

courtesy of the Prairie Farm Rehabilitation Administration, Saskatchewan; Agriculture Canada.



Saskatchewan, Canada: A drought-devastated farm in the 1930s and a modern grain farm practicing soil conservation.

Coping with Climatic Change

Food supplies, national economies, and people's lives are at risk because of the variability of climate. The effects of climatic fluctuations and risk-mitigating adaptations are being analyzed as IIASA's contribution to the UN World Climate Programme, with financial support from the United Nations Environment Programme.

1983: the hottest summer in 200 years in Europe injured spring wheat crops while producing some extraordi-

narily good wines; drought in Australia led to farm incomes being cut nearly in half, with farm-related economic losses reaching two and a half billion dollars; ocean floods and torrential rains damaged coastal Ecuador and the western USA; Japan was faced with the possible need to import rice for the first time in many years instead of dealing with a surplus; drought conditions reduced crops in regions of Brazil, Canada, India, the USA, and the USSR, with effects on the international grain market; continued lack of rain led to famine deaths and near-starvation for millions of people in Africa.

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Dr. Martin Parry at an Institute meeting of scholars collaborating on the Climate Impacts Project.

Some of 1983's weather was probably modified by the eruption of El Chichón in Mexico in March 1982, which threw enormous quantities of dust into the atmosphere. Some was strongly influenced by "El Niño", the sporadic rapid warming of the equatorial Pacific Ocean (in 1983, more than 4°C (7°F) above normal) that reverses sea currents and affects rainfall patterns. Some agricultural losses were due to the fact that "the only constant is change itself" — temperature and rainfall vary from year to year.

Looking at a longer time period, the climate of the northern hemisphere this century seems to have been the most variable and the most "abnormal" in the past 500 years. There was a general warming from the turn of the century until the 1940s, a cooling until the mid-1960s, then another warming until 1982, sums up climatologist Dr. Jill Williams Jäger, an IIASA alumna. Since 1880, the end of the "Little Ice Age" that began in the 16th century, only half of the decades in the northern hemisphere have been as warm or warmer than 1960–1970. It has been colder for about 90 percent of the past million years than it is now.

Taking an even longer perspective, given that the time between past ice ages was 10 to 12 thousand years, we have been in an interglacial period that is now some 11,000 years old. During the Pleistocene Ice Ages, the Earth was probably only some 6°C (10°F) colder than present and the winters were not

much more severe, yet mountainous ice sheets covered much of the northern hemisphere.

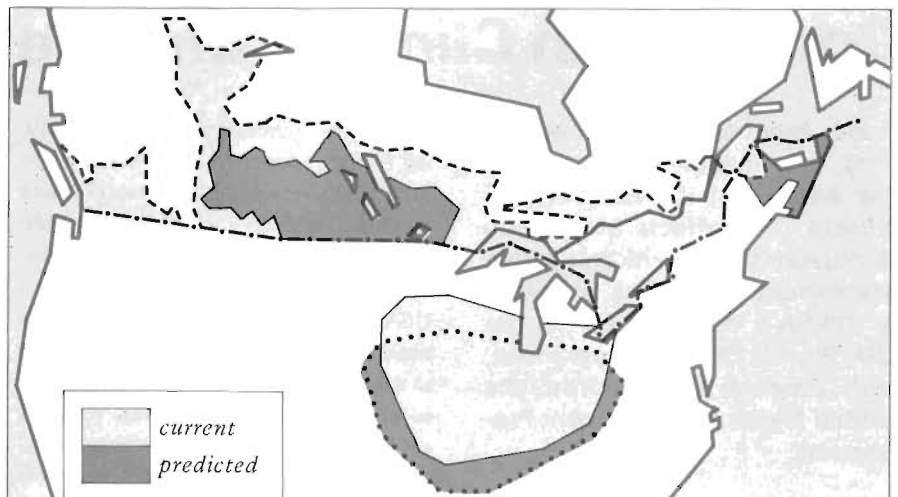
On the other hand, human activities may have so upset the natural balance of forces that we could have, not another Ice Age, but a global warming. Chemicals in the atmosphere, particularly the carbon dioxide formed by burning fossil fuels and no longer captured by the vast forests man has felled, may cause temperature increases through a "greenhouse effect".

As geographer Martin Parry of the University of Birmingham, UK, leader of the IIASA Climate Impacts Project, explains: "The field of climate impact assessment distinguishes between the role of short-term climatic variability and the role of long-term climatic change. Variability affects the range and frequency of shocks that society absorbs or to which it adjusts. Climatic change alters the resource base, the agroclimatic resources that help determine why some crops are grown in one place and different crops in another.

"Yet this distinction between short-term and long-term reflects more statistical convenience than an understanding of human behavior. Few societies or individuals look far ahead or behind. Any *future* impact from long-term changes in general climate can thus be seen as being embedded in *present-day* impacts from short-term climatic variability. It is likely that these short-term impacts will remain the medium

through which any long-term change is felt." Dr. Parry makes the point that the weather we have had, with the known social and economic reactions, is a good guide to probable future weather and enables us to prepare better for climate variations and change, now and to come.

The national teams working with IIASA therefore are validating analyses and various types of climate-crop yield-economic models using data from fairly recent actual weather conditions, as well as the estimates of future climate due to the increased amounts of carbon dioxide measured in the atmosphere. Their aim is to assess the range of impacts on agriculture most likely to occur as a result of climatic change and to identify appropriate mitigating policies. The common framework for the case studies involves analyses of impacts from a year of "extreme" weather (a drought for instance), a "back-to-back" run of two or more successive years of bad weather, a 10-year period of anomalous weather, and over the longer term, a climatic change from a doubling of atmospheric carbon dioxide. The last uses the general circulation model developed by James Hansen and colleagues at the Goddard Institute of Space Studies, USA, results of which were modified for the project by Professor Wilfrid Bach of the Center for Applied Climatology and Environmental Studies of Wilhelm's University, Münster, Federal Republic of Germany.



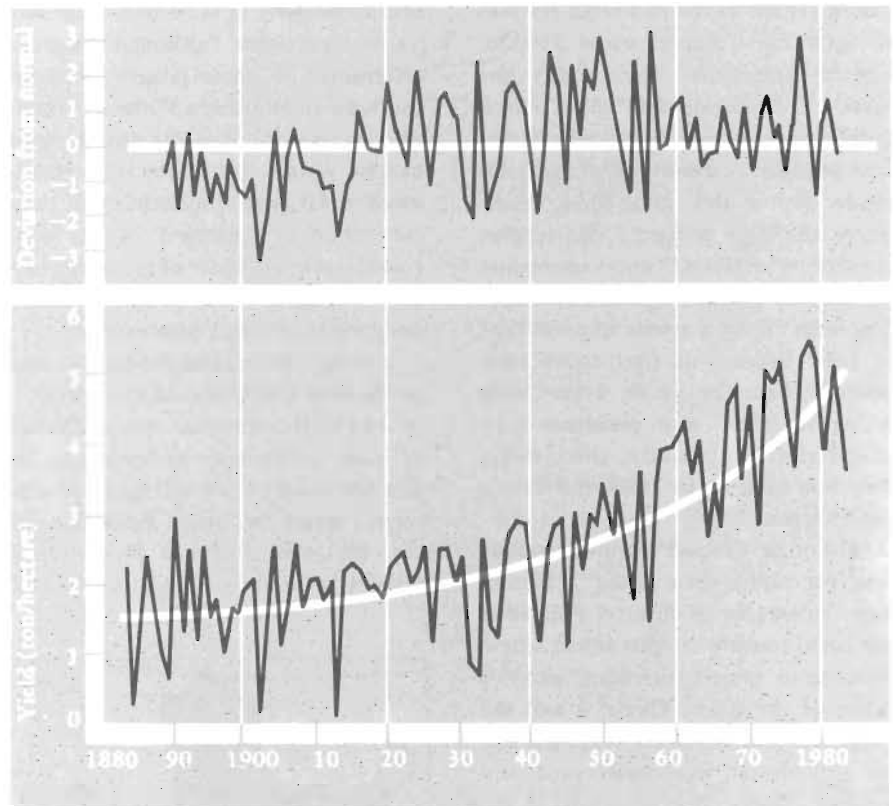
Contraction of Canadian wheat-growing area and southern movement of US corn belt with a 1°C decrease in mean annual temperature. The wheat limits are based on terrain and climate (G.D.V. Williams and W.T. Oakes); the corn limits (after J.E. Newman) are climate-based.

Dr. Parry notes that the potential impact of two successive bad years may be much higher than twice the impact of one bad year. Farmers normally can use the profits, seeds, etc. from a good season to tide their farms and families over an ensuing bad year. Two or more bad years in a row can mean that individual family resources would be completely used up.

The case studies concentrate on areas of agricultural production particularly sensitive to shifts in temperature and rainfall levels: high latitude, semi-arid and high altitude regions. Besides changes in crop yields, the amount of land physically available for agriculture contracts or increases as climatic patterns vary. Retreating glaciers in Iceland reveal abandoned farms. A 1°C decrease in mean annual temperature would cut the potential wheat-growing area in Canada by one-third, estimates G. Dan V. Williams of the Canadian Climate Centre. The US corn belt would move some 140 kilometers (about 85 miles) southwards. The general rule concerning altitude is a decrease of 0.6°C for each 100 meters upwards (some 3°F colder for every thousand feet gained in elevation). A study by Dr. Parry and Timothy Carter of the Lammermuir Hills in Scotland, comparing a cold period between 1661–1710 and the warm period of 1931–1980, finds that warmer climate permits farming 85 meters higher than previously. In Britain as a whole over one million hectares (one-sixth of Britain's unimproved moorland) have thus been opened to oat production. Indians in the Ecuadorian Andes shift their cultivation up and down the mountainsides as the temperature fluctuates, with some farms today at 3,800 meters (about 11,500 feet) above sea level.

Dr. Parry broadly describes the work underway as finding an answer to the question "what?" — the first order impacts on crop productivity as climate alters and the second order economic, social, and environmental effects, and then proceeding to the "then what?" — practical policy responses.

The national teams conducting the case studies vary in size and include government officials, agronomists, economists, meteorologists, livestock and crop specialists, with one expert acting



Temperature deviations from average (20°C) during July–August in Hokkaido, Japan, 1880–1980.

Change in rice yield (tons per hectare) in Hokkaido, Japan, 1880–1980. (T. Uchijima).

as coordinator. The high latitude areas under study are Saskatchewan, Canada (coordinated by G.D.V. Williams, Canadian Climate Centre, Ontario); Finland (Dr. Veli Pohjonen, Finnish Forest Research Institute, Vantaa); Iceland (Pall Bergthorsson, Iceland Meteorological Office, Reykjavik); and the Leningrad and Cherdyn regions of the USSR (Dr. Sergei Pitovranov, All-Union Institute for Systems Studies, Moscow). The high altitude studies focus on Ecuador (Ing. Luis Cañadas Cruz, Ministry of Agriculture and Livestock, Quito) and Japan (Dr. Masatoshi Yoshino, Tsukuba University). The semi-arid regions being studied are New South Wales, Australia (Dr. Jack Hobbs, University of New England, Armidale); northeastern Brazil (Dr. Antonio Rocha Magalhães of the governmental Institute for Social and Economic Planning, Brasília); central India (Dr. Surinder Virmani, International Crop Research Institute for Semi-arid Tropics, Hyderabad); Kenya (Dr. Richard Odingo, University of Nairobi); and the Stavropol and Saratov regions of the USSR

(Dr. Ludmilla Petrova, Stavropol Research Institute for Agriculture and Dr. Oleg Sirotenko, State Committee for Hydrometeorology and Control of the Natural Environment, Moscow).

Traditional and High-Tech Agriculture: Some Case Studies

The need to feed more people has led to great advances in agricultural science and techniques. Yet one of the points arising from the Japanese investigations is that while yield has increased considerably through the development of agricultural techniques and seed strains, damage to rice crops from lower-than-expected temperatures has not been reduced. This can be seen in the accompanying graphs tracing rice yields and temperatures over a period of one hundred years. "When the air temperature during July and August is 2°C below average in Hokkaido, 20–30 percent yield reduction is expected even under the present advanced rice-producing technology," states Dr.

Takeshi Horie of the Hokuriku National Agricultural Experimental Station, Niigata prefecture. Rice from the island of Hokkaido and the Tohoku district usually supplies some 40 percent of Japan's carefully-regulated total production of this staple food. "Even under the large potential rice surplus conditions in Japan," notes economist Dr. Hiroshi Tsujii of Kyoto University, "we were facing a severe rice shortage in 1984 because of four consecutive years of bad rice yields, a very cold spring in 1984, and problems with stored rice. Fortunately, there was a very hot summer in 1984 and thus a good harvest."

Although Finland has more arable land per capita than Japan, it is even more vulnerable to climate. Finland is the only country in the world where widespread grain cultivation extends north of the Arctic Circle — and the usual situation since the 1950s is one of agricultural over-production and exports. Barley, for instance, is the oldest cereal crop cultivated in Finland, although now used predominantly for animal feed rather than for direct human consumption. "The average barley yield was less than 1000 kilograms per hectare until the 1920s, exceeded 1500 kg/ha in the warm period of the 'Golden 1930s', and reached an all-time record of 3210 kg/ha in 1983," records Professor Jaakko Mukula of the Finnish Agricultural Research Center at Jokioinen. "This remarkable improvement is a result of intensive plant breeding, improved cultivation techniques, increased use of fertilizers, and so on."

Increased yields of all crops is one of the prime factors behind the major changes in Finnish farming since the late 1960s. Professor Uno Varjo of the University of Oulu's Department of Geography reports "a rapid decrease in the number of farms, extensive areas of arable land left uncultivated in the naturally less productive areas of the country, and general changes southwards in the limits of cultivation." The last point is shown on the map of Finland. To minimize the climatic risk, Finnish farms traditionally combine crop production, animal husbandry, and forestry. A recent dramatic change is that forestry has become the principal element in farming all over the country,

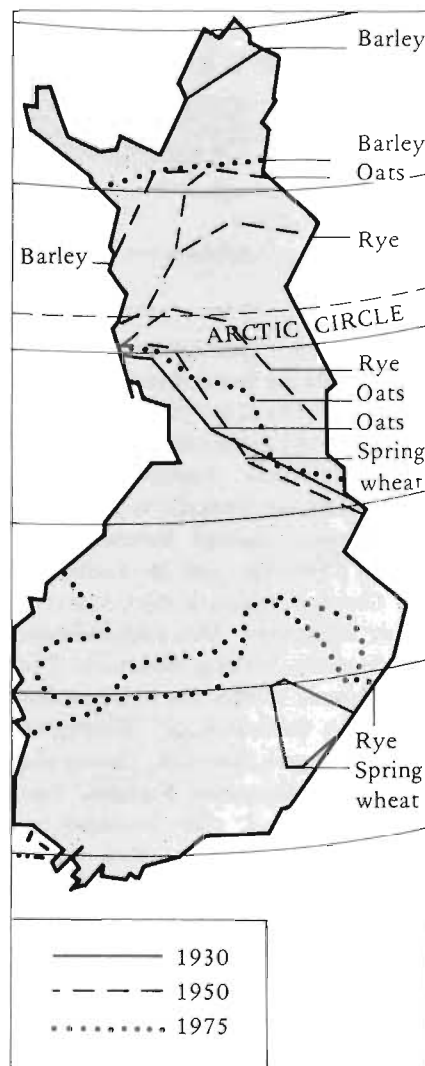
and particularly in the north, Professor Varjo argues that "although the great difference in temperatures between southern and northern Finland naturally does contribute to the difference in harvest yields, this effect is overshadowed as far as the profitability of crop cultivation is concerned by the very considerable influence of economic factors and agricultural policy measures designed to cut back production."

Average agricultural production and yields have also increased considerably in the USSR. "However, the sensitivity of crop production to variations of weather conditions has remained quite large," states Dr. Sergei Pitovranov of the All-Union Institute for Systems Studies in Moscow. "This is reflected

by the variability of grain output from one year to another," seen in the Table here. Dr. Vladimir Iakimets at IIASA from the same Institute recalls the extraordinary drought of 1975 and the extremely wet summer in 1976. Dr. Ludmilla Petrova of the Stavropol Research Institute for Agriculture says: "There are vast areas in the European part of the USSR where unfavorable factors hinder the development of agriculture, of which drought is the most detrimental. The increasing demand for agricultural produce urges the intensification of agricultural production not only in regions with favorable soil and climatic conditions but in semi-arid and arid regions as well."

The Stavropol region of the northern Caucasus Mountains, for instance, has registered 35 major droughts between 1900 and 1980. The region spans semi-deserts, forest steppes, foothills and mountains, but more than half the territory is dry steppe. Dry farming—intensive applications of fertilizer (especially phosphorus) to fallow land, later sown with drought-resistant, high-yield wheat varieties — was begun in Stavropol in 1977 to promote both high yields and soil conservation and restoration. It is now used on approximately 45 percent of the winter wheat-growing area of Stavropol, and the "fallow/wheat crop rotations account for about 60 percent of the total regional grain production," reports Dr. Petrova. "The use of the dry farming system from 1977 to 1981 resulted in a 74 to 82 percent increase of wheat yields. Currently, the wheat yield in the regions with 300–350 millimeters of annual rainfall (12–14 inches) averages 25 to 32 quintals per hectare (1 quintal = 100 kilograms = 220 pounds), exceeding the level of the previous Five-Year Plan period by 6 to 10 quintals." For comparison, the average annual rainfall in central Europe is around 650 mm (26 inches).

Some two-thirds of Kenya is arid and semi-arid, dependent on highly irregular twice-yearly rainy seasons. "Farming is extremely risky in eastern Kenya because of the frequency of droughts and the inevitable famine conditions. Normally the agricultural belt in the highlands and the Lake Victoria basin produce enough to transfer food



Finland: northern limits of widespread cultivation of barley, oats, and spring wheat in 1930, 1950, and 1975 (U. Varjo)

USSR Grain Output

Five-year plan period	Annual average	Maximum	Minimum
	(in millions of tons)		
7th (1961–1965)	130.3	152.1	107.5
8th (1966–1970)	167.6	186.8	147.9
9th (1971–1975)	181.6	222.5	140.1
10th (1976–1980)	205.0	237.4	179.3

(I. Yakunin cited by V. Iakimets and S. Pitovranov)

when there are crop failures elsewhere. Every ten years or so, however, there is a national drought affecting the whole country," says Professor Richard Odingo of the University of Nairobi. "With livestock the possibilities for coping with the vagaries of the climate become more varied, and the semi-arid areas of Kenya have traditionally been used for extensive, nomadic pastoralism," Dr. Harry Potter of the Kenyan Agricultural Research Institute at Kikuyu explains. "The catastrophic effects of a crop failure have been unacceptable to the farmers in such areas, especially as the frequency of such failures would be high given the unreliability of rainfall, the level of available technology, and the costs involved for improvements. Movement of stock and/or people, often over quite considerable distances, allows for maintenance of food and water supply to stock and hence subsistence to the people in all but the worst of seasons. There is little doubt that the nomadic system provides the 'least-risk' system in these semi-arid areas." Rapid population growth in Kenya is restricting such seasonal migrations and the government has a welfare policy of permanent settlement of the nomads, leading to the need for new management strategies regarding livestock, forage, and fodder as these people adapt to a new way of life.

Moderating Risk

Farming can still be a gamble and local food supply be at risk, subject to climatic forces we cannot control. Analysts in the IIASA project consequently deal with impacts from climatic shifts in terms of changes in agricultural risk levels. These can be expressed in both

time and space: the probability and frequency of climatic conditions leading to crop failures (or bumper harvests), and the locations at highest risk through a "risk surface", marking where the risk of crop failure is too great for cultivation of a specific crop to be worthwhile. Predicted climatic alterations, such as those from carbon dioxide-induced warming, can be mapped as changes in boundary isopleths denoting the area of maximum acceptable risk for the cultivation of a certain crop. An example of this is the map showing changes in the wheat- and corn-growing areas of North America if there is a 1°C decrease in mean temperature. As agricultural risk levels shift, government programs and farmers could adjust activities to match the new situation, having specified tolerable levels of risk.

Government policies regarding agriculture and national economies vary of course, but do exist in almost every country. Measures and legislation in the regions under study include stockpiling foods; mandatory crop insurance; irrigation and soil conservation programs; support of meteorological services and agricultural research; government crop monopolies; taxes, tariffs, farm loans; subsidizing farmers either to continue farming or to stop production in surplus situations; arranging imports and exports of agricultural products. Antonio Rocha Magalhães of the Institute for Social and Economic Planning in Brasília outlines four approaches since the 19th century as thinking and policy shifted in dealing with the semi-arid northeast region of Brazil. There was what he terms an "engineering phase" of public works constructing dams and reservoirs for irrigation; an "ecological phase" promoting new species and strains such as drought-resistant crops and plants re-

quiring very little moisture such as sorghum and palms; a "development phase" featuring industrialization for economic growth; a "socioeconomic approach" to overcome the poverty in the area through direct benefits to the needy and the creation of jobs to halt migration and maintain the viability of farmers through drought seasons.

Many of the researchers in the project comment that politicians are more sensitive to short-term crisis conditions – dramatically appearing with emergency relief supplies during famines, droughts, or cold spells – than to long-term planning and projects requiring heavy capital investment. Both long- and short-term responses and policies are necessary. Equally vital is constant monitoring. While we do not yet fully understand the complex interactions of oceans, land surface, ice and snow cover, atmosphere, and biomass that produce climate, we do have "early warning systems". We are, for example, beginning to understand the "teleconnections" between different parts of the Earth's climatic system. Meteorologists at Brazil's Institute for Space Research (INPE) near São Paulo see a connection between the air pressure of the central Atlantic and rainfall in northeastern Brazil. There is a good chance that further research along these lines will provide an ability to forecast late or weak rains in northeastern Brazil up to three months in advance, reports Luiz Baldicero Molion. Progress in this kind of long-term weather forecasting should help us mitigate the impact of climatic variations. Forewarned should be forearmed. To quote Dr. Parry, "There is a wide range of options and measures moderating agricultural and socioeconomic risk from climate fluctuations. As more of these are put in place and practiced, we will not only enable agriculture to adapt more resiliently to climatic variability now, but we will be better prepared for possible climatic change in the future."

Roberta Yared

Further information is available from Dr. Martin Parry, Timothy Carter, Nicolaas Konijn, and Marilyn Brandl, Climate Impacts Project, IIASA.

IIASA as Catalyst

Tibor Vasko presents the Clearinghouse activity at IIASA — promoting international cooperation through the establishment and maintenance of international networks pursuing issues outside the Institute's research program.

IIASA is taking advantage of its international nature, collaborators, and contacts not only for research projects at the Institute, but also to bring together respected scholars and analysts with industrial, government, and other officials to explore selected issues which are not on IIASA's own research agenda.

We serve as a clearinghouse in these endeavors — a central focal point enabling the exchange of information and experiences among a geographically-scattered community of those individuals and organizations addressing a problem context, an emerging issue, or new field of study.

It differs from the international cooperation and collaboration usual in every IIASA undertaking in that the Institute is not itself investigating the subject nor sponsoring research elsewhere. We help determine the focus of a *problématique* interactively, coordinate international contacts, arrange one or more meetings, sponsor publications, and so on. IIASA acts as a catalyst, providing a platform for the exploration of new ideas and problems, bringing together a community of interest and creating new international networks of common concerns.

It moves also beyond the typical scientific exchange within a field (through journals, associations, etc.) because the usual IIASA multidisciplinary, systems analysis, multicultural approach is carried over to Clearinghouse activities. The introduction and presence of responsible officials — governmental, industrial, international — at all stages also follows IIASA's normal practice.

The Clearinghouse activity is a direct extension of the Institute's mission, and fulfills its objective of promoting international cooperation.

Similar activities have been undertaken at IIASA before the "formalization" of the Clearinghouse function in the Institute's program. Sometimes

this was a "reconnaissance", a feasibility examination of a topic that subsequently became a research project; sometimes it stemmed from the need for continued communication among the interested parties and the constituency built around particular IIASA research that has been completed.

For example, several of the IIASA researchers on pest control under changing circumstances of ecological, social, and economic factors believed there were valid analogies between the approaches and models developed at IIASA and work in the field of plant pathogens and human disease organisms. IIASA sponsored an international conference of specialists and researchers in the three fields. The IIASA research resulted in several publications, including the seminal *Adaptive Environmental Assessment and Management* edited by C.S. Holling (International Series on Applied Systems Analysis, Vol. 3; John Wiley and Sons, 1978). One of the outcomes of the IIASA-sponsored conference is *Pest and Pathogen Control: Strategic, Tactical, and Policy Models* edited by Gordon R. Conway of the Imperial College of Science and Technology, London, UK (International Series on Applied Systems Analysis, Vol. 13; John Wiley and Sons, 1984).

Global Modeling

Global modeling first received widespread attention with the publication in 1972 of *The Limits to Growth* by Donella Meadows, Dennis Meadows, Jørgen Randers, and William W. Behrens III (Universe Books) and the campaign organized by the Club of Rome.

The controversy generated by the book led to requests from both advo-

cates and critics of global modeling that the international community of scholars scrutinize this new endeavor. IIASA, founded seven months after the appearance of the book, offered global modelers and potential users of these models a meeting place, assuming a monitoring role. When a major model was ready, IIASA organized an international conference so it could be presented and discussed. The term "clearinghouse" was first used by then-Director Professor Howard Raiffa in his introduction to the first Symposium on Global Modeling efforts at the Institute in 1974.

Nine such conferences were held at IIASA between 1974 and 1981, examining seven major global models developed in that time span. The Sixth Global Modeling Conference in 1978 was designed as a state-of-the-art assessment of the strengths and weaknesses of global modeling per se, with long questionnaires sent to each modeling team and others active in the field as practitioners and/or critics, by the three organizers of the Conference: Dr. Donella Meadows of Dartmouth College, Hanover, New Hampshire, USA; Professor John Richardson of the American University, Washington, DC, USA; and Professor Gerhart Bruckmann of the Vienna Institute for Advanced Studies and IIASA (now the representative on the IIASA Council of the Austrian Academy of Sciences).

They decided not to prepare the traditional volume of proceedings of the meeting, but to write a synthesis of existing knowledge, models, experiences, and problems: a real life history of global modeling "for those who make complex models of complex systems, those who have to make these systems work, and those who live in and care about the social systems that modellers describe and about which decision makers make decisions." (OPTIONS Spring 1982 published ex-

cerpts from *Groping in the Dark: The First Decade of Global Modelling* by Donella Meadows, John Richardson, and Gerhart Bruckmann (John Wiley and Sons, 1982).

Innovation Management in Industry

Research and comparative analysis of management practices related to the development, application, and implementation of technological, organizational, and social innovations in industrial enterprises was the subject of a Clearinghouse activity coordinated by Dr. Vadim Goncharov of the All-Union Research Institute for Systems Studies in Moscow, USSR. Several meetings of industrialists and researchers from East and West were held to focus on various aspects and factors, with the electro-technology industry selected to provide a real life empirical base for analysis of the broader issues and problems of adaptation.

They met in 1983 in Prague to discuss the impact of different organizational structures on innovative activity in industrial firms. IIASA was joined in sponsoring this meeting by the firm CKD Praha, the Institute of Management in Prague, and the Committee for IIASA of the Czechoslovak Socialist Republic. A follow-up session took place in October 1983 in Helsinki to consider ways of motivating people to be more innovative, such as fostering goal responsibility and awareness at all organizational levels, team building, and maintaining better communication channels among management and sub-units. The meeting was held under the auspices of the Finnish Committee for IIASA, the Technical Research Centre of Finland, and the Finnish firms Imatran Voima, Nokia Electronics, Kymmene-Strömberg, Kone, and Valmet.

Major interest at this meeting turned to the "anatomy" of a research team presented by Soviet scientists, incorporating new motivation schemes, and comparisons with practices in Western companies.

Strategic planning and design for the



Professor Tibor Vasko joined IIASA in 1980 and became leader of Clearinghouse activities at its inception in 1983, taking advantage of his fluency in seven languages. He had been involved in the establishment of the Institute, was a signatory to the IIASA Charter in 1972, and has served on the IIASA Council. Professor Vasko studied electrical engineering at the Czech Technical University in Prague, where he is now Professor of Computer Science, and received his Ph.D. from the Czechoslovak Academy of Sciences. Professor Vasko was a science attaché in his country's embassy to the USA from 1965 to 1969 and then Head of the Department of Computers and Automation of the Federal Ministry of Technology and Investment in Czechoslovakia.

management of innovation, concerned with both technological and economic changes, was the theme of the December 1983 gathering in Budapest, sponsored by the Hungarian Committee for Systems Analysis, the Ganz Electric Works, and IIASA. Management style and strategy in planning for innovation was discussed at a meeting in May 1984 at Varna, Bulgaria sponsored by the State Committee for Science and Technical Progress, the Institute for Social Management, the ELPROM Enterprise, the Bulgarian Industrial Association, the National Committee for Applied Systems Analysis and Management,

and IIASA. A major international conference on Innovation, Flexibility and Productivity Improvement in September 1984 was sponsored by IIASA, the Austrian Academy of Sciences, the Federation of Austrian Industrialists, the Austrian Electrotechnical Association, the Federal Chamber of Economics, Siemens AG and the Siemens Group in Austria, the United Nations Industrial Development Organization (UNIDO), the Hernstein Management Center, and the International Academy of Management. This conference was originally planned as the "culmination" of work in this field. However, the constituency developed through the meetings and publications and the benefit of East-West industrial contacts has led to new initiatives and spin-offs from the IIASA activity. Executives, researchers, and government officials will meet at Duke University, Durham, North Carolina, USA in March 1985 for a conference on East-West Trade, Scientific and Technological Cooperation: Opportunities and Perspectives sponsored by the American Committee on East-West Accord, Duke University, and IIASA, with support from the Dow Chemical Company and the Soros Foundation. "Comparative Innovation Schemes" is one of the topics for discussion at meetings in October 1985 at Ohio State University, Columbus, Ohio, USA and Case Western Reserve University, Cleveland, Ohio, USA. This will be cosponsored by the Honda Manufacturing Corporation of America, the Ford Motor Company, the Allen-Bradley Corporation and the universities, along with the State of Ohio Thomas A. Edison Program, the American Academy of Arts and Sciences, and IIASA.

Socioeconomic Impacts of Developments in Artificial Intelligence

Technologies based on the principles of Artificial Intelligence (AI) promise to yield considerable benefits to society but at the risk of rupturing current structures of employment, education, business, law, and science. The real challenge is to anticipate the probable consequences of these technologies

and to translate this knowledge into timely policies conducive to societal well-being.

Applications of AI are rapidly expanding, particularly in the fields of robotics, flexible automation, and intelligent teaching systems. Professor Robert Trappl of the Austrian Society for Cybernetic Studies organized a meeting of researchers engaged in studies of the socioeconomic impacts of AI. The conference, held at IIASA in August 1983, was supported by the Austrian Federal Ministry for Science and Research and brought together experts from Austria, Czechoslovakia, the German Democratic Republic, Hungary, Italy, Japan, the United Kingdom, and the United States to survey the impacts of AI technologies.

It was generally agreed that a period of some ten years still remains before society will experience the full impacts of AI systems in the production of goods and services. Thus governments would be well advised to launch broad retraining programs and adopt new methods of work-sharing and income distribution in order to avoid massive unemployment and other problems created by the inevitable transition to a world in which AI systems play a

major role. The proceedings of the conference are being prepared for publication by North Holland.

Computer-Based Education

Most of our children take computers for granted: they play video games and they use them at school. Whatever the future changes wrought by AI and cognitive science research into human and machine intelligence and creativity, computer-based education is a reality and widely used in most developed countries.

There is enough experience — and criticism — available to attempt an assessment of practices and consequences. It becomes particularly appropriate to do so as national educational policies are being revised to incorporate this new development on a large scale. IIASA, with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the State Committee for Science and Technical Progress of the People's Republic of Bulgaria, and the Bulgarian National Committee for Applied Systems Analy-

sis and Management held a small international meeting in May 1984 at Albena, Bulgaria for a preliminary survey of experiences. This led to the convening of an international conference on Children in an Information Age to meet in Varna, Bulgaria in May 1985, with more than one hundred papers already submitted by specialists from thirty countries and with the World Health Organization and the United Nations Children's Fund (UNICEF) as additional sponsors.

The first meeting highlighted the fact that the disparity of views, interests, and needs of teachers, educational administrators, computer technicians — and the children and their parents — is wide. Concentration on computer applications in education is also an excellent point of entry into the social, cultural, and economic impacts and consequences of a new technology on society.

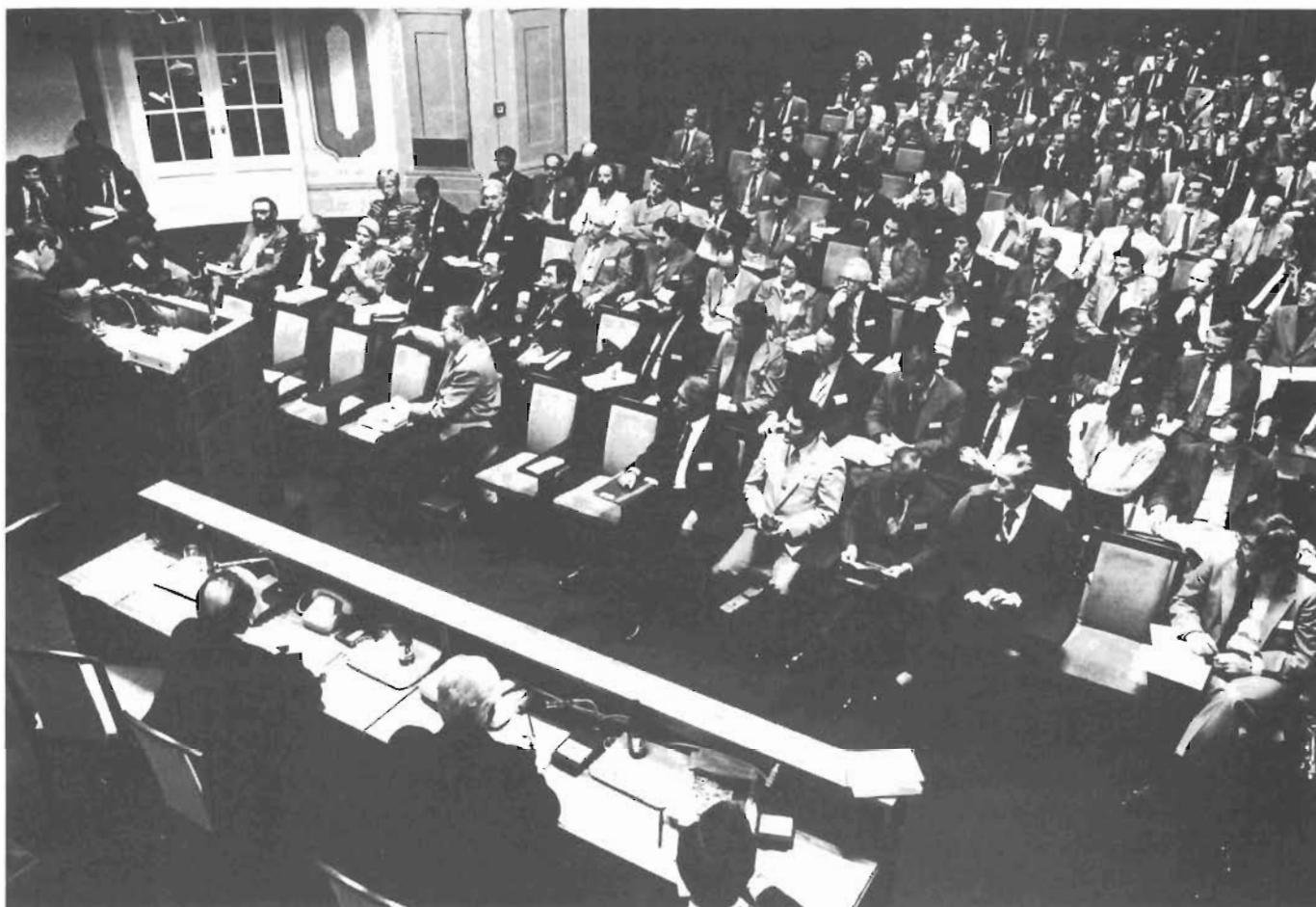
Long Waves

As traditional economic theories fail to adequately explain recessions or upswings in national economies, scholars have revived interest in cyclical behavior theories, such as the Kondratieff 50–60 year cycles of economic movements. While there is still an ongoing debate about whether such “long waves” exist, there is also much new work seeking the causes and consequences of repetitive economic cycles. (The various long-wave theories were discussed by Professor Gerhart Bruckmann in *OPTIONS* 1983/2, while Dr. Cesare Marchetti posited a 54 year-period based on invention and innovation cycles, Darwinian competition, and market substitution in *OPTIONS* 1983/1.)

A meeting, the first, of the leading representatives of the different theories was organized by IIASA and the Institute of Regional Economic Planning of Tuscany (IRPET), with an emphasis on national and regional policy design and implementation. Industrial and government planners met with scholars in economics, biology, demography, and sociology in Siena and Florence, Italy, hosted by the banking concern



Discussions on the socioeconomic impacts of developments in Artificial Intelligence.



Global Modeling Conference session.

Monte dei Paschi di Siena, Tuscany region authorities, and the cities of Florence and Siena.

The consensus reached was that policies should focus on encouraging the maximum diffusion of innovations while minimizing social costs. Innovation was central to all theories, whether considered endogenous or exogenous, a cause or result. There was also agreement among the proponents of divergent theories that the diffusion process was the key element. An invention per se, or group of inventions, is irrelevant until it is adopted as an innovation and its use becomes widespread.

Nobel laureate Jan Tinbergen and others stressed the importance of social and institutional changes as innovations, as well as the more traditional technological sense of changes in product and process. The social "climate" has to be receptive to change, and will be more open to new things and to innovations if policies are in place to ease transitions and dislocations.

An additional benefit of the meeting was the opportunity for recognition of elements of complementarity and the integrative features of the various, and varying, models and theories.

The Academy of Sciences of the German Democratic Republic and IIASA have organized another conference on Long-Term Fluctuations in Economic Growth: Their Causes and Consequences, to meet in Weimar, GDR in June 1985 for further exploration of long-wave theories and economic structural change, the role of new technology, and monetary factors.

In Summary

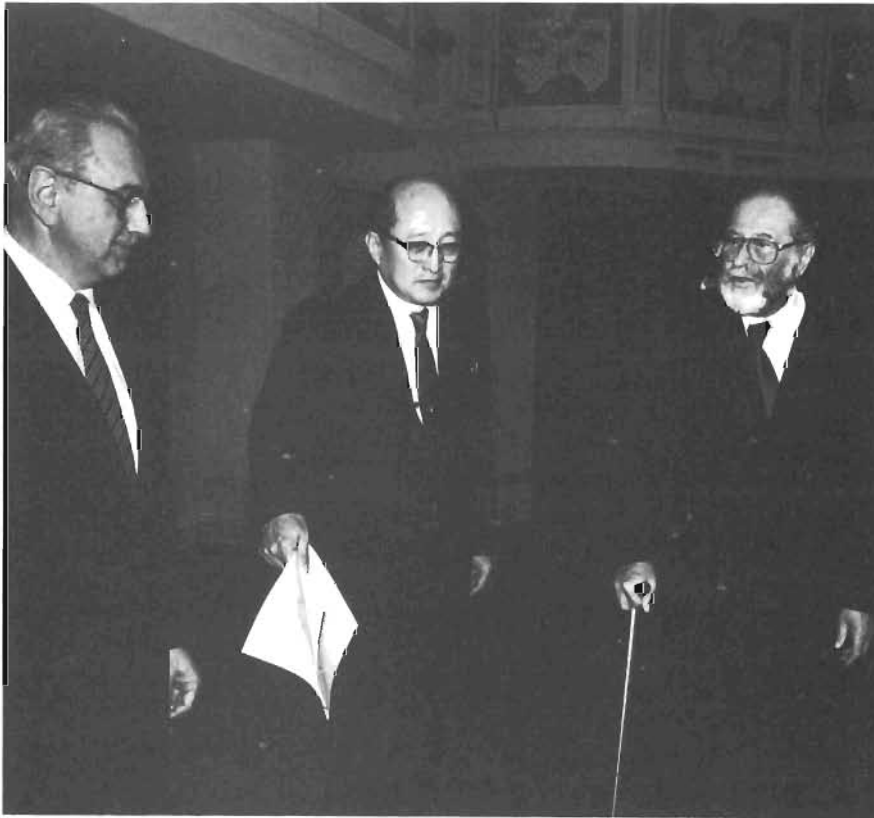
The experience we have had with Clearinghouse activities to date, and the interest aroused for future topics and participation, demonstrates the useful role a catalyst can play. IIASA has proven it can fill that role well,

extending its function of creating international collaborative networks for multidisciplinary research, bringing together scientists with industrial and government officials for "real-world" appreciation and analysis, and monitoring new trends and ideas. We believe it enhances the mission of the Institute and increases the international cooperation so needed in these times.

IIASA is often described as a bridge, linking science and real problems, scientists and decision makers; spanning disciplines, cultures, political practices. IIASA is a means of connection for the exchange of ideas, knowledge, and experience in its own research, and now reaches out to provide the connections and contacts for others. Information is a companion of creativity. Even in the last century it was clear to philosophers that creativity defies the bookkeeping (cause and direct effect) character of the majority of economic theories.

This is the lifeblood of science, and a basic *raison d'être* of IIASA.

News from the Institute



Dr. Bruno Kreisky (right) at the Institute with IIASA Council Chairman Academician Jermen Gvishiani (left) and Director Professor Thomas H. Lee to inaugurate the "Dr. Bruno Kreisky Lecture" series. The establishment of the series is an expression of IIASA's deep gratitude for Dr. Kreisky's continuous and dedicated support for the development of the Institute and the advancement of its objectives.

Dr. Bruno Kreisky argued that "every effort should be made to return to a policy of détente so as to secure peace" and benefit all countries by helping resolve their economic and social problems.

"What we have to overcome is the present substantial and verbal hostility. Then we have to try to overcome the mutual misunderstandings," stated the former Austrian Chancellor during the first "Dr. Bruno Kreisky Lecture" at IIASA, noting that "the form of peaceful relations presently possible cannot be understood as being valid for the ideological sphere."

Dr. Kreisky said that while people in different countries feel differently about détente, for Europeans "it is a pure reality." Besides increased trade, he cited the "necessity of an overall European cooperation for an integrated energy supply" and also suggested the establishment of a "nuclear cordon sanitaire across Europe."

Because of the basic differences of the existing political systems and orders of society, Dr. Kreisky believes "the relationship between the big powers will continue to alternate between mutual antagonism and rapprochement" and will at best resemble what Schopenhauer, the German philosopher, describes in a fable: "On a cold wintry day a company of porcupines moved closer to each other, seeking each other's warmth so as to find protection against the frost. Soon, however, they felt each other's spines — which made them separate again. Whenever the need for warmth brought them together, the other ill repeated itself. Thus they moved from one pain to the other until they found a proper distance to each other which they could tolerate."

The complete text of the Dr. Bruno Kreisky Lecture is available from the Secretariat, IIASA.

IIASA Council Meeting

The IIASA Council, the Institute's governing body, approved the proposed plan of research and budget for 1985 at its meeting in November.

Academician Jermen Gvishiani of the Academy of Sciences of the USSR was re-elected Chairman of the Council. The new Vice-Chairmen are Professor Ognyan Panov of the National Committee for Applied Systems Analysis and Management, People's Republic of Bulgaria and Professor Wouter Tims of the Foundation IIASA—Netherlands.

The Executive Committee of the Council is now composed of Academician Gvishiani as Chairman; Professor Hiromi Arisawa of the Japan Committee for IIASA; Academician Jan Kaczmarek of the Polish Academy of Sciences; Professor Anders Karlqvist of the Swedish Council for Planning and Coordination of Research; Professor Panov; and Professor Tims.

The new Chairman of the Research Committee is Professor Dr. Gerhart Bruckmann of the Austrian Academy of Sciences, serving with Mr. Andre Danzin of the French Association for the Development of Systems Analysis; Ing. Pavel Majersky of the Committee for IIASA of the Czechoslovak Socialist Republic; Academician Wolfgang Schirmer of the Academy of Sciences of the German Democratic Republic; and Professor Guido Torrigiani of the National Research Council, Italy.

Senator Dr. Michael J.L. Kirby of the Canadian Committee for IIASA was re-appointed Chairman of the Finance Committee, comprised of Academician Gvishiani; Professor Helge Gyllenberg of the Finnish Committee for IIASA; Professor Wolf Häfele of the Association for the Advancement of IIASA, Federal Republic of Germany; Academician Istvan Lang of the Hungarian Committee for Applied Systems Analysis; and Professor Howard Raiffa of the American Academy of Arts and Sciences.

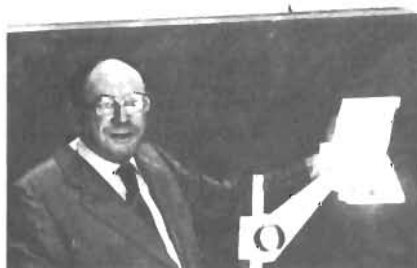
The Council awarded the title of "IIASA Honorary Scholar" to Professor Dr. Karl Bichtler, retiring representative of the Academy of Sciences of the German Democratic Republic. Academician Wolfgang Schirmer is the new representative.

Meetings

Anticipated as well as current scientific and technological changes and trends were examined in terms of their implications for the development of Third World countries during a meeting at the Institute from August 1–3 organized by the United Nations Centre for Science and Technology for Development.

The cultural and social factors creating varying perceptions of an issue and underlying the decision-making process were analyzed at an IIASA meeting held in Sopron, Hungary from August 16–26. Discussions on plural rationalities and interactive decision processes explored the usefulness of the mediation function of computerized decision support systems in the resolution of conflict situations. Various versions of decision support systems were demonstrated in interactive experiments. The proceedings are being prepared for publication. Please contact Professor Alexander Kurzhanski at IIASA for further information.

Natural and social scientists met at IIASA from August 27–31 to present their investigations of the interactions between economic activities and the global environment. These studies of energy–agriculture–biosphere linkages have been developed in the framework of a feasibility study on sustainable development of the biosphere, and will be published shortly. Additional information can be obtained from Dr. William Clark.



Nobel laureate Leonid Kantorovich of the Academy of Sciences of the USSR making a presentation at the IIASA workshop on the dynamics of macro-

Recent advances in the mathematical theory of systems dynamics and applications in biology, immunology, and economics were reported at an Institute workshop on the dynamics of macrosystems from September 3–7. Publication is planned of the new approaches and techniques to describe the behavior and regulatory controls of macrosystems, including work at IIASA on viability theory. More information is available from Professor Jean-Pierre Aubin.

An international conference on stochastic optimization, jointly organized by IIASA, the Ukrainian Academy of Sciences and its V. Glushkov Institute of Cybernetics, and the Academy of Sciences of the Union of Soviet Socialist Republics, was held at Kiev, USSR from September 10–16. The proceedings will be published, including discussions on stochastic programming, Markov decision processes, optimization with incomplete information, and applications of stochastic techniques in several fields. Professor Alexander Kurzhanski can supply additional details.



Yuri Vislousov, Vice President of Sojuzgazexport, Moscow (left) with Dr. Jonathan Stern of the British Institutes' Joint Energy Policy Programme in London and Dr. Raimund Dietz, Vienna Institute for Comparative Economic Studies, Austria at the IIASA International Gas Study meeting.

An IIASA conference on Innovation, Flexibility, and Productivity Improvement, with case studies drawn from the electrotechnology industry, brought together industrial managers and academic scholars. The conference from September 17–21 was sponsored by the Institute, the Austrian Academy of Sciences, the Federation of Austrian

Industrialists, the Austrian Electrotechnical Association, the Federal Chamber of Economics, Siemens AG and the Siemens Group in Austria, the United Nations Industrial Development Organization, the Hernstein Management Center, the Office of the Lower Austria Provincial Governor Siegfried Ludwig, the City of Vienna and Mayor Helmut Zilk, the Committee of the German Chamber of Commerce in Austria, and the International Academy of Management. Professor Tibor Vasko has further information.

Motivations and applications were emphasized at an Institute workshop on nondifferential optimization in Sopron, Hungary from September 17–22. The recent uses, algorithms, and techniques presented will be published. More information can be obtained from Professor Alexander Kurzhanski.

IIASA and the Nordic Council for Research Policy organized a symposium on applied mathematics, systems analysis, and computer software, leading to an open discussion of possible research

strategies in these areas in the Scandinavian countries. The symposium met in Oslo and Geilo, Norway on September 17–21. Five topics were discussed at the symposium: computer oriented mathematics; applied mathematics, dynamics, and systems analysis; applied mathematics for biological and social sciences; large-scale systems optimiza-



Chinese State Counsellor Fang Yi (center) and Director Thomas Lee met in Beijing in November to discuss the activities of the People's Republic of China setting up a National Committee with the intention of joining the Institute in 1985. Participating were (front row, left to right) Professor Lu Yingzhong of Tsinghua University, Mrs. Wu Dalan of the State Science and Technology Commission of China (SSTCC), Professor Lee, State Counsellor Fang Yi, Mrs. Thomas Lee, Mrs. Yang Weizhe of the SSTCC, and Professor Xu Guozhi, former Director of the Institute for Systems Science of the Chinese Academy of Sciences, with SSTCC staff members (second row) Xu Shequan, Peng Chungiao, and Kong Chaoxiang.

tion; systems analysis, computers, and society. It is planned to publish the proceedings. Professor Åke E. Andersson or Dr. John Casti can provide further information.

Industrialists, policy analysts, and energy researchers assessed the economic and technological factors affecting the development of natural gas as a major energy source. Their meeting at the Institute on October 18–19 provides a realistic framework for the IIASA analysis of natural gas prospects in energy markets on the European continent and internationally. Dr. Hans-Holger Rogner has more information.

The effect on agriculture of historical and possible future climate shifts is being explored to improve policy responses to variations and changes in the weather. Recent climate impact assessment work and models were presented at an IIASA meeting on October 1–12 of government officials, meteorologists, agronomists, and economists dealing with climatically-sensitive high altitude, semi-arid, and high latitude areas, and will be published as part of the UN's World Climate Impact Pro-

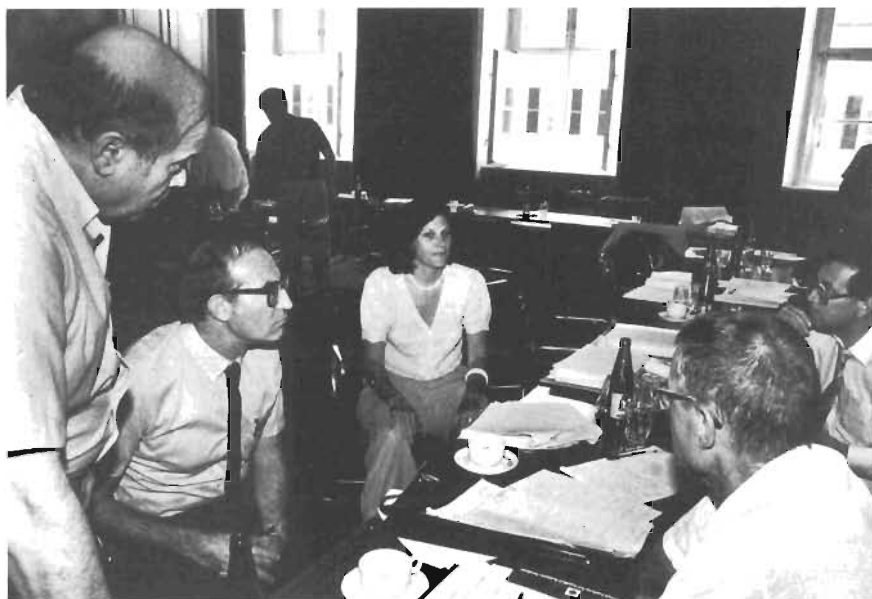
gramme. Dr. Martin Parry has further information on the IIASA/United Nations Environment Programme project.

An IIASA meeting from October 4–6 on input-output modeling discussed model linkage and changes in input coefficients as part of the international effort to develop a world economic model focused on trade flows, using the common INFORUM framework specifications for forecasting and data exchange needed among partners. Dr. Anatoli Smyshlyaev can supply further details.

Successes and failures in using model-based research and analysis with governmental and industrial managers and policy advisors were described at an Institute meeting on "dialoguing with decision makers" from October 8–10. A book is planned, stressing direct client involvement at several stages of an analysis and the need to take advantage of new computer technology such as graphics to make technical results more accessible, usable, and useful. Contact Dr. Jagmohan Maini for more information.

The nontechnical factors — social, organizational, and political — influencing the style, structure, and content of regulating risk to the public from industrial activities were analyzed at a meeting sponsored by IIASA, the Programme on Man and the Biosphere of the United Nations Educational, Scientific and Cultural Organization, and the Commission of the European Communities at the latter's Joint Research Centre in Ispra, Italy on October 16–17. A book on risk and regulation is being prepared. Additional information is available from Dr. Jagmohan Maini.

Theoretical foundations to understand and analyze the dynamics and problems of metropolitan areas were presented to an international meeting at IIASA of urban planners and social scientists on October 29–31. There was also a joint session with the Cost of Urban Growth Group (CURB) operated by the University of Vienna. A publication is being prepared on dynamic analysis of spatial development as part of IIASA's metropolitan and regional issues research. Further information is available from Professor Åke Andersson.



A discussion at the IIASA meeting on the sustainable development of the biosphere among (from left to right) Professor Michail Antonovsky, Chief of the Laboratory of Climate and Environmental Monitoring, Moscow, USSR; Professor Giandomenico Majone of IIASA; Dr. Jessica Tuchman Mathews of the World Resources Institute, Washington, DC, USA; Professor Paul Crutzen, Director of the Air Chemistry Division of the Max Planck Institute for Chemistry in the Federal Republic of Germany; and Professor Thomas Schelling of Harvard University, USA.



Dr. Pekka Kauppi of the Forest Research Institute, Helsinki, Finland (left); Ms. Elaine Wheaton of the Saskatchewan Research Council, Canada; and Dr. Olafur Dyrmondsson of the Agricultural Society of Iceland at the Institute meeting assessing climate impacts in high-latitude regions.

Peccei Scholars

Sarah Johnson and Cornelis (Kees) van Paridon, participants in the 1984 Young Scientists' Summer Program at IIASA, have been chosen as the first Peccei Scholars of the Institute. The award of financial support for an additional three months' work at IIASA is named in honor of the late Aurelio Peccei, President of the Club of Rome and active in the establishment of the Institute. Ms. Johnson is a Ph.D. candidate at Stanford University, California, USA and Mr. van Paridon at Erasmus University, Rotterdam, the Netherlands.





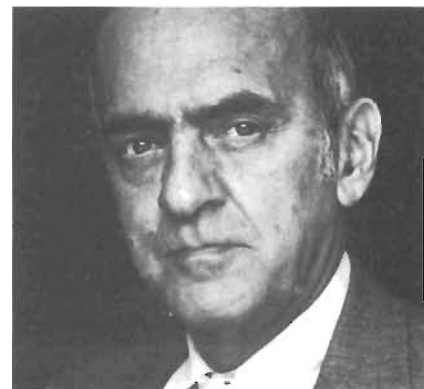
Director Thomas Lee briefing the heads of American firms in Austria on IIASA research relevant to industry and management.



Dr. Marjorie Matthews of the Canadian Federal Department of Transport discussing hazardous waste management with (from left to right) Professor Paul Kleindorfer, at IIASA from the Wharton School, University of Pennsylvania, USA; Dr. Chester Cooper, Special Advisor to the Director; and Dr. Jagmohan Maini, at IIASA on leave from Environment Canada.



Ambassadors in Austria or their representatives from the countries of IIASA's National Member Organizations meeting with Director Thomas Lee.



Dr. William Carey, executive officer of the American Association for the Advancement of Science, was briefed on IIASA research projects by scientists and management during his visit to the Institute. The AAAS is joined with the American Academy of Arts and Sciences, the US National Member Organization, and the Social Science Research Council in a consortium to support the work of IIASA.

Institute Scholars



Professor Alexander Kurzhanski is now Chairman of the Systems and Decision Sciences Program at IIASA. Awarded the National Lenin Prize in Science and Engineering, he comes from the Institute of Mathematics and Mechanics of the Ural Scientific Center of the Academy of Sciences of the Union of Soviet Socialist Republics. He is a corresponding member of the USSR Academy of Sciences.

Science Digest's listing of "America's 100 Brightest Scientists Under 40" in its December 1984 issue includes ecologist Dr. William Clark describing his

current biosphere work at IIASA, and the research of alumnus Dr. Joel Cohen, now head of the Laboratory of Populations at Rockefeller University, New York, USA.

New Titles

Books

Pest and Pathogen Control: Strategic, Tactical, and Policy Models. Gordon R. Conway, editor. The Wiley IIASA International Series on Applied Systems Analysis, Volume 13, John Wiley and Sons.

Distinguished Lecture

József Bognár: Dealing with Global Problems in an Interdependent World Economy. IIASA Distinguished Lecture 3.

This is available from the Secretariat, IIASA.

Research Reports

RR-84-9 Material Substitution: Lessons from the Tin-Using Industries. J.E. Tilton. Reprinted from *Material Substitution: Lessons from Tin-Using Industries*, J. Tilton, Editor. Resources for the Future and Johns Hopkins University Press, 1983.

RR-84-10 Methanol, Natural Gas, and the Development of Alternative Transportation Fuels. M.L. Kliman. Reprinted from *Energy*, Volume 8(11), 1983.

RR-84-11 On the Role of Science in the Postindustrial Society. "Logos" – The Empire Builder. C. Marchetti. Reprinted from *Technological Forecasting and Social Change*, Volume 24, 1983.

RR-84-12 Interactive Water Quality Simulation in a Regional Framework: A Management Oriented Approach to Lake and Watershed Modeling. K. Fedra. Reprinted from *Ecological Modelling*, Volume 21, 1983/1984.

RR-84-13 Resource Requirements and Economics of the Coal-Mining Process: A Comparative Analysis of Mines in Selected Countries. A. Astakhov and A. Grüber.

RR-84-14 Education, Earnings, and College Enrollment in the United States. S. Dresch. Reprinted from *Review of Public Data Use*, Volume 11, 1983 and *The Crisis in Higher Education*, J. Froomkin, Editor. Proceedings of the Academy of Political Science, Volume 35(2), 1983.

RR-84-15 Multiple-Objective Decision Analysis Applied to Chemical Engineering. M. Grauer, A. Lewandowski, and A.P. Wierzbicki. Reprinted from *Applied Systems Analysis*, Volume 4, 1983.

RR-84-16 Decomposition of a Large-Scale Energy Model. E.A. Nurminski and T. Balabanov. Reprinted from *Large Scale Systems*, Volume 3, 1983.

RR-84-17 The Accuracy of Population Projections. M.A. Stoto. Reprinted from *Journal of the American Statistical Association*, Volume 78, 1983.

RR-84-18 Dynamic Estimation of the Consumer Demand System in Postwar Japan. K. Sasaki and Y. Fukagawa.

RR-84-19 Alternative Routes from Fossil Resources to Chemical Feedstocks. G. Dobrowolski, J. Kopytowski, J. Wojtania, and M. Zebrowski.

RR-84-20 Farm Supply Response in Kenya: Acreage Allocation Model. N.S.S. Narayana and M.M. Shah. Reprinted from *European Review of Agricultural Economics*, Volume 11, 1984.

RR-84-21 An Analysis of Indirect Mortality Estimation. W.B. Arthur and M.A. Stoto. Reprinted from *Population Studies*, Volume 37, 1983.

Research Reports can be ordered from the Publications Department, IIASA.

The International Institute for Applied Systems Analysis

is a nongovernmental, multidisciplinary research institution supported by scientific organizations in countries of both East and West. IIASA's objectives are:

- to promote international cooperation in addressing problems arising from social, economic, technological, and environmental change
- to develop and formalize systems analysis and the sciences contributing to it, and to promote the use of the analytical techniques needed to address complex problems
- to create a network of institutions in the countries with National Member Organizations and elsewhere for joint scientific research
- to inform policy advisors and decision makers about the applicability of IIASA's work to contemporary problems

OPTIONS

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Director's Corner



I have been Director of IIASA for just a few months. Certainly my understanding of the Institute — its strengths, weaknesses, problems, and opportunities — will improve with time. Still, I believe I have had sufficient exposure to the organization and to the realities confronting us to be able to state in broad but clear terms the strategy we must introduce and follow persistently over the long term to bring recognition to IIASA for its excellence.

My three decades of managerial experience in the United States have taught me some valuable lessons about how an organization must operate to achieve excellence and efficiency. Let me share with you some of my personal experiences.

From 1959 to 1974 I was happily employed by the General Electric Company, as manager of R&D for its Electric Power Transmission and Distribution Group. Then, in 1974, I was asked to become chief strategic planner for the power generation business at GE, which at that time comprised nuclear systems, steam turbines, gas turbines, and a host of related products and projects. My initial response was: "Why me? I don't know much about strategic planning." One of the vice-chairmen explained: "Virtually no one knows much about strategic planning. What is needed above all is someone who can think critically."

Over the years I have come to appreciate the value of critical front-end thinking. That assignment also taught me the necessity of consistency in defined objectives, strategies and activities.

As Director of IIASA, I find myself in a similar situation. I have discovered that systems analysis means different things to different people. Still, as my recent discussions with IIASA Council Chairman Academician Jermen Gvishiani and with many Council members have revealed, there is general agreement on the pressing need for critical thinking on the part of IIASA's Director and the Council.

The primary objective I want IIASA to have met by the end of my term of Directorship in 1987 is

To have determined one or two key areas where IIASA could make a

unique relevant contribution, and to have well-formulated programs, highly-qualified staff, and work underway that will enable IIASA to build a solid reputation as the leading institute in the chosen areas.

Our "uniqueness" may be in pioneering a new type of work or in a research area which we believe is necessary but which thus far has received little or no attention by others, or it may lie in working in an area that engages other institutes but where our advantage would allow IIASA to "do better".

The technique of market segmentation can aid an organization in determining its special niche. A critical assessment of what the market is offering and what it would demand over the long term can help a small organization successfully carve out a segment of the market.

IIASA has pursued a research strategy similar to the "full market basket approach" of producing all the market demanded. This has been justifiable so long as there were adequate resources. Today these conditions do not prevail. IIASA cannot study a large number of issues — be all things to all people. We must concentrate resources on a few key areas and work much harder and more persistently to build up a track record for knowledgeable, dependable, and useful work.

As a young institute committed to advancing systems analysis, IIASA understandably chose to speak primarily to the needs of systems analysts and scholars in various disciplines. And to this end it has performed well. But IIASA has not always placed sufficient emphasis on the usefulness of its work in terms of aiding decisions at the industrial and policy levels.

For industrialists and policymakers the world over, the challenge is to respond practically to near-term pressures but with prudence and foresight about major investments. Their pressing need is for impartial, reliable, and synthesized assessments.

Meeting the challenge of a broader constituency base will not necessitate major changes in direction, but rather in our approach and emphasis. For example, the involvement of industrialists in the planning stages of our work will

enable us to view problems, possible solutions, and potential applications through a more realistic lens.

The path to desired improvements in IIASA's operations lies in a well-formulated research plan, able staff, and excellence in output. Without these, we will not be able to achieve my second objective — improving IIASA's financial stability. My experience as manager of research laboratories has made me aware that there must be a healthy relationship between external funds and internal income. For an institute like IIASA, I believe a 25 percent level of externally-funded projects appropriate, both to enable us to respond to the needs of our member organizations and to maintain a critical mass of researchers geared to specific real-world problem solving. Another objective is to develop a firmly-rooted, long-term Institute strategy to improve the continuity of Institute operations.

Clearly, recognition cannot be achieved overnight, nor can it be measured tangibly. One yardstick we might use to determine whether we are on the right track is, of course, the number of quality "clients" willing to pay for IIASA's services. Other measures of recognition would be a notable increase in the number of industrial and public agencies working collaboratively with us or willing to financially sponsor our meetings or individual participation at meetings; staff secondments to IIASA from industry; publishers competing to publish our work; and more and more invited lectures and articles by IIASA scholars in leading media outlets.

Let me end on a note of firm optimism. We have defined our problems and solution paths. We are seeking external funds aggressively and broadening our constituency base. We are in the process of creating an Advisory Board and efforts are underway to strengthen the impact of our communication work, particularly with respect to dissemination of research results and to making IIASA better known to the industrial and policy communities. The trajectory is now a positive one.

Thomas H. Lee