Human dimensions must be put at the core of sustainable development to meet the needs of present generations without sacrificing the livelihoods of future generations

Ten years ago at the UN Conference on Environment and Development, also known as the Earth Summit, the world community of nations adopted the Rio Declaration and made a commitment to Agenda 21, a common framework for action toward sustainable development. The World Summit on Sustainable Development in Johannesburg in August 2002 is a critical opportunity to reinvigorate the actions for implementation of Agenda 21.

The first principle of the Rio Declaration states that "human beings are at the centre of concerns for sustainable development." Sustainable development can only succeed if it is for the people and by the people, and in that sense human values and actions must be the driving forces of systemic development efforts.

The central thrust of Agenda 21 was to integrate the economic, environmental, and social pillars of development to meet the needs of present generations without sacrificing the livelihoods of future generations. Agenda 21 points out that different populations have "common but differentiated responsibilities" for impacts on the environment. Hence the issues of economics and finance, environment and natural resources, and society and culture must be considered in an integrated and systemic manner.

In Rio, thinking was dominated by the goal of achieving development convergence among different parts of the globe. There was hope that the least developed countries would catch up with the more developed ones, and that the rich countries would become increasingly environmentally conscious and curb their pollution and unsustainable consumption patterns. This has not happened.

Global disparities not only persist, but in some cases have continued to worsen. A world of disparities is not sustainable and cannot be peaceful and secure in the long term. In an environment of persistent poverty, rural women are forced to walk greater and greater distances to collect water and firewood every day; with degraded land and water resources, farmers are unable to harvest enough food to feed their families; urban slum dwellers are unable to earn enough to pay for a single meal a day; and all are at the mercy of disease in an environment without access to health care.

Eradicating poverty and ensuring access to basic human needs such as food, water, energy, health care, safe shelter, and knowledge empowerment through education, both now and in the future, are fundamental to achieving sustainable development. Over and above these basic human needs there are "human wants," such as consumer goods, mobility, leisure, and entertainment. Individuals and societal groups decide how these needs and wants are to be satisfied within the context of their cultural heritage, ethics, and lifestyles.

Our understanding of the consequences of and responsibility for consumption can be improved by differentiating among various kinds of consumption. For example, some goods use more natural resources and energy than others, and some produce more pollution than others. Understanding the driving forces of consumption and how different types of consumption are distributed among different types of households can help guide policies aimed at curbing unsustainable patterns of consumption. Consumption *per se* is not something to be avoided, since it is one important aspect of improving human well-being. Equally important is the recognition that the relationship between well-being, consumption, and environmental degradation depends on value systems, technological means, and the effectiveness of institutions and governance mechanisms.

The core consideration of the "human dimension" in the sustainable development debate is, How will humans be affected by environmental and socio-economic change? To answer this question, we need to look at the kinds of changes that occur in ecosystems and resource availability, population and demographic

transitions, diseases and health care, economic activities and livelihoods, etc.—but we also need to look at how the vulnerability of coupled human–environment systems is affected by multiple, interacting stresses. These stresses result from both environmental and socioeconomic changes, and the fact that they interact highlights the need for a comprehensive systems analysis approach. Furthermore, it is increasingly clear that the sensitivity of the human–environment system to environmental and socioeconomic change is dependent on location, which defines the environmental, political, economic, and social context in which the change is occurring.

Whether addressing vulnerability to environmental change or responsibility for preventing environmental degradation, careful consideration of the particular groups of people involved and their social, economic, and environmental conditions is essential. Focusing on people—their rights, capabilities, limitations, and opportunities—has multiple benefits for individuals and for society.

At the societal level the vulnerability to environmental change inherently depends on the efficiency of institutions, including social and political organizations, infrastructure, and markets. To cope effectively with environmental changes, it is also important to have real choices through knowledge and education, on the one hand, and material means, on the other hand, with good governance being an additional decisive factor.

21st century. The human dimensions of sustainable development encompass the causes and consequences of and responses to changes within the interacting realms of environmental, social, and economic systems. Systems analysis research has played, and will continue to play, an important role in understanding these interdependent and interacting issues in our efforts to trace out a path toward sustainability.

In the past three decades, IIASA has made important policy analysis contributions to global and regional integrated assessments that address the interwoven, development-related issues of population change, food and agriculture, energy and technology, emissions and climate change, air pollution, forest resources, economies in transition, risk and vulnerability, radiation safety, and security and international negotiations. For example, the Japanese Ministry of International Trade and Industry and the Central Research Institute of Electric Power Industry funded an integrated assessment of global energy use that brought together IIASA's energy, transboundary air pollution, land-use change, and forestry projects, jointly applying their specialized systems models in a consistent framework.

Other opportunities for integrated regional and global studies and policy analysis arise from IIASA's research collaboration in China, Russia, and Central Europe. Development in these regions, which are now fully integrating into the world economy, will have broad global effects in terms of international trade, energy supply and demand, greenhouse gas production and sequestration, and the resulting reverberations in the increasingly globalized economy.

1972 UN Conference on the Human Environment, Stockholm
Preserving and Enhancing the Environment
Human Rights to a Healthy and Productive Environment

1992 Earth Summit in Rio
Commitment to Sustainable Development
Agenda 21 Global Action Plan

2002 Johannesburg Summit
Achieving Sustainable Development
Turning Plans into Implementation Actions

In the 10 years since Rio, various international conferences and negotiations have led to a wide range of agreements and goals that play a role in the progress toward sustainable development—agreements on food security, international trade, climate change, biodiversity, and stratospheric ozone depletion, to name a few. Understanding the successes and failures of such agreements and using that knowledge to further develop responses to environmental and socioeconomic challenges is an important part of the sustainable development research agenda.

Progress in science and technology, including the knowledge revolution and emerging capabilities to monitor environmental changes, has given us the potential to reshape and manage the challenges of the

Articles in this issue of *Options* show the contributions IIASA scholarship has made to the research agenda on human dimensions in sustainable development, including the role of population and demographic change, food security and climate change, energy and sustainability, risk and vulnerability, economies in transition, and security and negotiation. Policy analysis and assessments at the national, regional, and global levels lie at the core of IIASA's research agenda to contribute to achieving sustainable development and human well-being: A 21st Century Imperative.

Population and Human Capital

The human population matters for sustainable development in two important ways. First, it is an agent of change, inducing many of the environmental, economic, and social changes in the world that give rise to our concerns about the sustainability of our current development paths. Second, the human population and its living conditions are the ultimate objects of development, with long-term human survival, health, and well-being serving as criteria for judging whether development is sustainable or not. It is the human population and its individual members that ultimately will suffer the consequences of unsustainable paths of development.

IIASA's Population (POP) Project has dealt with both the determinants and the consequences of population trends for the past three decades. It has greatly benefited from the interdisciplinary setting at IIASA, which has been a constant stimulus to look beyond the boundaries of demography and respond to the questions of how alternative future population trends may influence such diverse concerns as deforestation, food supply, transboundary air pollution, and freshwater systems. Or similarly, how possible changes in these natural systems feed back on the human population by influencing its health and mortality, its migratory patterns, or even its reproductive behavior.

Over the past few decades, IIASA has made significant contributions to the study of population dynamics. Its methods of multi-state population analysis, developed for studying interacting sub-populations, are now in use around the world.

Similarly, POP has pioneered methods of probabilistic population projection and dynamic models of population–development–environment (PDE) interactions, which have been applied in a series of PDE case studies in Mauritius, Cape Verde, the Yucatán peninsula, Botswana, Namibia, and Mozambique.

Beyond Demography

Many of the studies share the goal of applying some of the more sophisticated demographic methods to research questions that go beyond demography in the narrow sense. In all the PDE case studies, the human population is structured not only by age and sex, but also by level of education, labor-force status, and, in the studies in southern Africa, by HIV status. Such projections based on the demographic multi-state model open new ways of anticipating future trends in human capital more comprehensively and in a more relevant way than the usual forecasts by age and sex only.

Human Development and Education

A recent application distinguishing between different educational states produced the first global forecasts of the population by educational attainment (see Box on Population and Education presented on pages 6–7 with POP graphics). This work shows how the momentum of population and education works. POP's projections of educational attainment for 13 world regions show how past investments in education affect current and future human capital formation in each region.

The region of China and Centrally Planned Asia, for instance, will benefit greatly from past efforts to increase enrollment rates: by 2030, more than 70% of the population will have at least a secondary education, up from 47% in 2000. In comparison, in South Asia, which did not make similar efforts to increase primary and secondary enrollment rates, this figure is expected to be less than 40%, even under identical scenarios for 2000–2030. Because of this "educational momentum," sub-Saharan Africa's population will have very low education levels for the next few decades, increasing from a current level of 19% of the population aged 20–65 with at least a secondary education to 35% in 2030.

Informing Policy Making

Such projections can also help to make international political goals more realistic. For example, at the International Conference on Population and Development (ICPD) in Cairo in 1994 a very specific quantitative goal was defined and approved, namely, that female illiteracy should be halved within 15 years (i.e., by 2010). However, owing to the great momentum of educational improvement of the adult population, it is practically impossible to halve adult illiteracy within

15 years (except in the unlikely case of massive adult training programs). Hence the goal as formulated was unrealistic. On the other hand, IIASA's calculations show that even without additional effort, female illiteracy will automatically be halved by 2030–2040 owing to the effect of past educational efforts. This is again a result of the momentum of which government delegates in Cairo did not seem to be aware. There clearly seems to be room for better scientific advice to the international policy community defining such programs of action.

Quantifying Uncertainty

IIASA also pioneered the methods of probabilistic population projection, publishing two key papers in *Nature*: "Doubling of World Population Unlikely" in 1997, and "The End of World Population Growth" in 2001. These probabilistic projections of future population size and age structure by major world region result from thousands of simulations based on stochastic fertility, mortality, and migration paths. The most recent findings are based on a synthesis of three alternative approaches to probabilistic projections: the consideration of *ex post* error analysis (looking how far off the mark earlier projections were); the application of time series models with annual fluctuations; and expert evaluation of alternative substantive arguments about future fertility, mortality, and migration trends.

The recent probabilistic population projections show that there is a 60% probability that the world population will not exceed 10 billion before 2100, and around a 15% probability that the world population at the end of the century will be lower than it is today. The median value of our projections peaks at 9.0 billion people around 2070 and then slowly decreases. In 2100, the median value is 8.4 billion people, with the 80% prediction interval bounded by 5.6 and 12.1 billion.

For different regions, the timing and size of the peak population will vary considerably. While over the next two decades the medians are expected to decline in Eastern Europe and the European part of the former Soviet Union, the populations of North Africa and sub-Saharan Africa are likely to double, even when we take into account the uncertainty about future human immunodeficiency virus (HIV) trends.

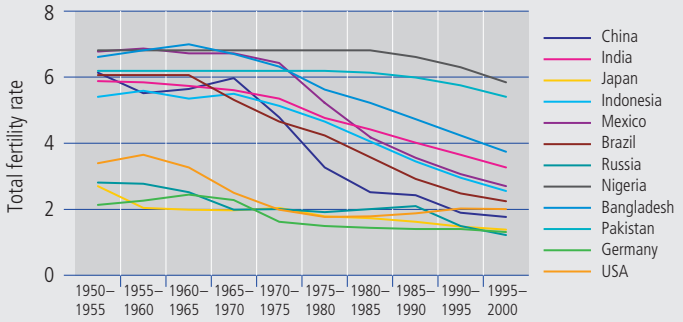
The China and the South Asia regions, which have approximately the same population size in 2000, are likely to show very different trends. Owing to an earlier fertility decline, the China region is likely to have around 700 million fewer people than the South Asia region by the middle of the century. This absolute difference in population size is likely to be maintained over the entire second half of the century, illustrating the strong impact of the timing of fertility decline on eventual population size.

Population Aging

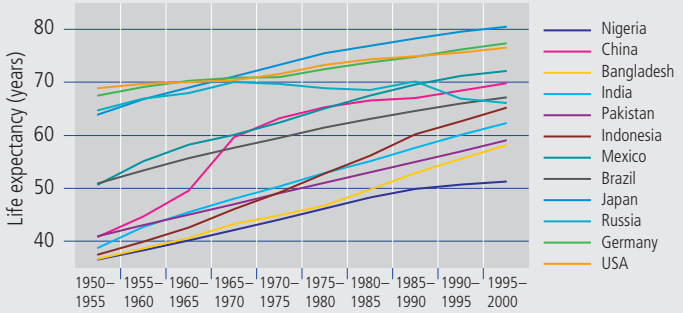
A stabilized or shrinking population will be a much older population. At the global level the proportion of the population above age 60 is likely to increase from its current level of 10% to around 22% in 2050. This is higher than the level in Western Europe today. By the end of the century it will increase to around 34%, and extensive population aging will occur in all world regions. The most extreme levels will be reached in the Pacific OECD (Organisation for Economic Co-operation and Development) region (mostly Japan), where half the population is likely to be age 60 or older by the end of the century, with the 80% uncertainty interval reaching from 35% to 61%. The extent of and regional differences in the speed of population aging—the inevitable consequence of population stabilization and decline—will present major social and economic challenges.

Rapid population aging is in itself a sustainability issue, even without considering environmental factors. Given the original definition of sustainable development by the Brundtland Commission, which aims at intergenerational equity, population aging in combination with pay-as-you-go pension schemes (in which the currently active pay for the currently retired) can lead to a situation in which the younger generation will have to carry a much higher burden than the older generation had to carry. This has called into question the sustainability of current pension schemes.

As early as the 1980s, IIASA's POP Project was one of the first to systematically study population aging and its consequences for society and the economy, and to extend this analysis to developing countries such as China and Indonesia. Today, population aging has become a top policy concern in all IIASA member countries, generating a new wave of interest in demographics. To address these challenges we have to go beyond demography in its narrow sense and expand our analysis to include such issues as intergenerational equity and human capital formation.



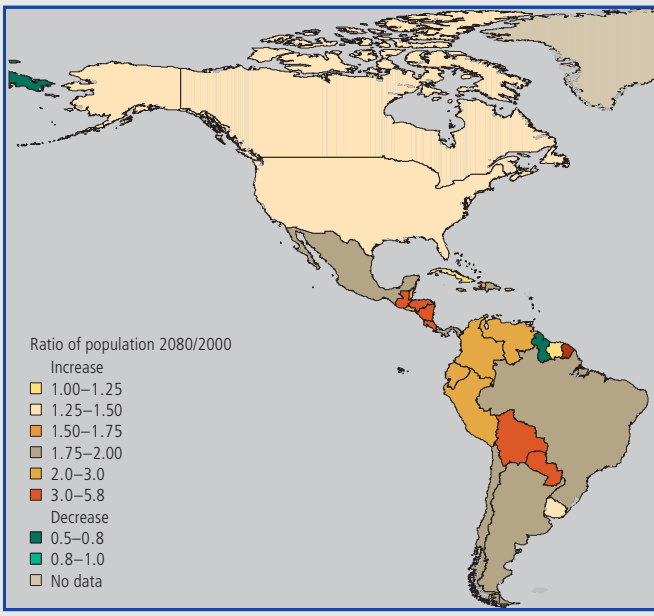
Total fertility rates for 12 of today's most populated countries (63% of the world population), 1950–2000.



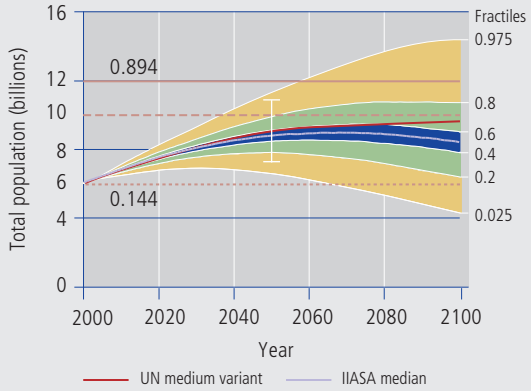
Life expectancies for 12 of today's most populated countries (63% of the world population), 1950–2000.

The two main trends during the second half of the 20th century were the dramatic declines in fertility rates in developing countries since the 1960s (the majority of countries with a population above 50 million had fertility rates below 3 children per woman in 1995–2000) and the constant rise in life expectancy at birth in most countries (Russia being an exception).

Expected Population Growth and Decline between

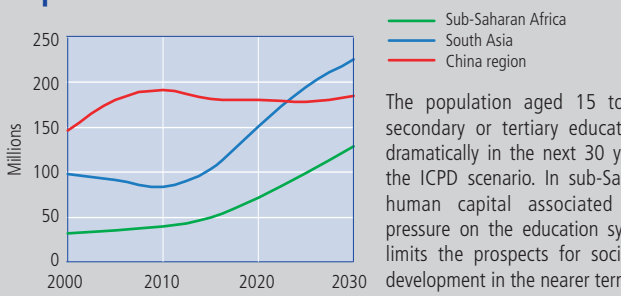


The 21st century is likely to see the end of population growth. However, because of the momentum of population growth and pockets of high fertility in most of Africa and some parts of Asia, total world population will likely increase by about 50% before it stabilizes or starts to decline.

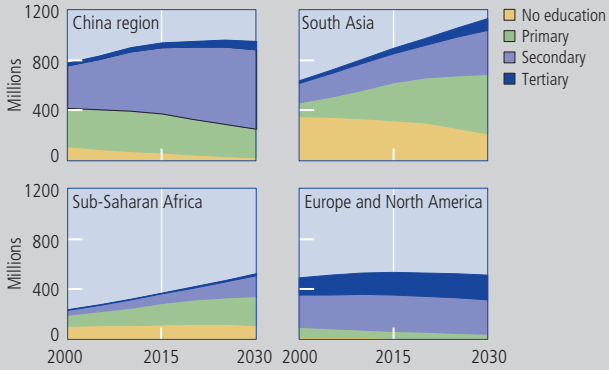


Uncertainty distribution of IIASA's world population projections. Blue line gives median of IIASA projections; red line gives medium variant of the UN's 1998 long-term projections.

Population and Education



The population aged 15 to 24 enrolled in secondary or tertiary education will increase dramatically in the next 30 years according to the ICPD scenario. In sub-Saharan Africa, low human capital associated with enormous pressure on the education system significantly limits the prospects for social and economic development in the nearer term.



Estimated population aged 20 to 64 (in millions) by level of education according to the ICPD scenario. Of the four major world regions shown, the working-age population in Europe and North America will continue to have the highest levels of education; however, in absolute terms this region will clearly fall behind China.

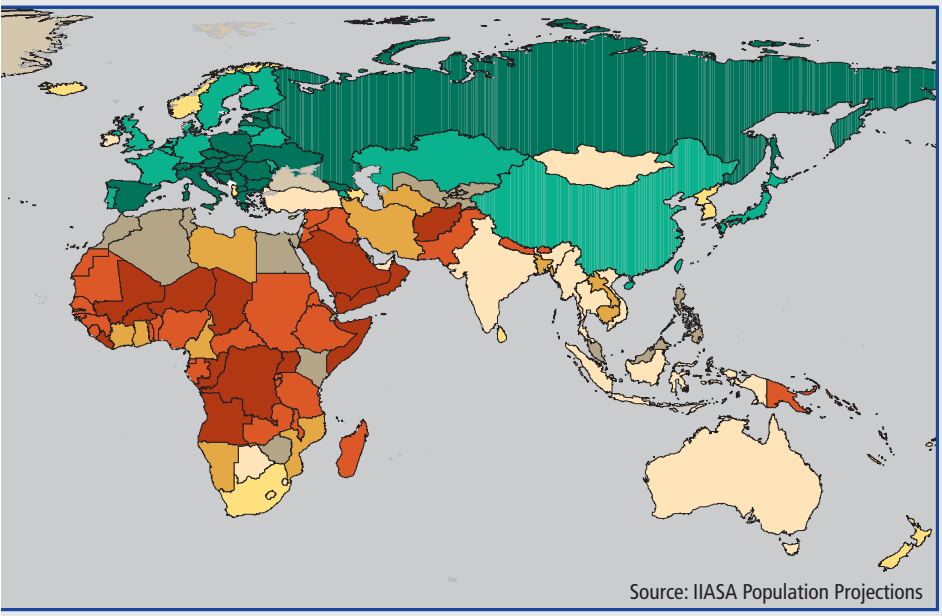
The ICPD scenario reproduces the quantitative education goals set at the International Conference on Population and Development (ICPD) held in Cairo in 1994. The general objectives are (1) to provide universal access to quality education, particularly primary education; (2) to combat illiteracy; and (3) to eliminate gender disparities in access to education. Specific goals were adopted for the ICPD scenario in order to reflect the objectives of the ICPD's Programme of Action:

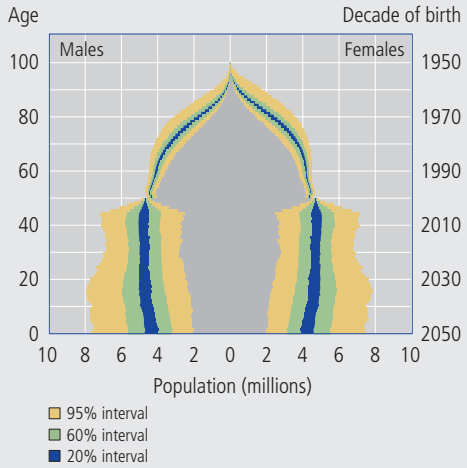
- The gender gap in primary and secondary school education will be eliminated by the 2005–2010 period.
- All girls and boys will have complete access to primary education by the end of the 2015–2020 period.
- The net primary enrollment ratios for children of both sexes will be at least 90% by the 2010–2015 period.
- Countries that have achieved the goal of universal primary education are urged to facilitate access to and completion of education at secondary or tertiary levels by the 2025–2030 period.

The ICPD Programme of Action does not set quantitative goals for secondary and tertiary education. Therefore, two components were added:

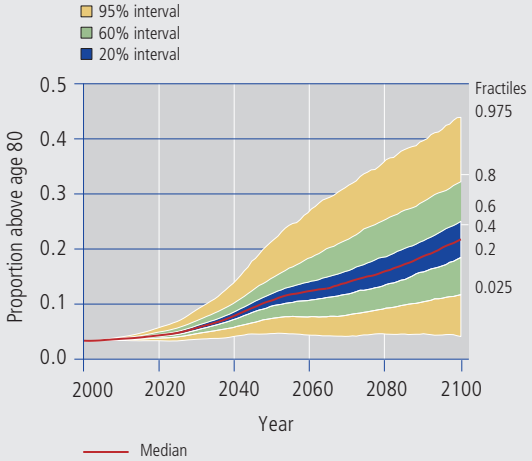
- All developing countries will achieve 75% of participation in secondary education for boys and girls by 2025–2030.
- The rates of enrollment in tertiary education will increase by 5% by the projection period in all regions except in North America, where transitions to tertiary education are already above 50% for both sexes.

2000 and 2080

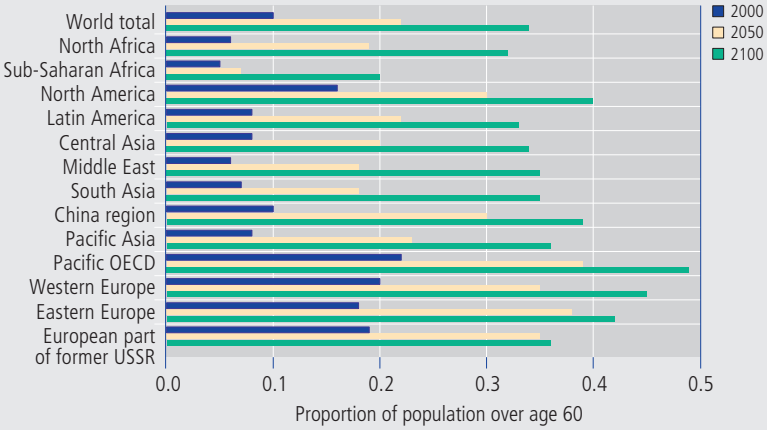




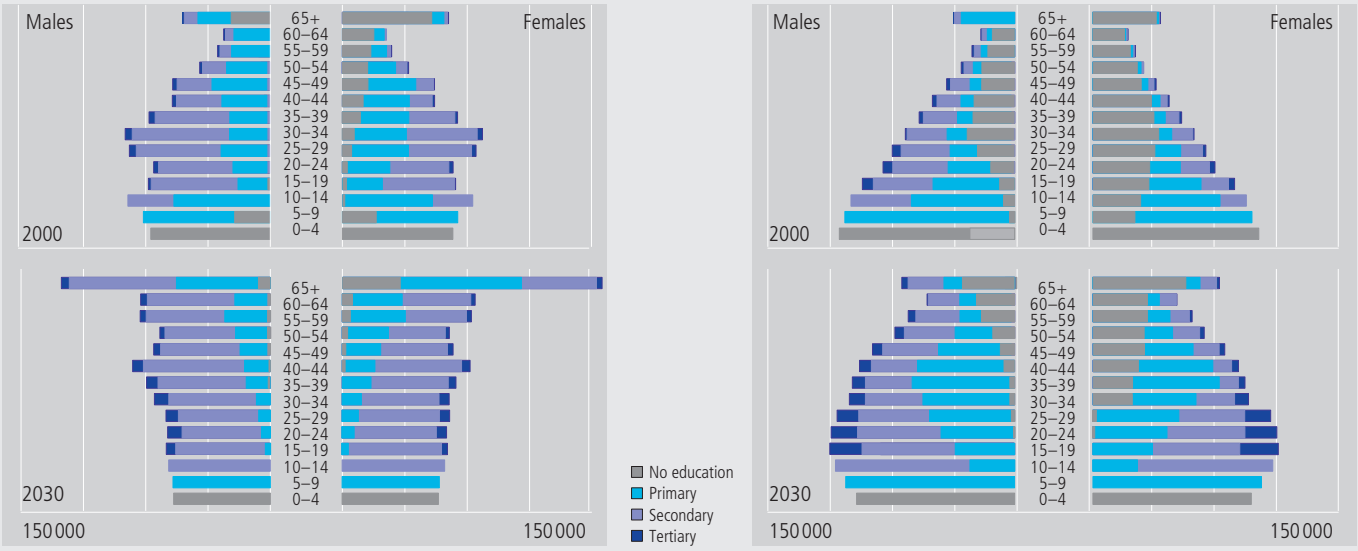
Probabilistic population pyramid giving the uncertainty ranges for the sizes of different age groups in Pacific Asia (mostly Southeast Asia) in 2050.



Uncertainty distribution of the projected proportion of population above age 80 in Western Europe, 2000–2100.



The 21st century is likely to be the century of aging, with the proportion of the world population above age 60 increasing by a factor of from three to four—from 10% in 2000 to 34% in 2100. This is about twice the level currently observed in North America and Eastern Europe. South Asia, which by the end of the century is likely to be by far the most populous region with around 2 billion people, is likely to see a dramatic increase in the proportion above age 60—rising from 7% in 2000 to around 35% by the end of the century.



Age and education pyramids for (left) the China region and (right) South Asia in 2000 and 2030 according to the ICPD scenario. China's past investments in education mean a well-educated labor force by 2030. In contrast, South Asia's current high female illiteracy will linger for decades, even with the strongest educational efforts.

Food Security and Climate Change

We are living at a moment in history that is unique with respect to the unprecedented progress in science, technology, and communication that has been achieved in the past three decades. Beginning with the Green Revolution of the 1970s, the information revolution of the 1980s, and the genetic revolution of the 1990s, the 20th century ended with the mapping of the human genome.

These scientific and technological achievements are formidable accomplishments with significant potential for creating future sustainable and equitable well-being around the world. But today we live in a world of disparities, where a fifth of the global population lives in poverty and hunger.

Some 800 million people go hungry every day, and some 2 billion live on less than two dollars a day. Every minute of every day, 15 children and 15 adults die of hunger in the developing world. Without social, economic, and scientific progress, by the middle of the 21st century more than a third of the world's expected population of some 9 billion could be living in poverty.

The poor are poor because they lack tangible assets, formal education, and technical skills, and have little access to health care. Moreover, the poor are often discriminated against, both politically and socially.

In this context, it seems a paradox that there is little international or national commitment to the development of the agricultural sectors of developing countries. Agriculture was the foundation of social and economic progress in the developed countries, and to this day it has extremely powerful political lobbies in these nations, even though less than 5% of the population derive their livelihoods from agriculture. In contrast, in many developing countries, where as much as 70% of the population derive their livelihoods directly or indirectly from agriculture, the weakest political lobbies are those of the agricultural and rural sectors. During the past decade, the share of total World Bank project funds for agriculture has declined from about a third to 10%. While the Organisation for Economic Co-operation and Development (OECD) countries annually spend some US$350 billion on agricultural subsidies, the world's expenditure on international agricultural research amounts to only about US$350 million.

Unless the national governments and the international community give agriculture and the rural sector the highest priority, progress on achieving international targets for poverty and hunger reduction will remain elusive.

Global Environmental Change and Food Production

Food production systems interact with land resources, forest ecosystems, and biodiversity. Maintaining the fertility and multi-functionality of soils, preserving genetic diversity, adopting effective water resources management and protection measures, and adapting to climate change are critical to enhancing agricultural production. By the same token, agricultural practices of inefficient fertilizer and pesticide use, lack of land and water conservation measures, and large-scale conversion of forest areas will result in irreversible damage to ecosystems and accelerated loss of production potentials.

Climate change, air and water pollution, pests and diseases, economic and social turmoil, and even genetically modified crop contamination do not recognize or respect political and geographical boundaries. Without responsible decision making, compromises, and even sacrifice, the children born in the wake of the 21st century may face a bleak future indeed. We must begin now to consider our response to global changes and challenges, because the actions taken—or not taken—today will affect the quality of life for us and for generations to come.

The rapid land-cover changes, biotic fluxes, and extinction of living species over the past 50 years are worrisome. The disturbing truth is that we do not even know what biodiversity is being lost around the world—in our forests, in the oceans, and on land. For instance, China, which once had 10,000 land-race varieties of wheat, now has fewer than a thousand. No one knows what genetic traits leading to insect and disease resistance, stronger plants, higher yields, or even better-tasting crops may have been irrevocably lost. The damage we are inflicting on the environment is increasingly evident: arable lands lost to erosion, salinity, desertification, and urban spread; disappearing forest and threats to biodiversity; and water scarcity.

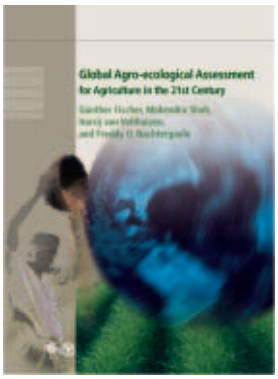
About 70% of the world's currently used fresh water goes to agriculture. Reliable supplies of good-quality water are a matter of survival, particularly in countries such as China and India, which rely on extensive irrigation. Though renewable, fresh water is a finite resource that is not evenly distributed across or within countries or regions, or even seasons. Two-thirds of the world's population lives in areas that receive only one-quarter of the world's annual precipitation, while sparsely populated areas such as the Amazon Basin receive a disproportionately large share. Because of extensive upstream use, some of the world's major rivers—the Nile, the Ganges, the Colorado, and the Yellow Rivers, for instance—barely

carry water to the sea any longer. The growing water scarcity will pose a serious threat to food security, poverty reduction, human health, and protection of the environment.

Thirty years ago, the world faced a global food shortage that some predicted would lead to catastrophic famines. The danger was averted because an international research effort enabled scientists to develop and farmers to adopt high-yielding varieties of major food crops. The lessons of that Green Revolution indicate that an integrated biological, environmentally sound, and socially viable strategy has to be at the core of the next precision green revolution.

Global Agro-ecological Assessment

The Food and Agriculture Organization of the United Nations (FAO) and IIASA have developed a methodology based on environmental principles that provides a comprehensive framework for the integration of climate, soil, and terrain conditions relevant to agricultural production. This approach, referred to as the agro-ecological zones (AEZ) methodology, uses crop modeling and environmental matching procedures to identify crop-specific environmental limitations under various levels of inputs and management conditions.

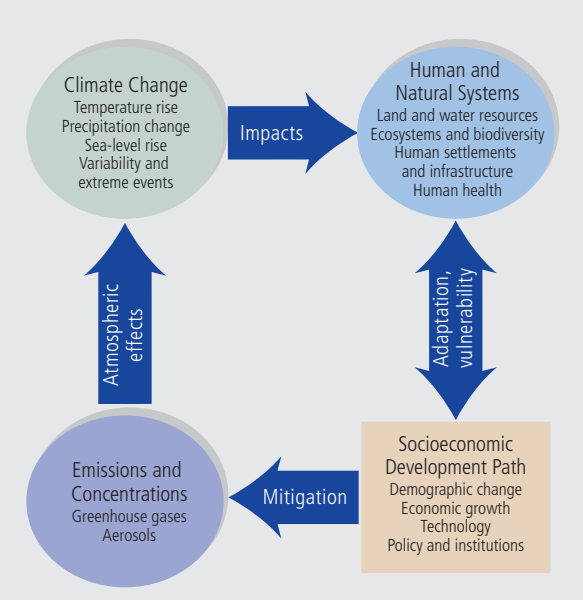


The AEZ approach is a GIS-based modeling framework that combines quantification of plant production potentials with socioeconomic and multiple-criteria analysis to evaluate spatial and dynamic aspects of agriculture.

Human Development and Climate Change

During the past 200 years, human influence on the functioning of the Earth's systems has reached unprecedented levels. Massive burning of fossil fuels and widespread land conversions have altered the global carbon pools. As a result, carbon dioxide concentrations in the atmosphere have increased by over 30% since 1800 and concentrations of methane, another important greenhouse gas, have doubled.

Among the feedbacks that characterize such coupled human and natural systems, land use is affected by climatic change as well as by socioeconomic trends and population dynamics. In the complex chain of events from population pressures on land use to land pressures on the regional and global environment, policy may also intervene—for instance, by setting standards for local water and air quality, or by developing rules for greenhouse gas emission limitations or the trading of sequestered carbon.



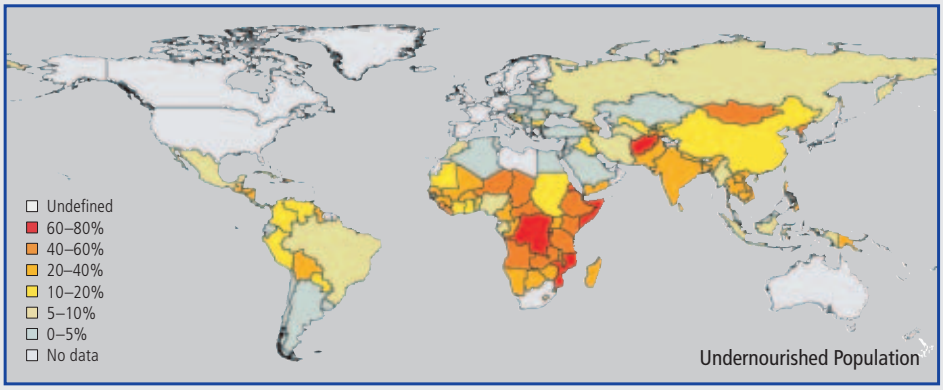
The climate change–development syndrome (adapted from IPCC).

Global warming will alter agro-environmental conditions and thus affect the suitability and productivity of crops. On the one hand, it will increase the risk of pest and disease infestations. On the other hand, the increasing atmospheric concentration of carbon dioxide will enhance plant photosynthesis and contribute to improved water-use efficiency.

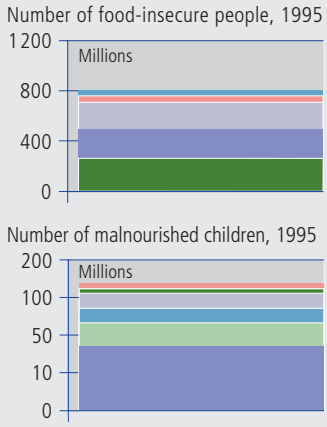
Responses to climate change can be of two types: adaptive measures to reduce adverse impacts and risks and to maximize the benefits and opportunities created by climate change; and mitigation measures to reduce anthropogenic contributions to climate change. Both adaptive actions and mitigation measures are necessary elements of a coherent and integrated response to climate change. If we are to stem global warming, we have no choice but to reduce the rapidly increasing emissions of greenhouse gases such as carbon dioxide. But in doing so, the contribution to and consequences of such emissions, as well as the different national development needs and priorities, have to be central in reaching economically efficient and environmentally effective agreements.

The good news here is that the scientific understanding of global warming is growing by the day, and we are already at the point where uncertainty is no longer an acceptable excuse for inaction. These are the challenges that politicians, decision makers, and scientists must meet, in the interest of everyone everywhere.

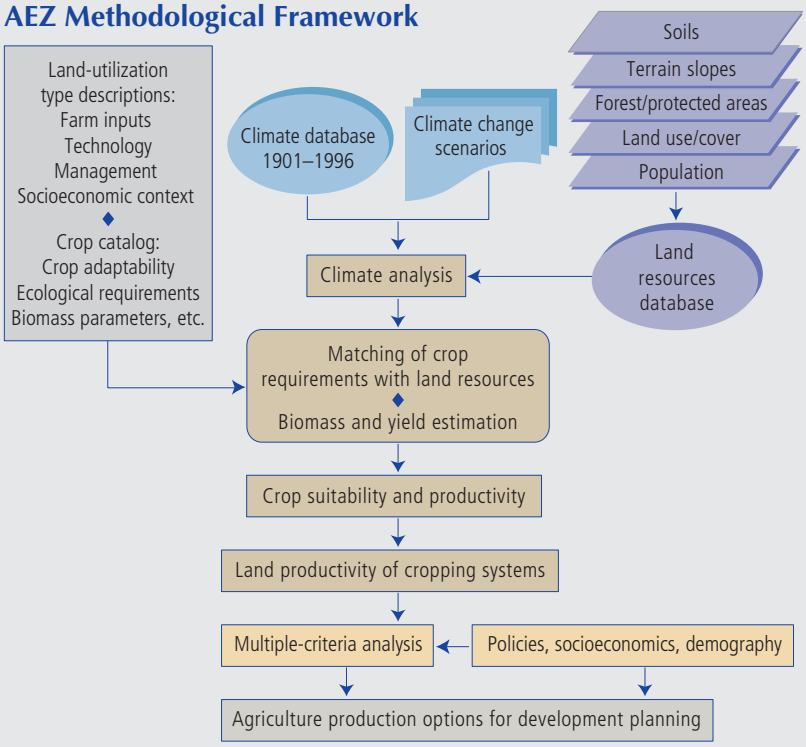
World Food Summit: Reduce Hunger by 50% by 2015



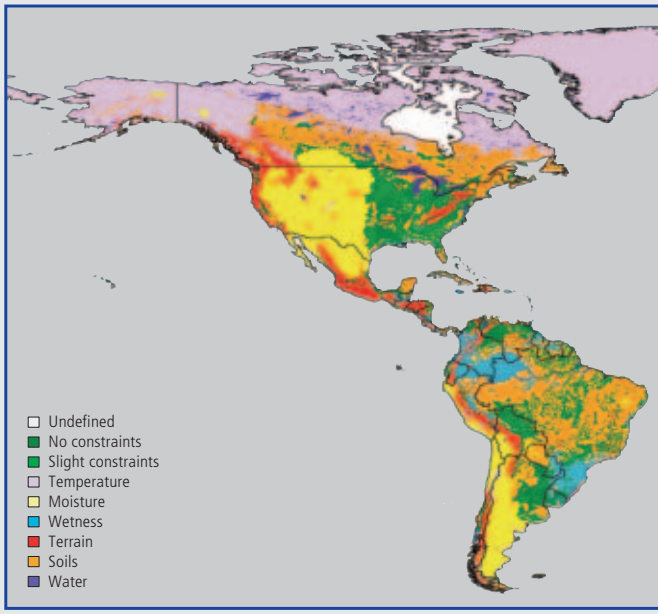
World Hunger



AEZ Methodological Framework



Environmental Constraints to Rain-fed Agriculture

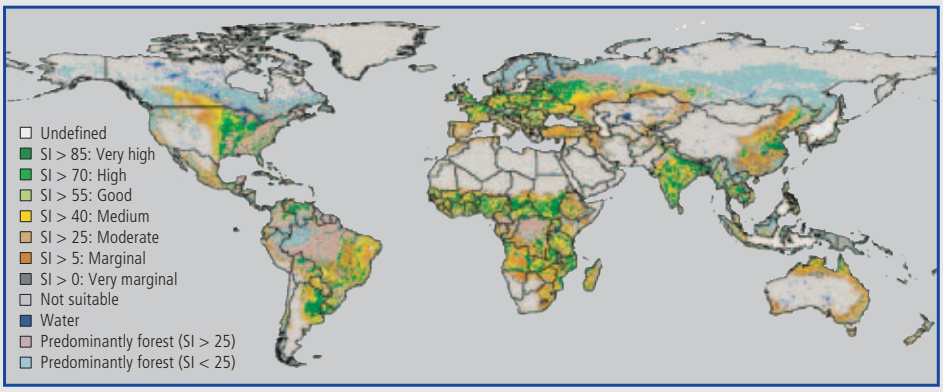


The AEZ methodology is based on environmental principles which provide a comprehensive framework for the integration of climate, soil and terrain, and land-cover characteristics that are relevant to agricultural production.

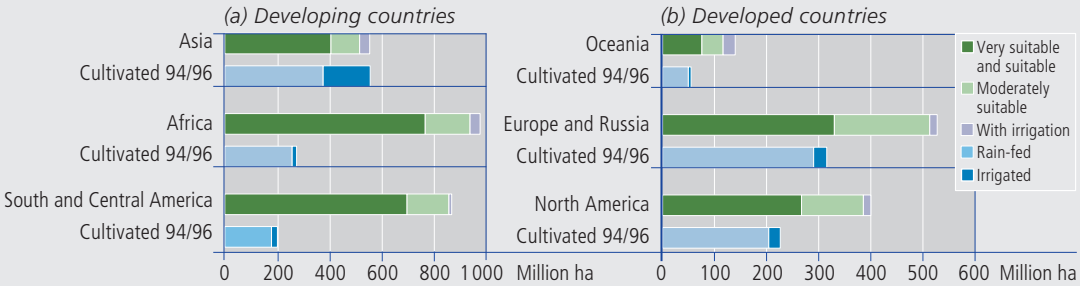
AEZ combines a quantification of crop production potentials with socioeconomic and multiple-criteria analysis to evaluate spatial and dynamic aspects of agriculture under assumed levels of inputs and management conditions.

AEZ procedures also provide quantifications of productivity of multiple-cropping systems.

Suitability for Rain-fed Crops



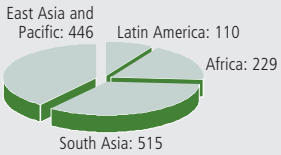
Cropland Potential and Land Used for Cultivation



Over 70% of the potential for expansion of cultivated land in the world is in Africa and South America, with just seven countries—Angola, Democratic Republic of Congo, Sudan, Argentina, Bolivia, Brazil, and Colombia—accounting for half this cultivable land. Although a fifth of the world's 2.8 billion hectares of forest ecosystems has good potential for crop cultivation, any conversion would have severe environmental consequences.

and Poverty

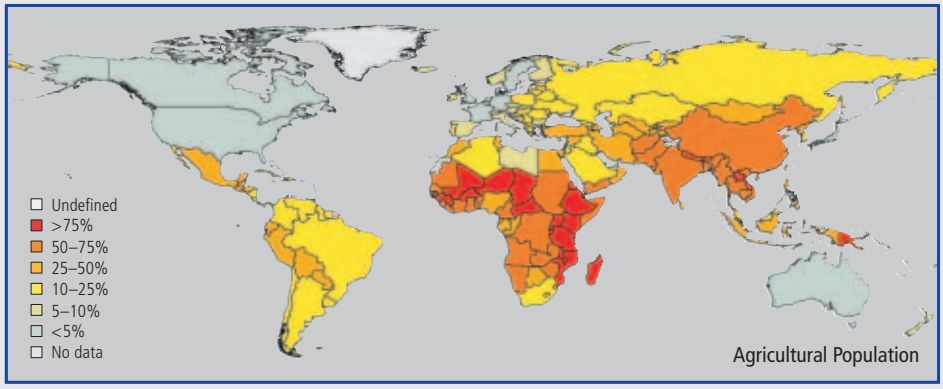
Population living below US$1 a day (millions)

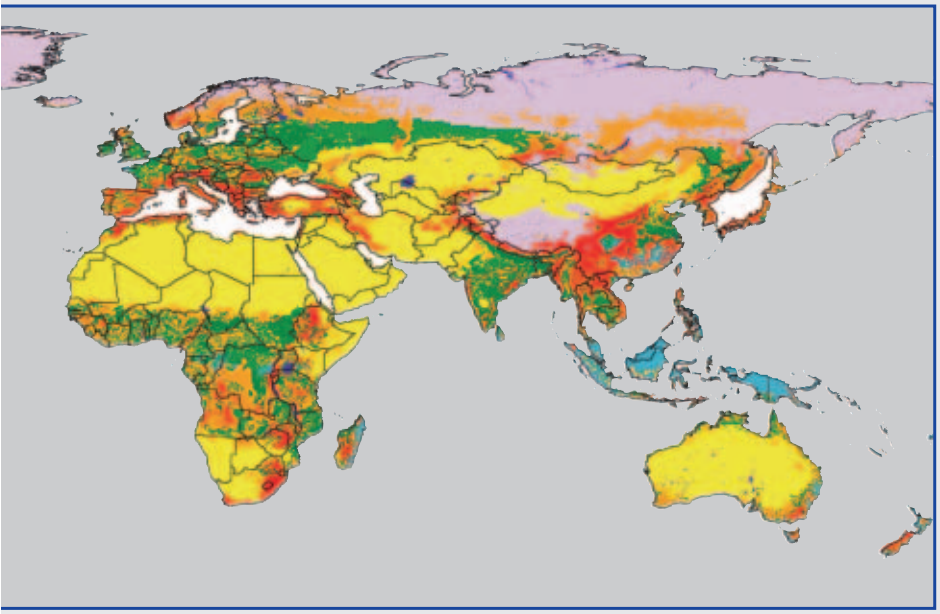


Source: FAO and World Bank

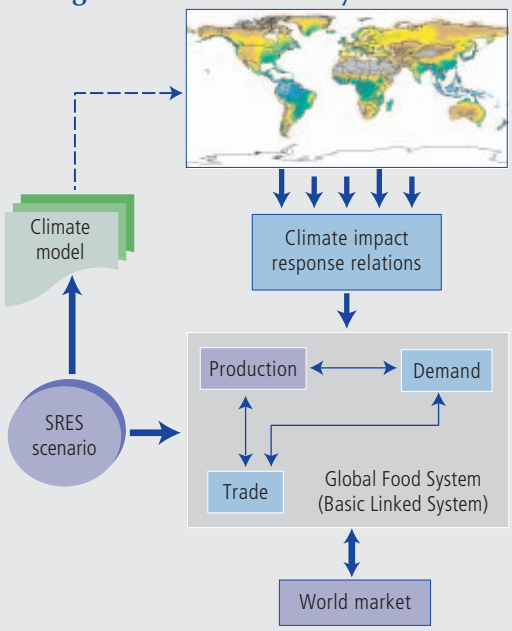
- East Asia
- South Asia
- Sub-Saharan Africa
- Latin America
- West Asia and North Africa
- Southwest Asia

Millennium Summit: Reduce Poverty by 50% by 2015



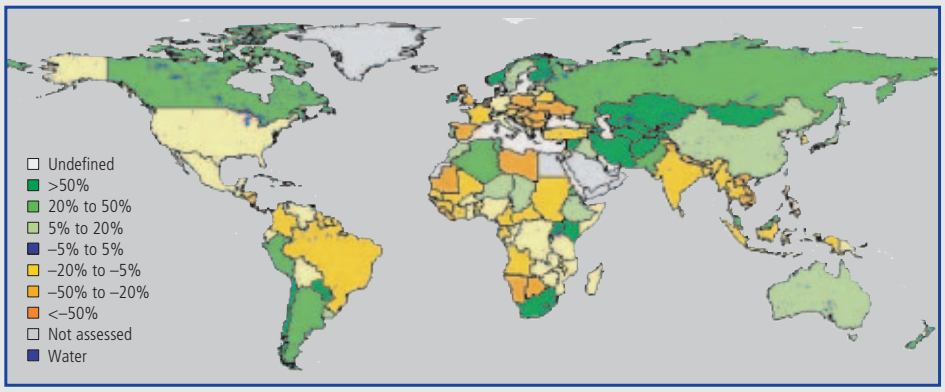


Ecological–Economic Analysis



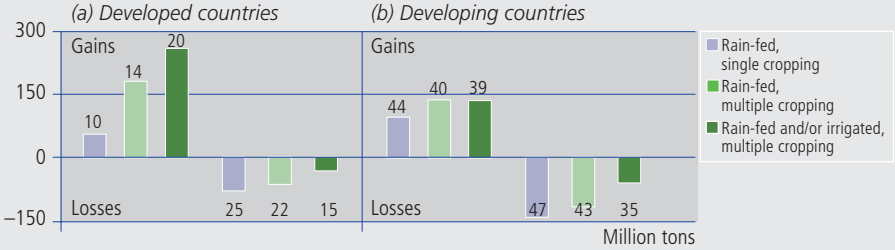
An important current step in IIASA's research is to assess the sensitivity of agro-ecosystems to climate change, as determined by the AEZ methodology, within the socioeconomic context of scenarios defined by the Intergovernmental Panel on Climate Change (IPCC) *Special Report on Emissions Scenarios* (SRES). IIASA's research has provided a modeling framework for analyzing the world food system, viewing national agricultural systems as embedded in national economies, which in turn interact with each other at the international level.

Climate Change Impact on Cereal Production



Projected climate change will result in mixed and geographically varyied impacts on crop production. Developed countries may gain substantial production potential, while many developing countries may lose.

Winners and Losers



Using the climate change projections of the Max-Planck Institute for Meteorology global coupled model for the 2080s, production losses due to climate change may severely hinder progress toward alleviation of poverty and undernourishment in some 34 poor developing and food-insecure countries, one-fifth of whose current population of 2 billion is at risk of hunger. These countries often lack the foreign exchange to finance food imports.

Climate Change and Food Production

The Global Agro-ecological Assessment can provide a detailed understanding of the sensitivity of agricultural crops and regional land-use systems to climate change. The results of changes in cereal production in the 2080s based on three climate models—namely, the ECHAM4 model of the Max-Planck Institute of Meteorology, the HADCM2 model of the Hadley Center for Climate Prediction and Research, and the CGCM1 model of the Canadian Center for Climate Modelling and Analysis—highlight that climate change will benefit the developed countries substantially more than the developing countries in terms of net gain in cereal production potential due to climate change.

An important feature of IIASA's global AEZ assessment of climate change impacts is its uniformity and consistency across all developed and developing countries. This provides for a level comparison of the impacts of climate change. The information is particularly relevant to many developing countries and some developed countries that have not yet assessed the impact of climate change on their economies and environment, especially their agricultural sectors.

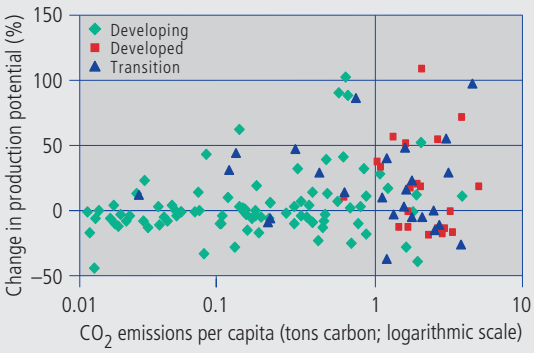
Any negotiations between the well-informed and the less-informed, such as those surrounding the Kyoto Protocol, will always be constraining. The results of the IIASA study with worldwide coverage contribute to closing this knowledge and information gap.

Food Insecurity and Climate Change

Of the 117 developing countries in the world, some 94 countries account for 800 million undernourished people, as estimated by the FAO. Sixteen of these countries, each with a relatively high per capita gross domestic product of over US$3,000, are not considered here.

The total population of the remaining 78 countries, currently some 4.2 billion, is projected to increase to over 7 billion by 2050. In many of these countries more than two-thirds of the population derive their livelihoods from agriculture. Also, agriculture accounts for more than one-third of the total gross domestic product in these countries. The current food gap for the 780 million undernourished people in these countries is estimated to be in the order of 25 million tons, some 2.5% of their total cereal production.

The impact of climate change on cereal production is cause for serious concern in some 34 "losing" developing countries under climate change as projected by the Max-Planck ECHAM4 model (between 29 and 50 countries for other climate model projections). These countries have a total combined population of 2 billion, of which about a fifth are undernourished. The current food gap of the undernourished amounts to 13 million tons. The population of these 34 countries in 2080 is projected to be 3.5 billion, and the estimated cereal production loss due to climate change amounts to over 100 million tons. Many of these countries are poor, agriculture-based economies, often lacking the foreign exchange to finance food imports. Hence domestic production losses resulting from climate change will further worsen the prevalence and depth of hunger, and this burden will undoubtedly fall disproportionately on the poorest and the most vulnerable.



Climate change impacts and carbon dioxide emissions.

Climate Change: Fairness and Equity?

Global warming raises the issue of fairness. The total carbon dioxide emissions of developing countries, which account for more than four-fifths of the world's population, amount to less than a quarter of global emissions. Yet, it is many of these developing countries that will suffer substantially from the negative impact of climate change on food production.

The world community of nations must fairly and equitably meet the challenge of addressing climate change mitigation policies. It must take stock of the differences between nations in their past and future emissions, and must take into account prevailing socioeconomic conditions. The timely implementation of economically efficient and environmentally effective international agreements on climate change and national adaptive measures will be critical in the context of achieving worldwide societal goals of equity and sustainable development.

In view of the expected persistence and resilience of the driving forces of global environmental change, even a drastic global mitigation effort will need to be complemented by proactive action toward adapting food systems to cope with the impacts of climate change, particularly in many developing countries with food-insecure populations. Agriculture research will be critical for a timely response to this unprecedented challenge. A concerted worldwide commitment entailing networking of specialists, allocation of necessary research funding, and inter-regional collaboration and technology transfer is essential to enable long-term food security.

China's Integration into the World Food and Trade System: A Policy Analysis

Accession to the World Trade Organization calls for major changes in China's agriculture and land management policies. Chinese policy makers currently face the challenge of defining transition strategies that maintain a socially sustainable level of rural income and employment, meet the needs of rapidly growing urban populations, and are environmentally sustainable.

Recent policy analysis highlights three issues:

- China can feed its growing population in the next three decades, but only if necessary policy measures are implemented to effect farmland preservation, water-use efficiency, pollution prevention, infrastructure development, improved risk and disaster management, product quality improvement, and sustained agricultural research and development.
- The extent of income inequality in China is mainly determined by two gradients: rural–urban disparity and inland–coastal disparity. Within a given rural community, township, or village, income distribution across households is relatively equal, largely owing to the egalitarian land tenure system.
- Major policy changes concerning China's agriculture and land management are impending and will likely occur over the next decade.

China's food problems must be analyzed within a broader economic framework that incorporates various policy measures and is capable of testing a wide range of policy alternatives. The analysis cannot be confined to agronomic variables and resource assessments, as economic factors will have an increasing impact on the food system. China's labor force is moving from the agricultural to the industrial and service sectors, and the typical rural household has become less dependent on agriculture. Furthermore, national food self-sufficiency is becoming less of a priority, as China is increasingly generating foreign exchange through industrial exports.

IIASA's Land Use Change (LUC) Project, in collaboration with Chinese and European research partners and with financial support under the European Union's Fifth Framework Programme, conducts its analysis within a modeling framework that represents consumer, producer, and government decisions in the various regions, accounts for transportation costs in the economy, builds the supply response on a spatially explicit assessment of the resource base and its biophysical characteristics, and describes agricultural processing and supply of farm inputs.

LUC analyzes the spatial and intertemporal interactions among various socioeconomic and biophysical factors that drive land-use change. Taking the welfare approach as a point of departure, LUC's model for China aims at identifying and simulating socially desirable and economically efficient trajectories of investment and resource uses for the future, which are computed by solving a social welfare maximization problem subject to technological and resource constraints.

A multi-region, multi-sector, and multi-agent dynamic general equilibrium model is the principal tool for analyzing the diverse and complex processes involved in China's food economy. The model embraces a realistic representation of different social agents in various regions, their income levels, preferences, and resource constraints, and certain environmental implications of their activities. It includes internal feedback among supply, demand, and prices, both in the absence of and in response to policy changes.

Within this broad and comprehensive approach, the investigation remains based on solid disciplinary research and on a structured dialogue with decision makers and stakeholders. This ensures that scenario assumptions, model specifications, and parameterization of the welfare analysis have a firm foundation in science and engineering (agronomy, soil sciences, hydrology, demography, economics, statistics, and decision analysis) and are relevant to policy making.

Sustainable Energy–Economic–Environmental Scenarios

Although it is widely agreed that the concept of sustainable development is useful for guiding development policies, a generally accepted definition of sustainability remains to be found. As a possible step toward an uncontroversial definition, IIASA's Environmentally Compatible Energy Strategies (ECS) Project has proposed a quantitative "working definition" of sustainable development E3 (energy–economic–environmental) scenarios. In focusing on scenarios instead of development in general, criteria can be proposed that have a chance of being widely accepted and that are applicable to a large set of development paths, thus also contributing to making the concept of sustainability operational.

As a point of departure for our definition, we used the "Brundtland definition" of sustainable development. Accordingly, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" is considered to be sustainable.

On this basis, ECS has proposed the following four criteria for sustainability:

- Economic growth (per capita gross domestic product [GDP]) is sustained throughout the time horizon.
- Socioeconomic inequity among world regions, expressed in per capita GDP, is reduced significantly over the twenty-first century.
- Reserves-to-production (R/P) ratios for exhaustible primary-energy resources do not decline.
- Long-term environmental stress is mitigated significantly (e.g., carbon emissions in 2100 are at or below today's level) and short- to medium-term environmental stress (e.g., acidification) does not exceed critical loads.

Using these criteria, some 40 long-term E3 scenarios generated by ECS models were reviewed, including scenarios contributed by IIASA to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report and to the World Energy Council. Applying our four criteria led to the identification of seven sustainable development (SD) scenarios; these were then analyzed to discern patterns among main scenario indicators characteristic for SD scenarios. In particular, we compared ranges for the main scenario indicators of the seven IIASA SD scenarios with those of the more than 400 scenarios comprising the IPCC's *Special Report on Emissions Scenarios* (SRES) database.

Sustainable Demographic and Economic Growth

Figure 1 shows the ranges for projections of global population. The 40 IIASA scenarios cover most of the range from all SRES database scenarios. Looking at SD scenarios only (cross-hatched area), we find that the highest population growth (11.7 billion in 2100)

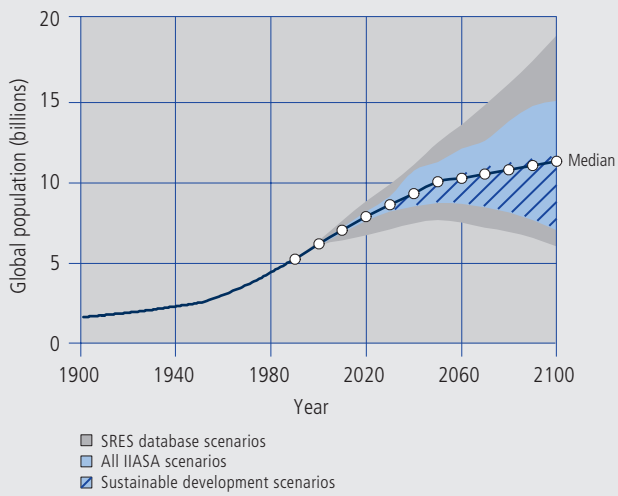


Figure 1. Global population, development from 1900 to 1990 and projections by the SRES database scenarios for 1990 to 2100.

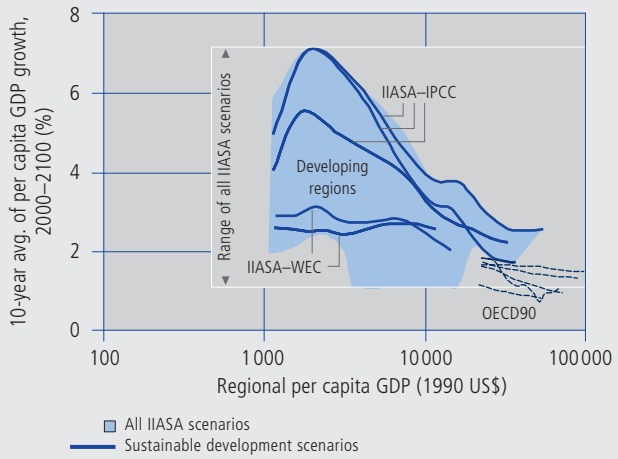


Figure 3. Developing regions' "catch-up" in the IIASA (WEC and IPCC SRES) scenarios, expressed as annual per capita GDP growth (10-year average) at a given per capita GDP. For comparison, the dotted lines show annual per capita GDP growth in the OECD region (defined as in 1990).

is roughly the same as the median of all the scenarios in the SRES database. The entire range of population projections in the SD scenarios is clearly in the lower part of the total range of scenario projections. From this observation we conclude that slow population growth at or below the median level is a characteristic of sustainable development.

Economic development is a fundamental prerequisite for the eradication of poverty in the world. As shown in Figure 2, many of the 40 IIASA scenarios assume considerably faster economic growth (expressed in terms of income) than that depicted by the SRES database scenarios. Most of the IIASA scenarios are well above the database median, and the range of the IIASA projections exceeds the upper bound of the database range by almost US$35,000 in 2100. Most notably, the range for the IIASA SD scenarios is practically identical to the range for *all* IIASA scenarios (including nonsustainable scenarios). This illustrates that future gross domestic product (GDP) levels *per se* are less critical for a sustainable future pathway than is the income distribution among regions.

The insert in Figure 2 illustrates some of the relationships between global population and per capita GDP in the scenarios. Higher per capita GDP usually is associated with lower global population projections. In all SD scenarios, global population stabilizes at around (or below) 11.7 billion people, corresponding to relatively high levels of economic development in the range of US$20,000 to US$80,000 per capita.

By design, the IIASA SD scenarios illustrate developments that reduce interregional (i.e., intra-generational) inequity worldwide. The scenarios do not eliminate all problems associated with international inequity, but the current trends of a widening gap between world regions are clearly reversed as a result of institutional, technological, and financial transfers. The decreasing income differences between the world regions in the IIASA SD scenarios are illustrated in Figure 3. The reduction in inequity can be measured as the ratio of per capita GDP in today's developing countries to that in Organisation for Economic Co-operation and Development (OECD) countries. The current ratio is approximately 6%, compared with long-term ratios in the IIASA SD scenarios of between 20% and 60% in 2100.

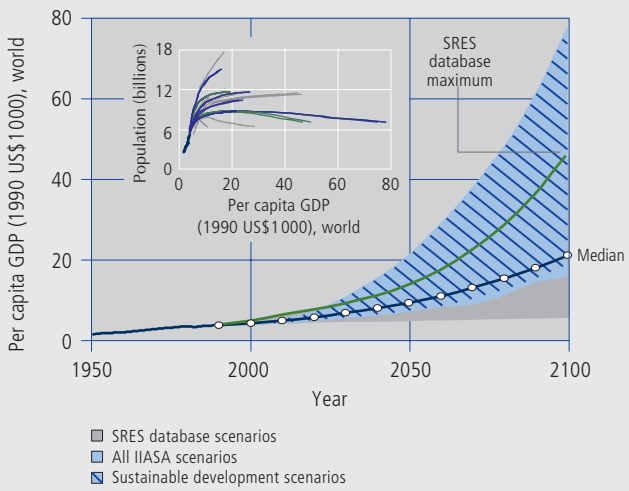


Figure 2. Global economic product (per capita GDP), development from 1950 to 1990 and in the database scenarios for 1990 to 2100. The insert shows global population versus per capita GDP. The gray lines in the insert depict 31 database scenarios (for which primary energy, GDP, and population data were available), the green lines show the IIASA SD scenarios, and the blue lines show other IIASA scenarios.

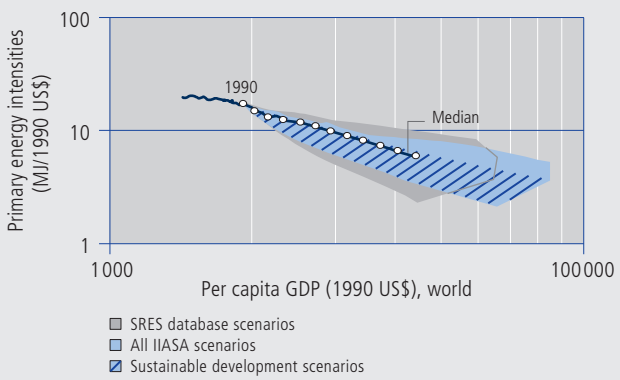


Figure 4. Global primary energy intensity in relation to per capita GDP, development from 1960 to 1990 and in the database and IIASA scenarios for 1990 to 2100.

Sustainable Energy Use and Resource Consumption

In addition to mitigating greenhouse gas (GHG) emissions, sustainable development strategies must also enhance energy conservation to increase the efficiency of resource consumption and energy use. The efficiency of the energy system is commonly measured as specific energy intensity; that is, primary energy requirements per unit of GDP. As shown in Figure 4, energy intensity reduction is particularly steep in the SD scenarios, illustrating the rapid shift toward advanced and more efficient energy technologies. The median improvement rate in the SRES database is about 1% per year, corresponding to the long-term historical trend; all SD scenarios are at or below the median.

It is often argued that crude oil, natural gas, and coal are utilized in a nonsustainable way. During the 1970s and 1980s in particular, some feared that the world could quickly run out of hydrocarbon energy. The longer-term historical evidence, however, suggests that the situation is not so drastic, mainly because of the technological potential to turn more and more primary-energy resources into recoverable reserves. Since reserves are defined as only that part of the

resources that is technically and economically feasible to extract, these amounts are a function of the available technologies and market conditions at a given point in time. Hence, for the IIASA runs, the assumed quantities of reserves depend strongly on the assumptions of the techno-economic situation assumed to prevail in a scenario at a given point in time.

This interplay between resources and reserves permits us to quantify intergenerational equity, as addressed in the "Brundtland definition" of sustainable development, in terms of R/P ratios in our working definition of sustainability. As a consequence of technological progress and changing market conditions, this ratio has remained fairly constant at the global level in recent decades—most notably for crude oil and natural gas. During the 1980s, the R/P ratio for oil and gas even increased as resources were continuously transformed into reserves. Hence, it can be argued that strategies aiming at non-decreasing R/P ratios meet the criteria of sustainable development. The long-term R/P ratios (for gas and oil for the year 2100) for the IIASA SD scenarios developed for SRES are illustrated in Table 1.

Carbon Emissions and Key Technologies in SD Scenarios

The range of carbon emissions projections by the IIASA scenarios in 2100 (2.3 to 32.7 gigatons of carbon [GtC]) covers the emission trajectories of more than 95% of all scenarios from the SRES database (Figure 5). Only a few of the database entries fall outside the projections by IIASA scenarios. Among the IIASA scenarios, carbon emissions are lowest for SD scenarios and mitigation scenarios which aim at stabilizing atmospheric concentrations at 450 parts per million by volume (ppmv) by 2100.

Carbon emissions projected by SD scenarios range from 2.9 to 8 GtC in 2100. This corresponds to carbon intensities of primary energy that decline much faster (1% to 1.9% per year) than the historical trend of 0.3% per year. This overall tendency toward significantly lower carbon intensities can only be achieved by the rapid and continuous replacement of carbon-intensive technologies with new, advanced, and cleaner ones. But which energy-sector technologies are the most promising for accomplishing an efficient transition from the present energy system to a more sustainable one?

This question was addressed by analyzing technology clusters of the power-generation sector in SD scenarios. Using this cluster-type analysis, solar photovoltaic and hydrogen fuel cell technologies were identified as the most promising long-run options for sustainable development. For the medium-term transition, natural gas combined-cycle power plants and fuel cell technology clusters have been identified as key targets of policies aiming at decarbonizing the world energy system.

Conclusions for SD Scenarios

The ranges of seven selected scenario indicators for SD scenarios compared with the SRES database ranges are summarized in Figure 6. The seven axes of the figure show the range across the scenarios in 2100 of carbon dioxide emissions in GtC, population in billions, gross world product (GWP) in trillion US dollars (T$) at 1990 prices, gross world product growth rates in percent per year, energy intensity in megajoules (MJ) per US dollar at 1990 prices, primary energy in zettajoules (ZJ; 10^{21} joules) and carbon intensity in tons of carbon (tC) per terajoule (TJ).

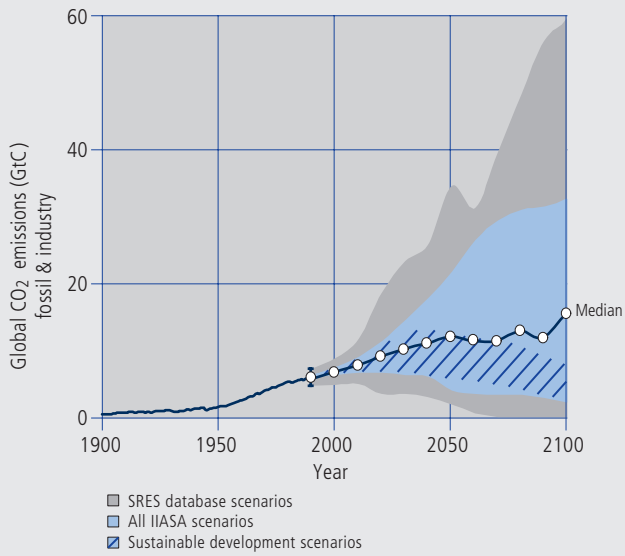


Figure 5. Global carbon dioxide emissions, actual development from 1900 to 1990 and in the scenarios (140 of which from SRES database) from 1990 to 2100.

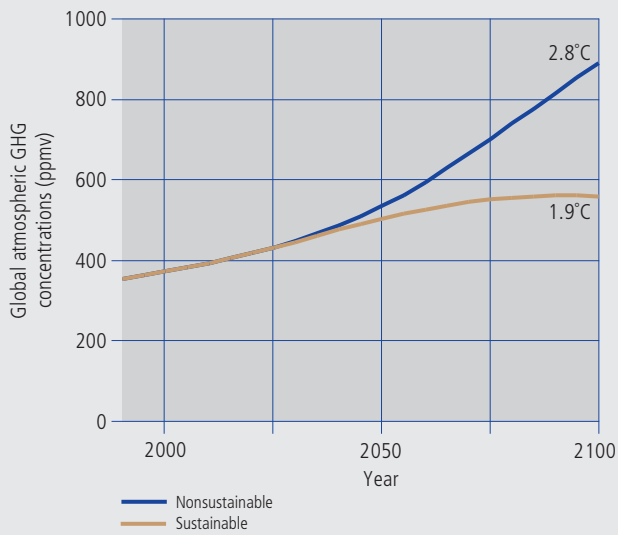


Figure 7. Global atmospheric GHG concentrations and "best guesses" (climate sensitivity assumed to be 2.5 °C) of average global temperature increase in two typical scenarios.

In summary, from the analysis of SD scenarios we conclude the following:

- Slow population growth or stabilization of the global population appears to be a prerequisite for sustainable development.
- Global future economic growth alone does not guarantee a sustainable future. More important in this respect is whether or not the economic and environmental inequities among regions are reduced.
- In a sustainable future, energy intensity must improve at least as fast as the historical trend (1% per year), and carbon intensities of total primary energy must decrease much faster than the historical trend (0.3% per year).
- To achieve sustainable development, strategies for fossil resource consumption must aim at non-decreasing R/P ratios by making sure that technological progress continues to convert subeconomic resources into economically recoverable reserves as long as fossil fuels are produced.
- Carbon emissions may increase in the short run, but they must be near or below today's level at the end of this century.
- Consistently high market shares of solar photovoltaic and hydrogen fuel cell technologies in the SD scenarios suggest that these technologies could be the most promising long-run options for achieving sustainable development. Natural-gas technologies, particularly fuel cells and combined cycles, could accomplish a smooth and efficient transition to eventual sustainability.

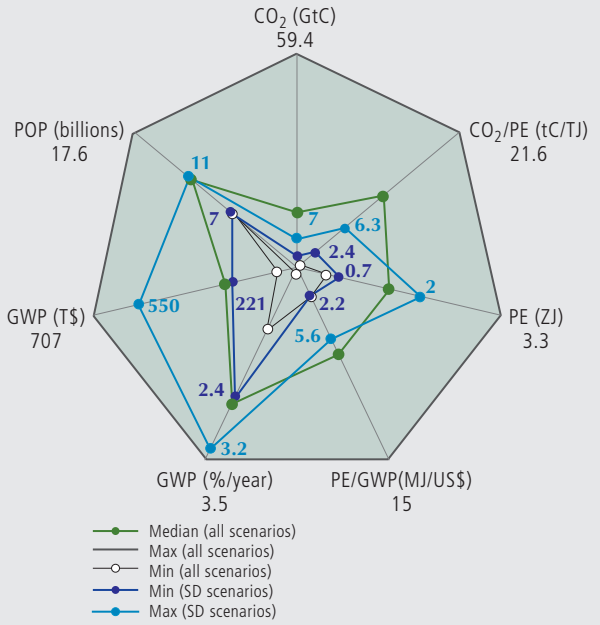


Figure 6. Global carbon dioxide emissions and their main driving forces. Minimum and maximum values for the SRES database and the SD scenarios are shown on the seven axes of the heptagon. The axes show the ranges across the scenarios in 2100: CO_2 emissions in GtC; population in billions; gross world product (GWP) in trillion US dollars (T$) at 1990 prices; gross world product growth rates in percent per year; energy intensity in megajoules (MJ) per US dollar at 1990 prices; primary energy in zettajoules (ZJ; 10^{21} joules); and carbon intensity in tons of carbon (tC) per terajoule (TJ).

Table 1. Reserves-to-production (R/P) ratios and global production of natural gas and oil in sustainable development scenarios.

	Natural gas		Oil	
	Global production (EJ/yr)*	R/P ratio (years)	Global production (EJ/yr)	R/P ratio (years)
SD scenario estimates for 2100**				
SRES-A1T	196	127	77	178
SRES-B1	215	49	45	55
SRES-B1G	244	40	53	44
SRES-B1T	166	81	48	54
1990 value	72	58	139	43

*EJ = exajoules.
**The R/P ratios for the three WEC SD scenarios are not available.

Figure 7 illustrates the difference between a typical SD scenario and a scenario that does not fulfill the criterion of environmental sustainability according to our working definition. In it, we show two trajectories of global atmospheric GHG concentrations, one typical of an SD scenario and one that belongs to a nonsustainable scenario. Assuming a middle value of climate sensitivity of 2.5 °C, the average global temperature increases by 2.8 °C in the nonsustainable scenario and by 1.9 °C in the SD scenario compared with the average global temperature in 1990.

Neither of the two scenarios complies with the "Kyoto targets." As has been generally acknowledged, fulfillment of the Kyoto targets would be an important beginning, but in itself is not sufficient to stabilize the global climate. This goal needs to be followed by many more steps, and by many more commitments from the Parties to the Framework Convention on Climate Change. From the same longer-term view, however, the fulfillment of the Kyoto targets is not necessary either, provided that their under-fulfillment in the 2008–2012 time period is compensated for later. The analysis of SD scenarios is therefore an important step toward formulating long-term strategies aimed at climate stabilization and at sustainable global development in general.

Our working definition of SD scenarios is just an initial step toward making sustainability operational. Next steps might include the extension of our analysis to other sustainability indictors, such as global GHG concentrations, temperature change, or sea level rise. In addition to analyzing our scenarios with refined definitions of sustainable development, IIASA's ECS Project also plans to develop new global scenarios that include the goal of sustainable development from the very beginning.

Sustainability and Justice

Can insights into how communities and countries distribute environmental burdens within and across borders give insights into how the international community might share the burgeoning losses of weather-related disasters? IIASA researchers are asking this question as they explore public views on fairness in sharing the burdens of flooding in Hungary's Upper Tisza River basin and in transporting wastes across Austria's borders.

During the past decade, economic losses from floods, storms, and other disasters have increased dramatically—about 14-fold from the decade of the 1950s, according to Munich Re. Most of the deaths and about one-quarter of the economic losses occur in the developing countries. Considering a recent conclusion of the Intergovernmental Panel on Climate Change that global warming will likely increase the intensity and frequency of extreme weather events, and considering the North's contribution to global warming, issues of equity become paramount. How should and how can the North contribute to reducing the vulnerability of developing countries to weather disasters?

Equity in the distribution of society's risk burdens—whether at the global, transnational, or local scale—is a prerequisite for sustainable development. While experts focus on estimating environmental risks, the public often asks, *Who is responsible? Who bears the risks? Who decides*? These questions of fairness and democratic process are core to IIASA's research at the local, national, transnational, and global scales.

Justice at the Local Scale: Floods on the Upper Tisza River

Most recently, IIASA has been asking how insights on local justice in the management of flood risks in the Hungarian Upper Tisza River basin can inform distributive policies for victims of extreme events at the global and transnational scales. IIASA researchers have found that *responsibility* for the imposition of environmental and health risks plays a key role in how people judge the fairness of policies to deal with these risks.

The Upper Tisza River flows through one of the highest flood-risk and poorest agricultural regions of Hungary, where the communities are accustomed to government protection in the form of flood levees and compensation to flood victims. While many view taxpayer support as fair for this destitute region, there are mounting concerns that it is unsustainable. Levees inevitably increase flood risks farther downstream, and compensating flood victims is not only discouraging local efforts to reduce flood losses, but is also causing serious fiscal problems for the Hungarian budget. The government would welcome increased private responsibility and insurance, a measure that few could afford and thus a measure that would force many villagers to leave the area. Moving the villagers out and renaturalizing the river are measures many consider to be more

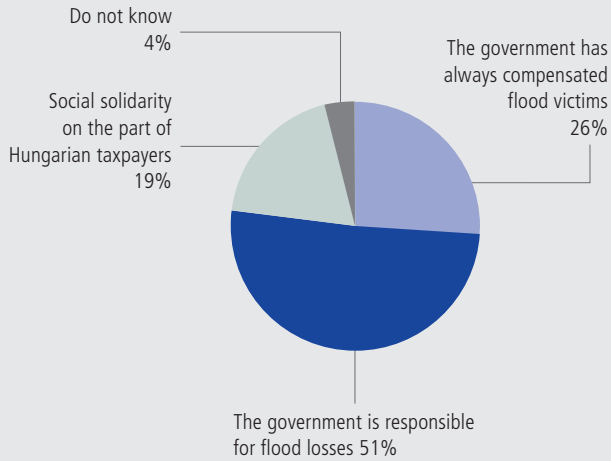


Figure 1. What is the most important argument for government compensation to flood victims?

Table 1. What measures do you think would be most effective for reducing flood losses in Hungary?

	Chosen by (%)
Heightening and strengthening the existing levees	74
Reforestation	61
Maintenance of the drainage systems	45
Preventing construction in high-risk areas	27
Removing levees to increase catchment areas	21
Development of forecasting and warning systems	21
Provision of more resources to water management authorities	16
Financial support for transferring people out of high-risk areas	14
Informing the public about flood risks and their mitigation	10
Introducing appropriate agricultural activities	9
Re-naturalization of parts of the river	6

ecologically sustainable but, at the same time, unfair. This dilemma illustrates the complexity of the human dimensions and sustainability debates.

As pointed out in the lead article of this issue of *Options*, multiple stresses result from both environmental and socioeconomic change, and the fact that these changes interact points up the need for systemic analysis. The IIASA team, in collaboration with its Hungarian and Swedish partners, is developing an integrated systems approach to address the human and environmental dilemmas in the Upper Tisza case. Interviews with key stakeholders and a public survey to elicit views on equity and sustainable development form the basis of a flood catastrophe model that is giving insights into the types of insurance and mitigation measures that are likely to command widespread public support.

Figure 2. Developing countries with over US$1 billion in losses over the past 20 years.

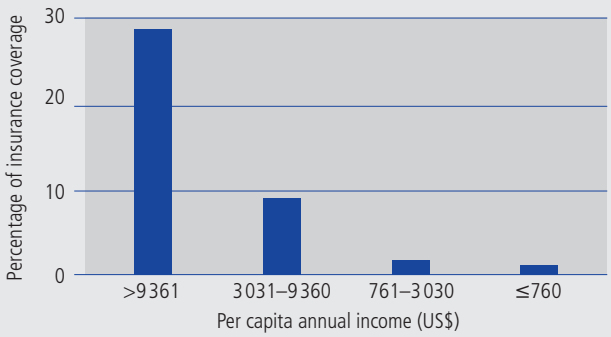


Figure 3. Risk transfer/insurance in low-income countries.

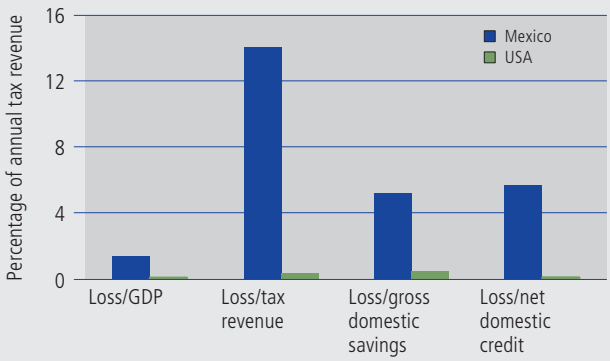


Figure 4. A comparison of financial vulnerability: Mexico and the USA.

The interviews show that many local mayors in this region are enthusiastic about policies that return the river to a more natural state and promote soft tourism at the expense of flood protection. However, the public within and outside the region is more cautious about renaturalizing the river: the mitigation measure that received the most support is investing in levees, but reforestation and zoning to limit construction in high-risk areas also received a great deal of support. Less popular measures include relocating people out of the region and placing more responsibility on the local population (see Table 1).

In contrast to the assumptions of many economic models, the views of the Hungarian public often do not coincide with their personal economic interests. The majority of the survey respondents, *including those facing no risks,* thought the taxpayers should continue to aid Tisza victims. As shown in Figure 1, the main argument given for government relief was that the government—by not pursuing more sustainable policies in the region—is largely *responsible* for these risks. This strong public commitment to social responsibility and solidarity is essential to IIASA's work aimed at helping Hungarian policy makers design more sustainable mitigation measures and a public–private insurance system.

Justice at the Transnational Scale: Hazardous Waste Disposal in Austria and the Czech Republic

Fairness and responsibility are also key concerns across political borders, for example, in siting hazardous waste facilities. In the face of public resistance to siting a waste incinerator in Austria, an IIASA survey explored the fairness of constructing a state-of-the-art waste incinerator across the border in the Czech Republic, but only on the condition of Czech consent to the deal based on sufficient compensation to reduce the country's much higher risks in other areas (e.g., infant mortality). Economists would regard this as a Pareto fair deal, where all parties consent and feel themselves to be better off. Yet, *over 80%* of the Austrian respondents rejected this option, mostly on the grounds that Austrians should take responsibility for their own wastes and thus dispose of them in their own country. As in the Tisza River flood study, it turns out that responsibility for imposition of the risks is a key concern to the public. These and other IIASA results on local justice are shedding light on environmental debates at the global level. Might, for example, the attribution of responsibility explain the opposition voiced in developing countries to other Pareto efficient and fair deals, like tradable emissions permits and joint implementation for reducing greenhouse gas emissions?

Justice at the Global Scale: Weather-related Disasters in Poor Countries

Moving from local and transnational to global justice, as the North accepts greater responsibility for global warming, how might this translate into fair procedures for aiding the South in adapting to these changes? One form of adaptation will be to extreme weather events, from which the poor suffer disproportionately more, especially in their dependency on critical infrastructure (see box below). As shown in Figure 2 on the previous page, about 50 developing countries have experienced losses in excess of US$1 billion over the past two decades.

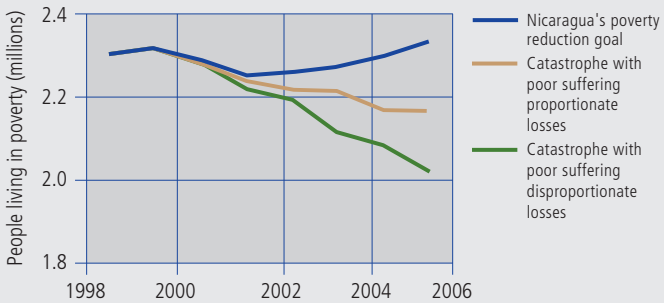
Disproportionate Impacts of Climate Variability on the Poor

The poor bear a disproportionate burden of direct damage from catastrophes, and climate change will exacerbate this effect. It is only in poor countries that drought turns to famine, often resulting in substantial economic losses, population displacement, suffering, and loss of life. The social and economic costs of such occurrences may undo the achievements of years of development efforts. The poor generally are more vulnerable, suffer greater costs, and have less capacity to take compensating action.

One factor in this heightened vulnerability to the devastating consequences of natural disasters is the reliance of the very poor on critical infrastructure. Reliable access to essential services such as clean water, energy, shelter, transportation, and medical care is critical to achieving and maintaining minimum living standards for the very poor. Research shows that long-term disability and destruction of infrastructure and services can trap families in chronic poverty. Furthermore, the poor not only have relatively fewer assets to lose, but the assets they do have are often of lower-quality construction and lie predominantly in higher-risk areas.

Catastrophes not only affect the sheer number of those living in poverty, they also accentuate the poverty gap. To the extent that the poor are disproportionately affected by catastrophes, and if no additional relief for catastrophe exposure is planned, the poverty impacts of disasters will be magnified, as illustrated in the figure below.

The challenge of integrated mitigation and adaptation to climate change, climate variability, and extreme events will entail incorporating these issues into long-term development strategies that are equitable and sustainable.



Governments of very poor and very disaster-prone countries—for example, Honduras, the Philippines, China, and Mexico—face such enormous risks that a single disaster can set them back years in their development. When calamity strikes, the poor may be barely able to meet their basic human needs. In Central America, over half the population lived below the poverty line even before Hurricane Mitch struck the region in 1998 leaving a large percentage of Guatemala's citizens destitute. As shown in Figure 3, few citizens (or governments) of poor countries hold or can afford insurance policies to transfer their risks of private property or public infrastructure losses from catastrophic disasters. Insurance would enable governments to expedite the recovery process, especially since many governments of poor countries face budgetary restrictions in providing disaster relief and repairing public infrastructure after a major disaster.

The ability of developing countries to share their losses by shifting risks internally—or even externally to the global insurance and capital markets—does not approach the ability of developed countries to do so. For example, the US$4 billion loss from the 1985 earthquake in Mexico City in current dollars is equivalent to 14% of Mexico's annual tax revenue; in the United States this same amount is equivalent to 0.4% of US tax revenue (Figure 4). Compared with domestic savings and with net domestic credit, the relative cost to Mexico is, respectively, 13 times and 70 times higher than to the United States.

IIASA research has shown that Mexico and many countries in the developing world could potentially benefit from insurance or insurance-related financial instruments (e.g., catastrophe bonds) that are put into place before the disaster occurs, especially if these instruments are designed to create incentives for loss-reduction measures. However, since poor countries can least afford risk-transfer instruments, the central issue is whether disaster hedges combined with loss-reduction policies could become a new form of aid from the North to the South. This issue takes on increasing topicality as the North accepts partial responsibility for the rising toll of weather extremes in the developed world.

Might responsibility-led risk transfer, by taking advantage of new financial instruments for this purpose, eventually lead to the extension of social security systems from the national to the global level? Did analogous issues of responsibility motivate the extensive social security systems we find today not only within countries, but also across many cultural and jurisdictional borders? IIASA and its partners at the University of Bergen Rokkan Center, who are collaborating on a seven-country study of citizen participation in welfare reform, are exploring whether the future of global security can be informed by examining national social security histories.

The Experience of Transition in Central and Eastern Europe

The collapse of the communist system in Central and Eastern Europe was not caused primarily by economic crisis or the growing public perception of extensive environmental damage; rather, the political and social transformations were spurred, apart from the political thaw due to the Gorbachev reforms in the Soviet Union, by the realization that the communist system was unsustainable in the long run. Transition from a centrally planned to a democratic, market-based system promised sustainable economic development for the benefit of the people living in those countries.

It is, however, justifiable to ask—as the citizens of the transition economies began doing quite early in the transition process—if the transformation has really fulfilled this promise. Three questions arise:

- Did the changes bring the promised results, particularly in the form of faster economic development?
- Have the benefits been felt by a broad group of ordinary citizens?
- Has integration into the world economy been the proper way to enhance this development?

Answering questions such as these requires comparative analysis and research into the complex phenomena of the political, social, and economic transformations that have taken place in more than 25 transition countries over the past decade. It is crucial to distinguish apparent developments from essential ones and transitory events from long-term tendencies, and to identify policy packages that initiate the required radical changes but that are also politically feasible. The results should not be reserved for scholarly discussions, but should be made available for policy discourse and for the preparation of alternative development scenarios for policy makers.

Ensuring Sustained Growth of Output: Economies in Transition

The first puzzle faced by researchers and policy makers alike was the unexpected and unprecedented output decline that followed the start of transition in every economy of Central and Eastern Europe. Although after some years limited recovery was felt, even after a decade of transition several economies still perform substantially below their pre-reform levels and show vulnerability to external shocks (such as the Asian and Russian crises in 1997–1998).

Identifying the causes of the "transformational recession" and the conditions necessary for a rapid recovery has required thorough investigation, in which IIASA's Economic Transition and Integration (ETI) Project has played an important part. Recent analyses of the output decline have provided some explanations for the considerable differences seen across countries in terms of the depth and length of the recession. It was found that adverse initial conditions (e.g., high trade dependency, overindustrialization, strong repressed inflation, macroeconomic imbalances, etc.) were largely responsible for the steepness of the output decline in the early years of transition, particularly for the severe drop of output in the former Soviet Union. However, these starting conditions were found to be less important for determining the differences in the development of gross domestic product in the recovery phase. At that stage, structural policies became pivotal, including establishing property rights, tightening the budget constraints of firms, establishing a healthy banking system, and creating and maintaining true competition on the domestic markets. The importance of these policies was frequently overlooked in the early phases of the transition.

The challenge for the 10 East European countries aiming to join the European Union (EU) is to catch up with the Union's advanced market economies. Not only do politicians favor this "return to Europe," but economic theory, too, predicts that if certain, admittedly strict, conditions are met, poorer countries will catch up with the standard of living in the more advanced ones. This process of *real convergence* is not automatic. Understanding the factors and mechanisms that accelerate growth, particularly in the context of accession to the EU, requires theoretical clarification and empirical assessment of economic and political conditions for alternative development scenarios.

With the exception of 1999, in each year since 1995 the growth rate in the 10 candidate countries has been higher than the average in the EU. To sustain this growth difference, it is not enough for the new members of the EU to benefit from the expected growth bonus of membership in the Union (through more intense trade and lower transaction costs in trade, increasing inflows of foreign direct investments, and substantial transfers from the Union). Proper policies and further institution building will be crucial. For instance, to ensure a higher rate of domestic and foreign savings, the financial systems of the candidate countries must be made more transparent and robust, and the budgetary reforms must progress. Since most of the candidate countries are small, their technology potential relies heavily on technology spillovers from

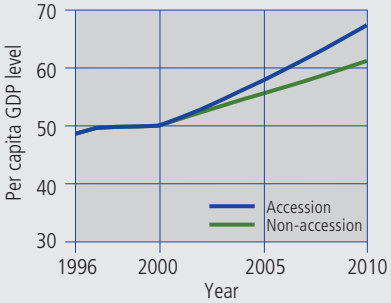
abroad, particularly through foreign establishments in these countries. This suggests the need for policies that increase and maintain the attractiveness of the candidate countries for foreign direct investments by multinational companies. The new EU members will be beneficiaries of financial transfers from the Union. However, to be able to absorb these potential transfers, proper national and regional institutions must be set up, and appropriate development projects must be elaborated, monitored, and efficiently carried out.

Benefits for a Broad Public?

In Central and Eastern Europe, the rosy expectations concerning a well-functioning democratic political system and a thriving capitalist economy evaporated quickly. There have been obvious political and economic advantages to the new system, such as freedom of speech, freedom of organization and movement, the disappearance of shortages and inferior-quality goods and services, new possibilities for private initiatives, etc. However, these opportunities were able to balance the hardships of transition only for a short period of time and only for small groups of citizens. The public at large had to face the loss of employment (or the threat of it), the implications of high inflation, declining real wages, and the loss of the previous stability in general. This has led many to ask if the changes have really served the people as a whole, or only a small stratum of the new elite. Disappointing changes in various indicators of human development, such as growing income inequality, increasing poverty, and in some countries deteriorating health and educational standards, show that transition so far has focused much less on the human dimension of development than originally envisaged. Certain groups and strata of the society have clearly lost out in the transformation and show increasing deprivation. People who have become unemployed and are now living on social benefits, farmers, households with many dependents (especially where the head of the household has a low level of education), and minorities (particularly the Roma minority) see fewer and fewer avenues for maintaining their previous position in society.

The egalitarian communist regime ensured a respectable level of income equality by implementing

Scenarios for Catching Up

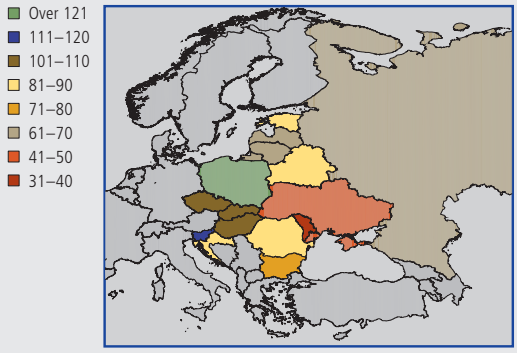


In 1999–2000, ETI contributed to the EU-financed international collaborative project *PREPARITY*. Here, ETI elaborated development scenarios for the East European EU candidate countries according to (1) accession to the EU in 2005, and (2) no accession before 2010.

See www.iiasa.ac.at/Resesarch/ETI and www.preparity.wsr.ac.at

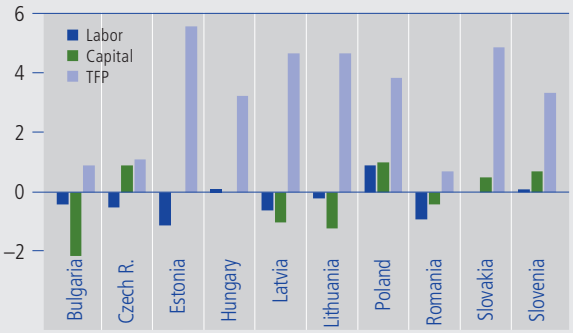
Scenarios for catching up with the per capita GDP level of the EU (at purchasing power parity rates) in five candidate countries (Poland, the Czech Republic, Slovakia, Hungary, and Slovenia), EU15=100. Source: Calculations for the *PREPARITY* project.

Cumulative Shift in GDP



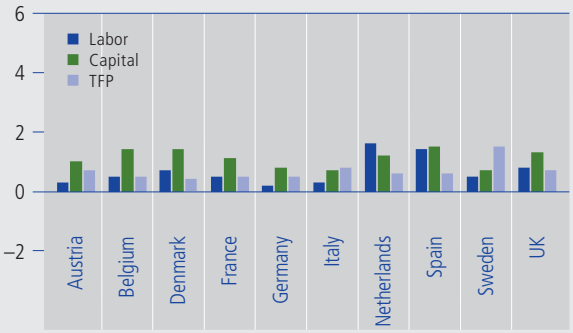
Real GDP in East European countries in 2001 as percentage of GDP in 1989.

Factors of Growth: Candidate Countries



Candidate countries: Contribution of labor, capital, and total factor productivity (TFP) to growth of GDP in 1995–1999, annual average rates, percent. Source: Dobrinsky (2001), IIASA IR-01-038.

Factors of Growth: EU Countries



EU members: Contribution of labor, capital, and total factor productivity (TFP) to growth of GDP in 1995–1999, annual average rates, percent. Source: Dobrinsky (2001), IIASA IR-01-038.

In 2000–2001, ETI's project *Catching Up and EU Accession* investigated the conditions of a rapid convergence of the candidate countries before and after their accession to the EU. *Left*: As the growth patterns in the candidate countries in recent years illustrate, the contributing factors were dominated by gains in total factor productivity (TFP), indicating the presence of large reserves for improvements in allocative efficiency and X-efficiency in the region. *Right*: This predominance of TFP was in sharp contrast to the pattern in the EU in the same period, where growth was dominated by contributions of fixed capital.

measures incompatible with market economies and democratic principles. These included: mandatory work; centrally financed full employment; centrally supported notional prices for staple products and services; centrally set, highly equalized wages; strict statutory limits on incomes and the use of these incomes, etc. It was obvious that in order to establish a market-based economy, this system of measures had to be completely eliminated. Nevertheless, the inevitable growth of income inequality could have been moderated to prevent the emergence of poverty at the scale experienced in some Central and East European countries.

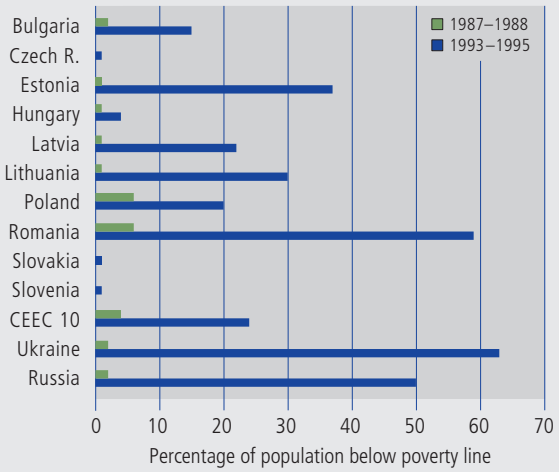
The lesson from the fairly complex, but mostly disappointing, picture of human development in the transition countries is that even if the optimistic expectations for a rapid catch-up with the advanced market economies are realized, new institutions must be established and operated to alleviate poverty, moderate extreme income inequality, and provide broad social security in the new market environment. Without this institution building, the transition process in Central and Eastern Europe will create lasting social tensions that will threaten the social cohesion of these societies.

In 1995, ETI's project on *Output Decline in Eastern Europe* found the following:

- The output decline was primarily due to factors on the demand side.
- The lack of institutions that could have enabled relocation of resources from old, shrinking sectors to new ones also played a role.
- A timely recovery required filling the institutional and entrepreneurial void, sanitizing the financial system, and supporting export-led growth.

See Holzmann, R., Gács, J., and Winckler, G., eds., 1995, *Output Decline in Eastern Europe: Unavoidable, External Influence or Homemade?* Dordrecht: Kluwer Academic Publishers.

Poverty Increase: Early Years of Transition



The increase of poverty in the early years of transition (% of population under the poverty line). Source: Milanovic, B. (1998), *Income, Inequality, and Poverty During the Transition from Planned to Market Economy*, and ETI calculations. Based on income data from Household Budget Surveys; the poverty line is defined as US$4 per day (in 1993 US$ at purchasing power parity).

One of the disappointing changes in human development in Eastern Europe has been the increase in poverty.

Transition under External Guidance

The transition countries have benefited considerably from external advice and from the adoption of those institutions and procedures that have proved useful in other parts of the world. After the break with their autarkic past, increasing exchange and interaction with the world market were key elements in the acceleration of their transformation: in this way they could not only increase their turnover in trade, but "import" world market prices, competition, and managerial and technological knowledge. Increased participation in global networks—whether economic, cultural, scientific, or political—has substantially accelerated systemic transformation since the early 1990s. However, this growing external influence has also spurred tensions that seem to have intensified recently. The sensitivity to external influence is particularly strong in the transition countries because they are in the process of redefining themselves as independent nation-states; they emphasize self-determination based on their traditional historical and cultural values. Consequently, with good reason or not, external advice and pressure are regularly blamed for misguided policies.

In recent years the transition economies have become members (or active members) of many international organizations, such as the IMF, the World Bank, the WTO, and the OECD. The more international organizations they become members of, the narrower the array of discretionary policy actions their governments can choose from autonomously. In addition, in recent years most of the reforms and policies in the EU candidate countries have been geared to EU accession. Consequently, policy changes in these countries are increasingly influenced by the EU: the planned membership requires the countries to fulfill the so-called Copenhagen criteria, to adopt the *acquis* (the EU's body of legislation and rules), and to face regular evaluations by various institutions of the EU. For decision-making bodies in the candidate countries, it is not easy to give up the independence that was regained after so many decades of subordination. While the general public has only vague ideas about the future benefits of EU membership, they see the road to accession as a process in which the new independent nations will lose their long-awaited autonomy. It is not by chance that recent public opinion surveys and parliamentary elections in the candidate countries have shown growing uneasiness and dissatisfaction with the coming accession.

Researchers and politicians alike are faced with the important task of clarifying—not only for the policy and research communities, but for the public as well—the advantages and disadvantages of the growing internationalization for the countries of Central and Eastern Europe. They must search for the proper institutional reforms that will strengthen local initiatives in the European political and economic framework.

Environmental Security in the Context of Sustainable Development: New Challenges for Negotiation Analysis

Because of their transboundary character, many environmental hazards require international cooperation. International environmental regime building has typically been characterized by the strong role reserved for the scientific community. For example, the Intergovernmental Panel on Climate Change (IPCC) represents a new kind of institution created to facilitate the participation of scientists in international policy making. However, in many cases purely technical approaches do not produce satisfactory solutions to ecological problems, because these risks have important repercussions outside the environmental sector. The issue of climate warming illustrates part of this complexity. Policy measures to cope with or preempt climate change pertain to numerous policy areas, including agriculture, transport, and industrial production. In developing countries, this predicament can be described as a link between environmental policy and development. Hence international environmental policy making has to be better integrated into long-term strategies to promote *sustainable development*. In this context, one of the problems confronting many policy makers—including governments, actors in the private sector, and nongovernmental organizations—is that the economic, social, and political consequences of environmental problems contribute to their being regarded as security issues.

Experts have suggested various definitions of environmental security, but no single definition has prevailed. Most analysts would probably agree, however, that environmental insecurity has to do with the likely loss of what we consider to be of especially high value—such as human lives or essential natural resources like clean drinking water—as a result of ecological destruction. Labeling an issue a security problem is not merely a matter of classification. Security issues tend to be treated in a special way by policy makers. For example, governments are ready to accept higher economic or political costs and to take greater risks when they are working with security issues than when they are engaged in normal day-to-day affairs, or "low politics." Therefore, environmental security issues may represent threats for some parties, not only because of the environmental destruction they may cause, but also because of the policy responses they may generate.

The significance of environmental security is highlighted by its rising profile on the agenda of the upcoming World Summit on Sustainable Development in Johannesburg, South Africa. Coping with environmental security is a complex task that may require new approaches, including institutional reform in the United Nations (UN) system and in other international regimes. Effectiveness and relative success in environmental regime building have so far depended on continued issue fragmentation, today manifested by the existence of more than 200 international treaties on environmental issues. The efforts of the UN Conference on Environment and Development (UNCED) process to bring some coherence to policy making in the environmental sector should not be underestimated. Agenda 21 doubtless has been important in that regard. Nevertheless, additional measures are necessary to take linkages across different environmental issues into consideration more systematically.

The most important challenge, however, is to put environmental problems—including environmental security—into the context of sustainable development. Transboundary environmental problems often have a global reach and hence are the responsibility of the international community. Environmental security has primarily been a concern of the more developed countries. In many developing countries, environmental risks have been overshadowed by the interrelated difficulties of economic and social development. Poverty—not the risk of deteriorating environmental quality—has represented the main threat in the developing world.

It is not surprising that industrialized and developing countries have developed different agendas to cope with the new security issues. This in itself is an obstacle for effective international cooperation. Differing priorities should not be permitted to conceal the interdependence of environmental degradation and poverty. On the one hand, decreasing environmental quality is associated with the destruction of natural resources—for example, water or wood used for cooking or heating—which, in turn, worsens poverty. On the other hand, poverty exacerbates environmental destruction—for example, in the form of accelerated desertification. Poverty is also a potential cause of more traditional security problems,

including different forms of organized political violence driven by extreme frustration and desperation.

Institutional reform is necessary for integrating environmental problem solving into efforts to promote sustainable development in global institutions in a more consistent and far-reaching way. In theory, the overall UN machinery should have the capacity to deal with the various significant dimensions of sustainable development, including the special problems of environmental security. Furthermore, the Economic and Social Council (ECOSOC) and a few other UN institutions have a special responsibility for the kind of intersectoral policy coordination that is required for implementing effective sustainable development strategies.

However, a realistic and critical view suggests that a more effective approach to addressing environmental security in the context of sustainable development strategies and policies presupposes changes in the *forms* of international policy making and compliance control. Obviously, institutional design represents a critical part of such a reform, particularly with regard to intersectoral policy coordination. However, innovative process design is also an important, albeit somewhat neglected, element of regime-building reforms. For example, it is crucial to increase the direct or indirect participation of those people who are the principal victims of poverty in the international cooperative processes organized to promote sustainable development. As long as these groups have not become stakeholders in international negotiations, there is a risk that the solutions designed to cope with poverty and environmental security will backfire and generate more problems than they eliminate.

The outcome of complex international policy processes is certainly conditioned by various external, structural circumstances—for example, the prevailing international power "distribution," or the landscape of international regimes. The intentions of key actors also represent a crucial factor. However, it is equally obvious that structural background factors and actor intentions do *not* predict outcomes in a straightforward way. How the parties interact to attain a desired cooperative outcome is also crucial. In other words, it is important how the policy-making process is organized and how international policy making—that is, negotiation—is actually carried out. Therefore, analysis related to process design should precede the reform of institutional bodies set up to ensure effective strategies and programs of sustainable development in a global context. It is in this area in particular that IIASA's Processes of International Negotiation (PIN) Network has the potential to contribute to sustainable development.

PIN's focus is process, often ignored in substantive studies on specific issue areas. Analytical attention tends to be placed on where to go rather than on how to get there. Yet one of the basic lessons of the study of negotiation is that where one ends up largely depends on how one gets there. In decision studies, there is goal analysis and there is path analysis; policy makers need to understand and control the latter. Unless the processes of negotiation are mastered and improved, substantive findings to benefit human development and security will not be able to find their optimal use and application.

The theme that runs through all of the PIN studies of the processes of dealing with diverse challenges to human security and welfare underscores the importance of "giving something to get something" or "buying something when the price is not fixed," two popular ways of characterizing negotiations. Both definitions point to the need to distribute benefits and therefore to the need to optimize the allocation process when new benefits are created or stakes are reframed so as to avoid a zero-sum perception of distribution. Through the PIN Network, IIASA has been focusing on important human aspects of many scientific studies and the process of arriving at the goals they analyze and identify.

Human Security and Science and Technology

In October 2001, IIASA hosted the international seminar on Human Security and Science and Technology. This seminar brought together numerous members of diplomatic missions, Austrian ministry officials, and representatives from the United Nations. It was organized by Ambassador Raimundo Gonzáles Aninat of the Permanent Mission of Chile to the International Organizations in Vienna and sponsored by the Austrian Federal Ministry for Foreign Affairs, the United Nations Office at Vienna (UNOV), the United Nations Industrial Development Organization (UNIDO), and IIASA.

The seminar was inaugurated by Dr. Benita Ferrero-Waldner, Austrian minister for foreign affairs, and by Mr. Pino Arlacchi, director-general of the United Nations Office at Vienna, and focused on three key aspects: the concept of human security; science and technology: their contribution to human security; and the politics of science and technology necessary to guarantee human security.

Global Science Panel on Population and Environment

Population Belongs on the Johannesburg WSSD Agenda

If we do not put the human population at the core of the sustainable development agenda, our efforts to improve human well-being and preserve the quality of the environment will fail. The Johannesburg Summit must address the need to integrate population in sustainable development. (from the Global Science Panel Statement)

In 2001 IIASA, the International Union for the Scientific Study of Population (IUSSP), and the United Nations University (UNU) started a joint initiative to prepare a comprehensive scientific assessment of the role of population in sustainable development strategies, with the aim of producing a science-based policy statement as input to the World Summit on Sustainable Development (WSSD) in Johannesburg.

The Global Science Panel (GSP) comprises 30 distinguished scientists from various disciplines and comes under the joint patronage of Maurice Strong and Nafis Sadik. It is coordinated by Wolfgang Lutz and Mahendra Shah, and receives financial support from the United Nations Population Fund (UNFPA), the government of Austria, and the MacArthur Foundation.

Initial discussions were held at a meeting at the Netherlands Interdisciplinary Demographic Institute and at general conferences organized by the IUSSP and the International Human Dimensions Programme on Global Environmental Change (IHDP). Through two cyber seminars, GSP also received substantive expert input from the population, human dimensions, and sustainable development communities. Full documentation of these seminars can be found at www.populationenvironmentresearch.org.

The GSP statement was finalized at a Panel meeting held at IIASA in March 2002 and presented on 5 April 2002 at a WSSD PrepCom III Side Event at the UN Headquarters in New York. It reflects the views of the panel members and not necessarily those of the sponsoring institutions. The following is from a report on GSP's presentation (www.iisd.ca/2002/pc3/enbots):

Mahendra Shah and Wolfgang Lutz briefing the WSSD PrepCom III Event.

"Mahendra Shah, IIASA, underscored that population affects all problems addressed by Agenda 21 and the WSSD process, but noted that population issues are not integrated into all chapters of Agenda 21 nor throughout the Chairman's Paper for the WSSD. He emphasized that sustainable development will require concrete policy actions to achieve a balance between population and the resource base, which includes education, human development and livelihoods. He stressed that population is not just about numbers but about qualitative human dimensions, and underscored the need to employ a people-targeted approach and focus on poverty and unsustainable consumption.

"Wolfgang Lutz, IIASA, introduced the [GSP] science-policy Statement on Population in Sustainable Development.... The Statement calls on the WSSD to recall [the first principle of the 1992 Rio Declaration] 'that human beings are at the center of sustainable development,' by taking full account of how population and society interact with the environment. It highlights the demographic diversity of the world, with population growing in some areas and shrinking in others, and levels of mortality, mobility, urbanization and education varying among and within regions, and emphasizes that this diversity requires differentiated responses.

"The Statement emphasizes the impacts of population on development and the environment, noting that rapid population growth can exacerbate problems such as freshwater depletion, climate change, biodiversity loss and degradation of agricultural lands, and that high consumption rates magnify the environmental impacts of population growth in high-income countries. It emphasizes that the majority of the world's population will live in urban areas by the end of the decade.

"The Statement underscores that policy must account for differential vulnerability within populations, as deteriorating environmental conditions affect different countries, populations and households differently, and says vulnerability can be reduced by promoting empowerment, investing in human resources, and fostering participation in public affairs and decision making. The Statement emphasizes that empowerment through education and reproductive health has multiple benefits for people and the environment, and that efforts to achieve sustainable development should give these policies the highest priority."

For further information see www.iiasa.ac.at/gsp

IIASA Networking for Sustainability

At the Delhi Summit on Sustainable Development in February 2002, Günther Fischer of IIASA's LUC project presented "Climate Change and Food Security", coauthored by Mahendra Shah. The paper, based on a global agro-ecological assessment, highlights the varying impacts of climate change on food production around the world. Developing countries are likely to bear the brunt of negative impacts of climate change, whereas major developed countries are expected to make substantial gains in agricultural potential. While the international community addresses climate change mitigation policies, e.g., the Kyoto Protocol, it is equally essential to substantively strengthen agricultural research to develop adaptation strategies in developing countries. Without the latter, long-term world food security cannot be achieved.


Günther Fischer, *left*, and Nebojsa Nakicenovic, *right*, presented papers at the Delhi Summit on Sustainable Development.

At Plenary Session 9 of the Delhi Summit, Nebojsa Nakicenovic of IIASA's TNT Project delivered a talk on technological leapfrogging as an important component of the transition to sustainability, taking examples from energy, mobility, and information systems. Technological leapfrogging implies skipping many, if not most, rungs of the technology development "ladder" by directly adopting more advanced technologies. Most rural households cannot access basic energy services and rely heavily on traditional means, which adversely affect health and well-being in addition to depleting the country's limited natural resource base. Advancement in science and technology offers unprecedented opportunities for sustainable development.

In May 2002, Dr. Nakicenovic attended a "Synthesis Workshop on Science and Technology for Sustainable Development" in Mexico organized by the Initiative on Science and Technology for Sustainability (ISTS), the International Council for Science (ICSU), and the Third World Academy of Sciences (TWAS). The meeting aimed at articulating a shared vision of goals for linking science and technology to sustainable development, relevant to but reaching beyond the World Summit on Sustainable Development (WSSD); proposing general strategies and specific priority activities for achieving those goals, including but reaching beyond steps to connect with the WSSD; and specifying a set of benchmark indicators for 2005 and 2010 against which to evaluate progress in implementing the strategies and achieving the goals of sustainable development.

Workshop sessions addressed development-defined priorities for science and technology needed to advance sustainable development; science-defined priorities for fundamental research and innovation needed to respond to the immediate and future needs of the development community; and institutional needs for implementing the agenda described above.

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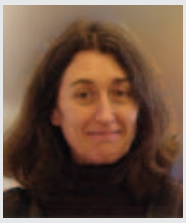
IIASA Scientists Honored



Joanne Linnerooth-Bayer, leader of IIASA's Risk, Modeling and Society (RMS) Project, was made a Fellow of the Society for Risk Analysis in December, 2001, in recognition of the major national and international contributions she has made to the discipline of risk analysis. Dr. Linnerooth-Bayer's current work at IIASA is twofold, involving global change and the risk of catastrophic natural disasters as well as social risks from pension policy.

An honorary doctorate has been awarded to Roger Wets by the University of Vienna in recognition of his contribution to the field of stochastic optimization. Dr. Wets was leader of IIASA's Adaptation and Optimization Project from 1982–1991. While at IIASA, Wets collaborated closely with Vienna's Institute for Statistics and Decision Support Systems on stochastic optimization and stochastic equilibrium theory.

YSSP Scholarship Recipients for 2001

IIASA's Peccei Scholarships for the summer of 2001 were awarded to Anna Gårdmark (ADN Project) from the Department of Theoretical Ecology, Lund University, Sweden, and Yanhong Jin (LUC Project), a Chinese national from the Department of Agricultural and Resource Economics at the University of California at Berkeley, USA. The Mikhalevich Scholarship was awarded to Elena Moltchanova (FOR Project), a Russian national from the National Public Health Institute, Helsinki, Finland.

For details, see www.iiasa.ac.at/Admin/YSP

Anna Gårdmark

Yanhong Jin

Elena Moltchanova

Recent Publications

Adaptive Dynamics of Infectious Diseases

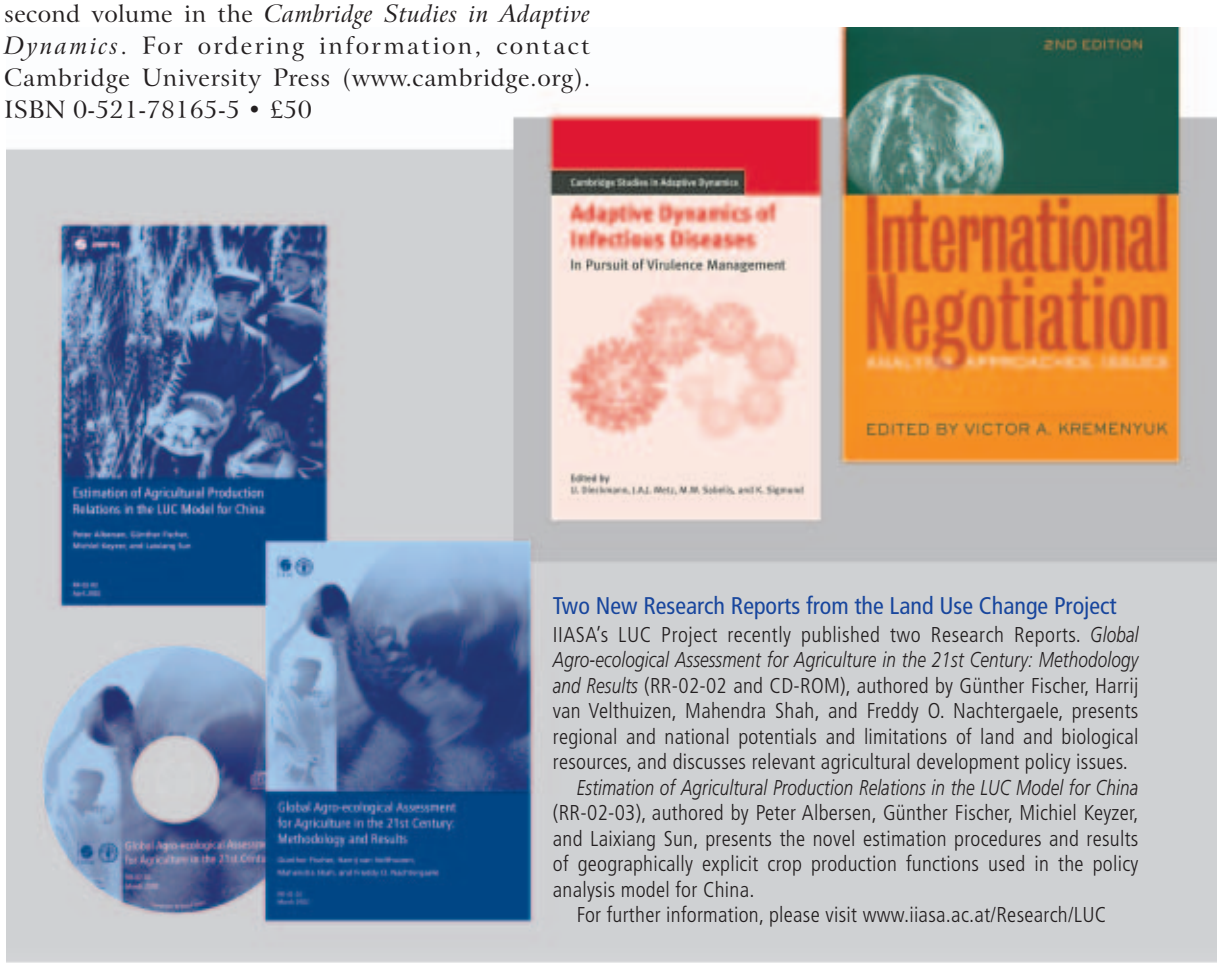
Emerging diseases pose a continual threat to public health. Fast multiplication and high rates of genetic change allow pathogens to evolve very rapidly. It is therefore imperative to incorporate evolutionary considerations into longer-term health management plans. The evolution of infectious disease is also an ideal test-bed for theories of evolutionary dynamics. This book combines both threads, taking stock of our current knowledge on the evolutionary ecology of infectious diseases and setting out goals for the management of virulent pathogens. Throughout the book, the fundamental concepts and techniques that underlie the modeling approaches are carefully explained in a unique series of integrated boxes. The book ends with an overview of novel options for virulence management in humans, farm animals, plants, wildlife populations, and biological control schemes.

Adaptive Dynamics of Infectious Diseases. In Pursuit of Virulence Management, edited by U. Dieckmann, J.A.J. Metz, M.W. Sabelis, and K. Sigmund, is the second volume in the *Cambridge Studies in Adaptive Dynamics*. For ordering information, contact Cambridge University Press (www.cambridge.org). ISBN 0-521-78165-5 • £50

International Negotiation Second Edition

The first edition of *International Negotiation* became a best-selling classic in the field of global conflict resolution. This second edition has been substantially revised and updated to meet the challenges of today's complex international community. In addition, two new chapters have been added on game theory and the legal perspectives on international negotiations. This important resource contains contributions from some of the world's leading experts in international negotiation, representing a wide range of nations and disciplines. They offer a synthesis of contemporary negotiation theory, perspectives for understanding negotiation dynamics, and strategies for producing mutually satisfactory and enduring agreements that is particularly relevant in these times.

International Negotiation. Analysis, Approaches, Issues is edited by Victor Kremenyuk of IIASA's PIN Network. The book is available from Jossey-Bass (www.josseybass.com). ISBN 0-7879-5886-7 • US$50



Two New Research Reports from the Land Use Change Project

IIASA's LUC Project recently published two Research Reports. *Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results* (RR-02-02 and CD-ROM), authored by Günther Fischer, Harrij van Velthuizen, Mahendra Shah, and Freddy O. Nachtergaele, presents regional and national potentials and limitations of land and biological resources, and discusses relevant agricultural development policy issues.

Estimation of Agricultural Production Relations in the LUC Model for China (RR-02-03), authored by Peter Albersen, Günther Fischer, Michiel Keyzer, and Laixiang Sun, presents the novel estimation procedures and results of geographically explicit crop production functions used in the policy analysis model for China.

For further information, please visit www.iiasa.ac.at/Research/LUC

In Memoriam

Gordon J.F. MacDonald

We were saddened by the death of Gordon J.F. MacDonald in May 2002.

IIASA's seventh director (1996–2000), Gordon was a renowned geophysicist and pioneer in global change research. He was a dedicated leader who truly believed in IIASA and strove to attain for it the recognition and support he felt our Institute deserved.

Gordon was a true scientist. He discussed scientific challenges directly with the Institute's researchers, demonstrating a desire to know, understand, and advise on the research carried out by each IIASA project and scientist. With his keen intellect and considerable experience in many scientific fields, he guided IIASA's research program. Gordon did this in his straightforward manner—leaving nothing unsaid—and his colleagues were never in doubt as to where he stood on an issue. Moreover, Gordon had a rare gift for communicating with young scientists at the beginning of their careers. He was particularly appreciated by the participants in IIASA's Young Scientists Summer Program (YSSP), who looked upon him as their personal advisor.

Gordon emphasized strict scientific standards and publication in international peer-reviewed journals and leading scientific publishing houses. He succeeded in making the Institute a leader in utilizing information technology, both for research and for disseminating research results. Gordon launched several new scientific initiatives at the Institute, such as those on Social Security Reform, National Catastrophes and Developing Countries, Transitions to New Technologies, and European Rural Development.

Gordon was educated at Harvard University (PhD in geophysics, AM, AB *summa cum laude*), and his career was one of distinction. He came to IIASA from the University of California, San Diego (UCSD), where he served both as professor of international relations in the Graduate School of International Relations and Pacific Studies and as research director for environmental policy at the Institute on Global Conflict and Cooperation (1990–1996). In 1991, while at UCSD, he founded the *Journal of Environment and Development*, now the premier journal in this field.

In earlier assignments, Gordon served as vice president and chief scientist of The MITRE Corporation (1983–1990), and as executive vice president of the Institute for Defense Analyses (1967–1968). He held tenured professorships and directed research institutes at Dartmouth College (1972–1979), the University of California, Santa Barbara (1968–1970), the University of California, Los Angeles (1958–1968), and the Massachusetts Institute of Technology (1954–1958).

Gordon served the US government at the federal and state levels, both on a full-time and a part-time basis. He was a member of the President's Science Advisory Committee under President Lyndon B. Johnson. In 1970, President Richard M. Nixon appointed him to the first Council on Environmental Quality, where he played a key role in formulating and implementing federal environmental legislation. He also directed a large number of interdisciplinary efforts for the US government, in the private sector, and in academia, focusing on issues related to global change, the environment, and US national security policy. As chairman of MEDEA from 1993–1996, he led a group of scientists who addressed such controversial issues as the declassification of data obtained by classified systems that are applicable to solving scientific and environmental problems.

Gordon published over 200 scientific articles and monographs. He received numerous awards for his scientific contributions and was a member of the American Academy of Arts and Sciences, The National Academy of Sciences, and the American Philosophical Society.

A man of intellect, a man of vision, a man of humor and distinction, Gordon had a warm heart for those who were privileged to know and work with him. He always tried to understand their needs and problems, and to offer advice and support based on his personal experiences. With Gordon's passing we have lost an outstanding scientist and a special friend.

IIASA National Member Organizations

Austria The Austrian Academy of Sciences
*Bulgaria** The Ministry of Environment and Waters
China The National Natural Science Foundation of China
Czech Republic The Academy of Sciences of the Czech Republic
Finland The Finnish Committee for IIASA
*Germany*** The Association for the Advancement of IIASA
Hungary The Hungarian Committee for Applied Systems Analysis
Japan The Japan Committee for IIASA
*Kazakhstan** The Ministry of Science—The Academy of Sciences
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Norway The Research Council of Norway
Poland The Polish Academy of Sciences
Russian Federation The Russian Academy of Sciences
Slovak Republic The Executive Slovak National Committee for IIASA
Sweden The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS)
Ukraine The Ukrainian Academy of Sciences
United States of America The American Academy of Arts and Sciences

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