International
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Analysis

OPTIONS

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Man and the Environment

December 1985

In recent years, environmental scientists have become more and more specialized. At the same time, environmental managers are requiring inputs from a widening array of scientific disciplines. It has been found, for example, that problems such as acid rain, climate warming, stratospheric ozone depletion and the enhancement of biological nitrogen fixation require the collaboration of chemists, meteorologists, oceanographers, biologists, engineers, soil scientists, and many others. What is noteworthy with respect to the four particular problems listed above is that they are all interrelated, the integrating theme being the global biogeochemical cycling of trace substances. It is in fact becoming increasingly counter-productive to try to bound an environmental issue. This is not to deny the need for specialists, but some of the most significant research is taking place at traditional interfaces between disciplines.

In addition to the inter-relationships amongst environmental issues, there are important connections with other societal problems. In the context of the so-called global problematique, for example, environment is linked to technology, resources, population and culture. If stress is applied to one of these "boxes", actions and feedbacks occur at other places in the system.

IIASA has had long experience in designing appropriate conceptual frameworks to accommodate the various interacting components of large and poorly understood systems. This experience has been put to good use in designing the current Environment Program, in which a conscious effort has been made to integrate the various projects in meaningful ways. For example, studies of economic and environmental history are illuminating how the global environment has responded to changing patterns of energy-, land- and water-usage over the past century. Concepts and methods are being developed for realistically dealing with the multiple equilibria, thresholds, and discontinuities that seem to be the norm rather than the exception in the interactions of human development activities and the environment. The technology is now available to enhance the early-warning capacity of global monitoring systems. And increasingly, institutions are learning more about linking incomplete science with critical policy issues.

IIASA and its research partners around the world are using this new frame of reference to help identify potential serious risks to the global environment and how we can beneficially influence and use the resources of soil, vegetation, water, minerals, and the atmosphere. We invite members of the scientific and policy communities to join our collective endeavor.

R.E. Munn, Leader,
Environment Program.

The Environmental Research Program

The substantive research projects to be carried out within the framework of the Environment Program in 1986 are as follows:

* **Ecologically Sustainable Development of the Biosphere.** The Biosphere Project has become the central theme within the Environment Program, and the main focus will be on it through the three-year period 1986-1988. It aims to study the long-term interactions between human activities and the environment. It seeks to identify the processes that are most likely to compromise the long-term sustainability of development of the biosphere, and to devise appropriate technological strategies and institutional structures to deal with these threats.

* **Acid Rain.** The already established IIASA Acid Rain Project (see OPTIONS 1984/1), for the investigation of the origins, atmospheric transportation and effects of the chemical substances involved, is being expanded and refined to increase its usefulness still further.

* **Climate Impacts.** An established project supported by the United Nations Environment Programme, the IIASA Climate Impacts Project is approaching a successful conclusion of the present work program, which deals with the vulnerability of food production in climate-sensitive areas (see OPTIONS 1984/4).

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* **Water policy.** Current IIASA research in the vitally important water resources field will terminate in early 1986 with the conclusion of the Regional Water Policies Project. This is to be followed by a study on "Decision Support Systems for Managing Large International Rivers".

Research being carried out under IIASA's Environment Program has three main cross-cutting themes:

1. Environmental monitoring. The optimization of environmental monitoring systems is a badly neglected field of study. Much of the information in data banks was collected for specific purposes, and is often used inappropriately to try to solve new problems. IIASA intends to try to correct this situation, at the same time meeting the needs of the various Projects in the Environment Program. Several topics have already been identified for study:

* Design of ecological monitoring systems.
* Optimization of monitoring systems (jointly with the System and Decision Sciences Program).
* Design of early warning systems.
* Improvement in the design of existing acidic deposition networks, including those for monitoring of effects.
* Design of monitoring systems for post-EIA (environmental impact assessment) evaluations.
* Selection and optimal use of ecological and environmental data banks.

The common goal here is to guide the development of existing and future systems, so that they are better able to meet specific user needs. The underlying principle is that monitoring should be undertaken within an integrated framework that takes into account both the environment and the biosphere. IIASA's efforts to design conceptual frameworks for monitoring systems are related to a number of international programs such as UNEP GRID and ICSU Global Change.

2. Historical reconstruction. The historical reconstruction of cases in which regional economic development has degraded/preserved/enhanced the environment and biosphere is of great interest. Following a workshop held in Bulgaria in October 1985, a funding proposal is being developed that will include the elaboration of several comparative case studies in different regions, e.g. the Lithuanian SSR in the USSR, the Seto Inland Sea and coastal areas in Japan, the Balkans, and an agricultural region of Central Poland. The final recommendations and decisions on the choice of development strategies could then be prepared by national teams in 1987. They might include:

* an analysis of environmental consequences of various alternatives in development of industrial, agricultural and other sectors of the economy in the case-study regions or countries.
* the final version of the system of models explicitly adapted for use in the case-study regions.
* publications of methodological results.

A related topic to be undertaken is "Rationalization of Dendrochronological Sampling and Analysis Methodologies". Special attention will be given to the use of tree-rings as an early indication of forest dieback. The work will be under the direction of Academician Leonardas Kairiukstis, Deputy Head of the Environment Program at IIASA.

3. Uncertainty/environmental risk assessment. A small scoping workshop on Environmental Risk (including risk perception) was held at IIASA in November 1985, sponsored jointly by the Environment and System and Decision Sciences (SDS) Programs. Cosponsors providing financial support included UNIDO, UNESCO/MAB, US EPA, Canadian FEARO, and Canada Health and Welfare. (See box below)

Selected publications

R.E. Munn, G.E. Likens, et al. (1984): *A Meteorological Analysis of the Precipitation Chemistry Event Samples at Hubbard Brook (N.H.). Atm. Env., 18, pp. 2777-2779.*

R.E. Munn (1985): *The Identification of Early Indicators of CO2 Climate Warming in Canada. IES Monograph No. 6, University of Toronto, 52 pp.*

R.E. Munn (1985): *Observing Networks. Chapter 11, Handbook of Applied Meteorology (ed. by D. Houghton). New York, Chichester, John Wiley & Sons.*

R.E. Munn (1985): *The Design of Integrated Monitoring Systems to Provide Early Indications of Environmental/Ecological Changes. Forthcoming in the Proceedings of the Third International Symposium on Integrated Global Monitoring of the State of the Biosphere, organized by UNEP, 13-19 October 1985, Tashkent, USSR.* Preprinted as IIASA Working Paper WP-85-71.

Y.A. Izrael and R.E. Munn (1985): *Monitoring the Environment and Renewable Resources. In: Sustainable Development of the Biosphere (ed. by W.C. Clark and R.E. Munn). Cambridge University Press (in press).*

Risk and Policy Analysis Under Conditions of Uncertainty

While enjoying the tangible benefits of technological development, societies must also keep long-term social, economic and environmental consequences under control. For new technologies there is no historical precedent, and the risks involved are inherently uncertain.

Since the same new technologies are penetrating many countries, there is a need to ensure that experience is shared and that adaptive procedures for coping with risk penetrate equally. For widespread technologies, or those with global environmental impact, risk analysis and management require an international strategy.

A task force of international scientists and policy makers met at the International Institute for Applied Systems Analysis, November 25 to 27, 1985. The purpose of the meeting was to identify opportunities to improve the practice of risk and policy analysis. Recommendations were made in four areas.

* *Protocols outlining procedures for risk and policy analysis.* The protocols should provide practical guidance to those engaged in decision processes. They should include insights into the opportunities and pitfalls arising from both the analytical procedures available and the context in which the issue is embedded. Early attention should be given to procedures for developing a consensus on the structure of the issue in terms of the interests and objectives at stake, causal events, and the range of options for consideration. Situations/locations involving a multiplicity of differing types of risks are of particular concern. The protocols should not be sets of rules, but should apply the principles derived from past experience.
* *Case Studies: International and cross-sectoral comparisons of issues.* Situations where risks spill across borders and require negotiation and consensus-building among countries with different institutional structures are of primary concern, for example international rivers, acid rain, transport of hazardous substances, climate warming and stratospheric ozone depletion. Case studies should draw on descriptive histories, and derive the principles underlying valid and credible policy-making.
* *Educational Materials.* Teaching and training programs are needed both to explain the process of risk analysis and facilitate participation of stakeholders with different backgrounds, interests and roles, and to motivate employees responsible for safety practices.
* *International Collaboration.* A more structured approach is needed for the exchange of information on current and proposed research, and centers of expertise in risk and policy analysis. IIASA should draw on its network of National Member Organizations to identify common needs and contribute to efficient international collaboration in the design and conduct of protocol development, case-studies and educational projects.

Uncertainty provides a mounting source of tension at a time when rapid change is already taxing the technological and psychological ability of societies to adapt. Improved risk and policy analysis can reduce this tension and contribute to international harmony.

Ecologically Sustainable Development of the Biosphere – the core of the Environment Program

An IIASA Feasibility Study on Sustainable Development of the Biosphere was formulated in early 1983. An initial scoping document was prepared for IIASA in late 1982 by Dr. W.C. Clark, an ecologist, of Oak Ridge Associated Universities, USA. (Dr. Clark has from the beginning provided leadership, first at Oak Ridge, and since the beginning of August 1984 at IIASA itself.) Subsequent exploratory meetings to review, critique and build upon that document were hosted by the Canadian Government in Ottawa and Toronto, by the American Academy of Arts and Sciences in Cambridge (Mass.) and Washington, and by the Soviet Academy of Sciences in Moscow and Leningrad.

As a result of these meetings, and with the support of the Canadian Ministry of Science and Technology and the German Marshall Fund, IIASA commissioned 16 essays to provide guidance on the feasibility and desirability of a major study on sustainable development of the biosphere. These essays, written by some of the world's leading scholars of environment-development interactions, were reviewed in August 1984 at a workshop involving scientists and policy advisers from 16 countries. The revised essays, critical commentaries on them, and the recommendations of the workshop are being published in book form.

A formal project proposal growing out of the workshop was approved at a planning meeting in Moscow in March 1985, and endorsed by the IIASA Council in June 1985.

What does the Biosphere Project do?

The scope of the IIASA Biosphere Project is literally worldwide, since much of the work is being carried out through an international network of collaborating research institutes. IIASA itself has a core team of scholars engaged in substantive and methodological research, as well as playing a central coordinating role. The work program at IIASA is being carried out partially with other Projects and Programs.

The Project seeks to provide useful policy analyses for decision makers and planners in government and industry who confront long-term trade-offs between development and environmental objectives in the face of significant scientific uncertainty and minimal social consensus. The goal is to develop a strategic perspective on the interactions of development and environment that will help to clarify the key issues, to order the knowns and unknowns, and to illuminate possible "future histories" for sustainable development of the biosphere. The Project therefore addresses several fundamental questions:

* What are the most serious constraints to the future improvement of human well-being that could arise through the interactions of economic development and the natural environment over the next century? Conversely, what concerns now being debated are likely to be of only minor long-term, large-scale significance?
* What technological initiatives in industrial, energy or agricultural development might be undertaken over the next decade that could most effectively relax those environmental constraints and expand opportunities for sustainable development of the biosphere?
* What institutional improvements in the present structure of international accords, regulatory agreements, or scientific cooperation would most improve societies' abilities to manage the emerging problems of environmental and economic interdependence?
* How could major environmental research and monitoring programs be modified so as to provide more knowledge that is directly useful in the design and evaluation of long-term, large-scale development strategies?

The Biosphere Project seeks to complement, rather than duplicate or compete with, other studies of interactions between development and the environment. Its long-term, global perspective focusses on issues not adequately pursued by most national programs. Its policy orientation leads it to questions not considered in many existing international studies. Close collaboration has been maintained with national environmental programs and international efforts like ICSU's "Global Change" initiative, the World Climate Programme, and UNESCO's Man and the Biosphere Programme.

Project participants

As already stated, the Biosphere Project is a collaborative effort involving IIASA and an expanding network of scholars, policy advisors, and institutions. Collaborative studies already well under way include the following:

* **Synoptic Studies of Anthropogenic Changes to the Biosphere.** With Resources for the Future (USA); AT&T-Bell Laboratories (USA); Duke University (USA); Max Planck-Institute for Atmospheric Chemistry (West Germany); Academy of Sciences (Hungary); State Committee for Hydrometeorology and Control of the Natural Environment (USSR); Biosphere Project (Canada); Carnegie-Mellon University (USA).
* **Impacts of Environmental Change on the World Forest Products Sector.** With the University of Agricultural Sciences (Sweden); the Biosphere Project (Canada); and Yale University (USA).
* **Options for Large-Scale Environmental Restoration and Redevelopment.**

With the Hungarian Academy of Sciences; the Biosphere Project (Canada); Council for Planning and Coordination of Research (Sweden); University of Gdansk (Poland); Man and the Biosphere Program (UNESCO).

* **Technologies for Ecologically Sustainable Industrial Development.** With the Nuclear Research Center Jülich (West Germany); University of Krakow (Poland).

* **A Global Survey and Symposium on Human Transformations of the Earth Over the Last Two Hundred Years.** With Clark University (USA); The Institute of Geography of the USSR Academy of Sciences (USSR); Duke University (USA); University of Linkoping (Sweden).

* **Exploring the Role of Surprise, Shock and Discontinuities in Interactions Between Development and Environment.** With Clark University (USA); American Academy of Arts and Sciences (USA); Biosphere Project (Canada); Council for Planning and Coordination of Research (Sweden); University of Lund (Sweden).

* **Long-Term Environmental Futures for Europe.** With the Dutch National Institute of Public Health and Environmental Hygiene. Other collaborators are currently being sought.

After more than two years of preparatory work, IIASA's Biosphere Program is now in focus. The output over the next several years should make a substantial contribution to our knowledge of environment-development interaction. The challenge for IIASA is to provide policy makers with rapid access to, and a critical appreciation of, this information, so that development decisions can be taken with the best possible understanding of their environmental implications.

The Doon Valley

Opportunities arise from time to time to develop activities that do not quite fit into the normal Program. One such case is the contract signed with the United Nations Industrial Development Organization (UNIDO) to undertake phase I of an environmental impact assessment of industrial development in the Doon Valley in north-western India. Phase I is for seven months (October 1985 to April 1986) and has the aim of designing a conceptual framework for the assessment, preparing a baseline report of current conditions in the valley, and transferring some demonstration computer models to India for training purposes.

Sustainable Development of the Biosphere

Edited by W.C. Clark and R.E. Munn
Published by Cambridge University Press, 1986 (forthcoming)

This book concludes the first phase of the IIASA Program on the Ecologically Sustainable Development of the Biosphere. The individual essays were originally reviewed in late 1984 at an international workshop attended by their authors, other scholars, and policy makers. The essays were revised, often extensively, to reflect discussions at the workshop. A further critical dimension was provided by the independent commentaries that accompany them. Taken together, these contributions provide the foundations and initial scaffolding on which IIASA's continuing inquiry into a sustainable development of the biosphere is being built.

PART ONE: INTRODUCTION
Chapter 1 **Sustainable development of the biosphere**
W.C. Clark (IIASA)

PART TWO: HUMAN DEVELOPMENT
Chapter 2 **World environmental history and economic development**
J.F. Richards (Duke Univ.)
With a commentary by *M. Williams (Oxford Univ.)*
Chapter 3 **Sustainable development of regional ecosystems degraded by exploitative development**
H.A. Regier and G.L. Baskerville (Univs. of Toronto & New Brunswick)
With a commentary by *L. Kairiukstis (IIASA)*
Chapter 4 **Agricultural development**
F. Crosson (Resources for the Future)
With a commentary by *C.F. Runge (Univ. of Minnesota)*
Chapter 5 **Energy patterns – in retrospect and prospect**
J. Darmstadter (Resources for the Future)
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Chapter 6 **Novel integrated energy systems: the case of zero emissions**
W. Häfele, H. Barnert, S. Messner, M. Strubegger, with J. Anderer (Nuclear Research Center Jülich; IIASA)
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M.B. McElroy (Harvard Univ.)
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Chapter 8 **The role of atmospheric chemistry in environment-development interactions**
P.J. Crutzen and T.E. Graedel (Max Planck-Institute for Atmospheric Chemistry; ITT-Bell Laboratories)
With a commentary by *E. Meszaros (Institute for Atmospheric Physics, Budapest)*
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With a commentary by *N. Haigh (Institute for European Environmental Policy)*
Chapter 13 **Monitoring the environment and renewable resources**
Yu. Izrael and R.E. Munn (State Committee for Hydrometeorology & Control of the Natural Environment; IIASA)
With a commentary by *M. Gwynne (UNEP)*
Chapter 14 **Some implications of climatic change for human development**
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With a commentary by *M. Yoshino (Univ. of Tsukuba Sakura Mura)*

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Chapter 15 **Usable knowledge, usable ignorance: incomplete science with policy implications**
J.R. Ravetz (Univ. of Leeds)
With a commentary by *S. Rayner (Oak Ridge National Laboratory)*
Chapter 16 **Mythodology and surprise in the sustainable development of the biosphere**
P. Timmerman (Univ. of Toronto)
Chapter 17 **Methods for synthesis: policy exercises**
G.D. Brewer (Yale Univ.)
With a commentary by *N.C. Sonntag (ESSA Ltd.)*

The Impact of Climatic Change on Agriculture

Over the past few years IIASA has been involved with the question of climatic change in various ways. Firstly, the Institute's seven-year Energy Systems Program studied the effects that alternative future global energy strategies, based on fossil fuels and nuclear and solar energy, might have on world climate, and treated the possible effect on global temperature as a constraint on feasible energy scenarios. Secondly, the National Agricultural Policies Program was concerned with the influence of climate on global food production, and with the impacts on climate caused by different agricultural policies, such as deforestation. Thirdly, IIASA research projects on the world's natural resources have included studies of the distribution of water supply and demand, which can be significantly affected by changes in climate.

The Climate Impacts Project was the result of an agreement between IIASA and the United Nations Environment Program. A Study Conference attended by scientists from 17 countries in the Austrian town of Villach in September 1983 served as a "springboard" for launching a pilot study along similar lines to those employed in the main Project. The Project itself was jointly funded by IIASA and UNEP, with additional support from the Austrian Government and the UN University, and was part of the World Climate Impact Studies Programme run by UNEP. It was implemented by a small in-house core group at IIASA, led by Dr. Martin Parry (UK), with a collaborative network of 77 scientists from 35 different institutes working on 11 case studies. An account of the Project was published in the 1984/4 issue of OPTIONS.

The overall goals of the Project were first to evaluate the impact of climatic change and variability on food grains and livestock production, and second to assess appropriate policy responses to reduce the impacts of climate on agriculture. The specific case studies were carried out in two global types of climatic region, i.e. high-latitude/cold areas, and semi-arid areas, some of them at high altitude. The possible agricultural responses were considered with a view to mitigating the impacts of climate. The possible climatic impacts and responses in other areas of comparable sensitivity will now be considered, making use of the results obtained in the case study areas. The focus of the research was on assessment of short-term climatic variations and the likely long-term effects of carbon dioxide-induced climatic changes on food output in climate-sensitive areas.

The probable consequences for a variety of future scenarios

For example, the sort of warmer and more drought-prone climate in the Saskatchewan province of Canada that might be anticipated under conditions of doubled atmospheric carbon dioxide is expected to decrease spring wheat yields across the province by an average of 25 percent. Taking into account variation in yield change from one soil type to another, and assuming the same area under spring wheat as today, IIASA's collaborating agrometeorologists in Agriculture Canada, the federal Department of Agriculture, estimate that total provincial spring wheat production would decrease by 2.6 million metric tonnes – a decrease of global significance, since Saskatchewan produces one eighth of the wheat traded on world markets.

The premise behind this set of studies is that, while we are not yet in a position to forecast how the climate may change, we can estimate the probable consequences for a variety of possible future scenarios. Agricultural planners can then consider the range of the most likely impacts with which they may have to contend, and can improve their analysis techniques. Consequently, when we begin at some point in the future to make successful long-term forecasts of climate, we shall also have acquired an ability to assess their probable impact.

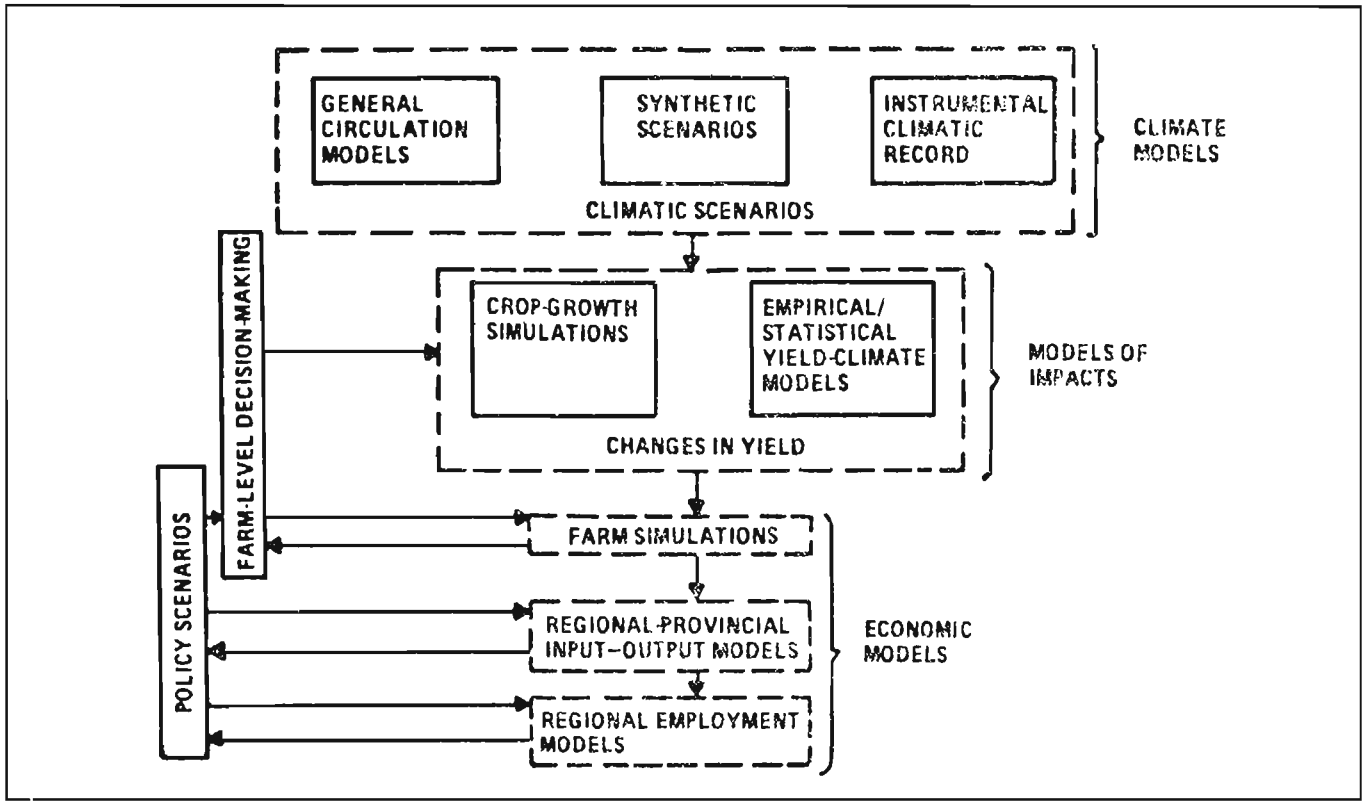
The two-year IIASA/UNEP Climate Impacts Project is approaching a successful conclusion of the present work program dealing with the vulnerability of food production in climate-sensitive areas. Two large volumes of climate impact assessments are presently being prepared for publication during 1986 (see the select list of publications), the target audience being scientific advisors and planning officers in regional and national agencies for agricultural planning.

As regards the future of work at IIASA on climatic impacts, two closely-connected tasks are planned for 1986:

1. Strengthening of the IIASA/UNEP work on integrated impact assessment, specifically by communicating results through the publication of the two volumes of impact assessment; writing an Executive Summary; and disseminating and evaluating results in several small meetings of users in the summer of 1986. This work will be largely funded by UNEP.

Evaluating priorities for further work

2. Evaluating priorities for further work. Part of the evaluation will involve synthesizing and summarizing the new methodologies developed over 1983-1985. The remainder of the evaluation will consist of consideration of other promising lines of climate impact research, e.g. the sensitivity of the world food trade system to climatic variations. These evaluations will be presented for discussion at a "scoping" workshop in climate impact assessment which will be held in June/July 1986. Support for the workshop has been pledged from several international



A hierarchy of models used for assessment of climate impacts and evaluation of policy responses: schema of the approach followed by the IIASA/ UNEP Climate Impacts Project (from Parry et al. 1986).

agencies and national climate bodies, who will participate in the meeting.

Looking ahead, it is expected that the 1986 Workshop will provide a basis for developing a substantial proposal for external funding, which may lead to several new lines of research in 1987-1988. In addition, collaboration will continue with the Biosphere and Acid Rain Projects.

The Project leader, Dr. Martin Parry, returned to the University of Birmingham in August 1985, but will be at IIASA for several months in 1986 to provide continuity until a new Project Leader is appointed in late 1986 or early 1987, if the necessary funding is obtained.

Selected publications

T. Carter, N. Konjin and R. Watts (1984): *The Role of Agroclimatic Models in Climate Impact Analysis.* IIASA Working Paper WP-84-98.

T. Carter and M. Parry (1984): *Strategies for Assessing Impacts of Climatic Change in Marginal Areas. In: Climatic Changes on a Yearly to Millenial Basis (ed. by N.A. Mörner and W. Karlen) pp. 401-415. Dordrecht, Reidel.*

N. Konjin (1984): *A Crop Production and Environment Model for Long-Term Consequences of Agricultural Production.* IIASA Working Paper WP-84-51.

M. Parry and T. Carter (eds.) (1984): *Assessing the Impact of Climatic Change in Cold Regions.* IIASA Summary Report SR-84-1.

M. Parry (1985): *Assessing the Impact of Climate Change on Marginal Areas. In: Climate Impact Assessment: Studies of the Interaction of Climate and Society (ed. by R. Kates et al.). New York, Wiley.*

M. Parry (ed.) (1985b): *Climatic Change 7(1), Special Issue: The Sensitivity of Natural Ecosystems and Agriculture to Climatic Change. Dordrecht, Reidel.* Reprinted as IIASA Research Report RR-85-01.

M. Parry, T. Carter and N. Konjin (1985a): *Climate Impact Analysis in Cold Regions. In: Nordia 18(2):67-79.* Reprinted as IIASA Research Report RR-85-8.

M. Parry, T. Carter and N. Konjin (1985b): *IIASA/UNEP Climate Impacts Project: The Vulnerability of Food Production in Climate-Sensitive Areas. In: Bulletin of the American Meteorological Society (forthcoming).*

M. Parry (1986): *Some Implications of Climatic Change for Human Development. In: W.C. Clark and R.E. Munn (eds.), Sustainable Development of the Biosphere. Cambridge University Press (forthcoming).*

S. Pitovranov, S. Pegov and P. Homiakov (1984): *Modeling the Impact of Climatic Change on Regional Ecosystems.* IIASA Collaborative Paper CP-84-7.

Project results:

M. Parry, T. Carter and N. Konjin (eds.) (1986a): *Assessment of Climate Impacts on Agriculture, Volume 1: In High Latitude Regions. Dordrecht, Reidel (in preparation).*

M. Parry, T. Carter and N. Konjin (eds.) (1986b): *Assessment of Climate Impacts on Agriculture, Volume 2: In Semi-Arid Regions. Dordrecht, Reidel (in preparation).*

Acid Rain–the Work goes on

The IIASA project for analyzing impacts of acid deposition was described in the 1984/1 issue of OPTIONS, but it is now at a more advanced stage, as regards both results to date and detailed plans for further development.

The computer model entitled RAINS (Regional Acidification Information and Simulation) currently contains three linked compartments, covering the whole range of the phenomenon from its origins to its effects: Energy Use and Pollution Generation, Atmospheric Processes, and Environmental Impact. Each of these compartments can be filled by different substitutable submodels. The submodels currently available include Sulfur Emissions, the EMEP Long Range Transport Model, Forest Soil pH, and Lake Acidity. In addition, two submodels are under development, namely NOx Emissions, and Direct Forest Impacts. Currently, the model is designed for use in Europe as a tool to be used to evaluate policies for reducing deposition of acidic substances.

In 1986 the process will continue of improving and extending the model. Research efforts will focus on model testing and uncertainty analysis, expanding the model to include cost analysis and additional submodels, development of other operational modes to RAINS (like searching techniques and optimization algorithms), applying the model to policy analysis, and distribution of RAINS to international and national institutions for their use in policy analysis.

The extension to cover policy analysis for the benefit of governmental and other decision makers is of particular importance. At the moment RAINS is a tool to analyze scenarios, but it is not yet suitable for establishing optimal policies for reducing acidification effects. For the latter operational mode of the model, additional effort is required. The current plan is to design an optimization mode of RAINS in collaboration with IIASA's System and Decision Sciences Program (SDS) and the Central Institute for Cybernetics and Information Processes (ZKI) of the Academy of Sciences of the German Democratic Republic. Adding a control cost submodel is regarded as being of crucial importance for policy applications. This demands at least two person-years, because of the relatively large number of countries involved, but a good start will be made by implementing the available cost functions of the Federal Republic of Germany.

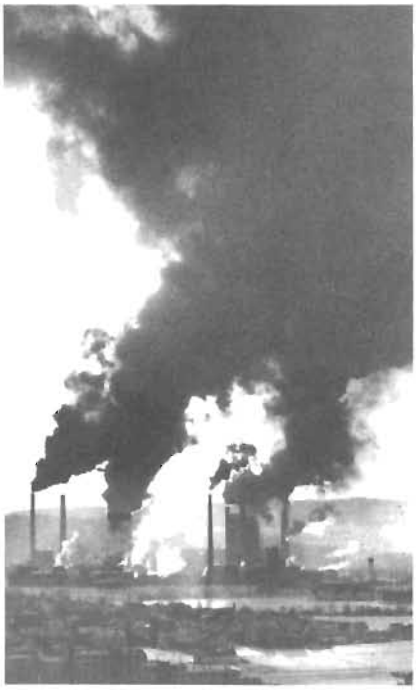


Photo: Votava

Further refinements planned include data base improvements, as well as sensitivity and uncertainty analysis for the different submodels. Such an analysis for the atmospheric submodel is being carried out in collaboration with the Institute for Meteorology and Water Management in Warsaw.

An NOx emission model will be constructed for Europe, partly through collaboration with the OECD. A transport and deposition model for NOx under development in Denmark and Norway will be implemented as an additional submodel to RAINS. Further work will be done on the completion of the environmental impact submodels. This includes the direct forest impact submodel already started in 1985, and testing of the forest soil and lake acidification submodels with data from Finland, Norway and Sweden. As a result of small feasibility studies carried out by participants in the Young Scientists' Summer Program in 1985, an additional submodel for groundwater acidification is being considered.

The IIASA Acid Rain Project is being developed with the intention of creating a practical, easy-to-use analytical computerized framework so that different strategies and options can be evaluated and assessed. The system, in fact, is virtually being "co-designed" in cooperation with potential users. A number of institutions in the Federal Republic of Germany, Finland, Hungary, Italy, the Netherlands , Norway, Sweden, the UK and the USSR have expressed interest in using RAINS, while the major client for the model, the Executive Body of the ECE Geneva Convention, will continue its support through the coming years.

Photo: Votava

The emphasis is on the practical usability of RAINS as an aid to the making of what may have to be far-reaching strategic decisions by national and international authorities. In order to support dissemination and policy applications, a start has been made with imple-

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News from the Institute

Scientific meetings

More than 50 industrialists, government representatives and academics from both East and West came to IIASA to attend an International Conference on *Transportation, Storage and Disposal of Hazardous Materials* (2-5 July). The conference highlighted key areas in the risk analysis and management of hazardous materials, including

* the role of compensation, insurance and regulation with regard to hazardous materials
* institutional and legal issues related to national and international regulation of hazardous materials
* assessment, perception and communication of risks
* strategies for emergency management of catastrophic events such as the Bhopal disaster
* bargaining, negotiation and conflict management with regard to hazardous waste facilities
* transportation of hazardous materials

Expert Systems for the Management of Risks Associated with Hazardous Substances was the subject of a task force meeting held at IIASA over the period 8-10 July. Twelve participants from seven countries and one international organization discussed with IIASA's Advanced Computer Applications group the progress of work undertaken in cooperation with the Commission of the European Communities' joint Research Center at Ispra, Italy.

IIASA hosted a two-day International Conference on *Structural Change in the Forest Sector* at Schloss Laxenburg (29-30 July). The conference, attended by 43 participants from 13 countries and three international organizations, was the final meeting of the IIASA Forest Sector Project, a four-year research effort with more than 100 collaborators in 35 countries, which has been working on the world's first comprehensive global model of the forest sector. The highlight of the conference was a demonstration of the use of this powerful and unique analytical tool to test the regional impacts arising from policy changes and environmental developments. The "test scenarios" presented by the IIASA team covered

* exchange rate variations
* trade liberalization policies
* alternative rates of economic growth
* increased exploitation of Soviet forest resources
* impacts of forest die-off in Europe
* effects of climatic warming due to increased levels of atmospheric carbon dioxide

Professor M. Kallio, Leader of IIASA's Forest Sector Project, at the "International Conference on Structural Change in the Forest Sector".

The Academy of Sciences of the German Democratic Republic, in cooperation with IMACS, IFAC and IIASA, sponsored the Second International Symposium on *Systems Analysis and Simulation*. The meeting was held in Berlin, GDR, on 26-31 August. The 500 participants discussed recent advances in systems analysis, mathematical modeling and simulation techniques for complex, including non-engineering, systems.

On 3 September, the IIASA Acid Rain Group presented the *scientific background to the problem of acidification in Europe* to 70 participants from 24 institutions in Warsaw, Poland. This general information, aiming at informing Polish policy makers and scientists about the relevance to Poland of transboundary air pollution, was followed by a technical presentation of the RAINS Model. On 4-5 September, a Task Force meeting of the Acid Rain Project also took place in Warsaw, and examined the *Atmospheric Computations for Assessment of Acidification in Europe*. These meetings were organized together with the Institute for Meteorology and Water Management, and the Polish Academy of Sciences.

The Mathematics of Dynamic Processes was the theme of a workshop organized by IIASA's System and Decision Sciences Program in Sopron, Hungary, on 9-13 September. Participants from 13 countries discussed the recent methodological advances in dealing with uncertainty in dynamic systems, and the successful application to biological models.

Together with the USSR Committee for Systems Analysis, IIASA co-organized a workshop on *Systems Analy-*

sis in Demography and Health in Moscow, USSR, on 9-15 September, in which Professor Nathan Keyfitz, Program Leader, and Dr. Anatoli Yashin, of the Population Program, participated. The meeting was attended by more than 30 demographers from the USSR and other countries.

IIASA hosted the Third Meeting of the COSPAR (Committee on Space Research of the ICSU) Ad-hoc Group on *Remote Sensing for Global Change* (25-27 September). Twenty participants discussed the state-of-the-art of space technology for long-term monitoring of atmospheric aerosols, trace gases, ice and snow.

Regional Resource Management was the theme of a workshop organized by IIASA and the Bulgarian NMO in Varna (30 Sep – 6 Oct). Forty-two participants from 15 countries addressed questions related to long-range climatic background fluctuations as apparent from dendrochronologies, to long-range transport of pollution and acid rain, and to resource management policies and sustainability of regional systems.

The Ohio State University, in cooperation with Case Western Reserve University and IIASA, sponsored a workshop on *Innovation Management: Innovation and Modernization*. The meeting was held in Columbus and Cleveland, Ohio, USA, on 7-11 October. Fifty-three participants from 13 countries discussed comparative experiences in dealing with the dual challenge of modernizing traditional "smokestack" industries and stimulating the development of new enterprises and technology-based new products. Other sponsors of the conference were the American Academy of Arts and Sciences, the State of Ohio Thomas A. Edison Program, the American Committee on East-West Accord, the Honda Manufacturing Corporation of America, the Ford Motor Company, Allen-Bradley Corporation, and the Ross Laboratories Division of Abbott Laboratories.

Four task force meetings are being held in 1985 as part of the planning process for the new IIASA research program on *Technology-Economy-Society*. The first of these meetings was held at Cambridge, Massachusetts, USA, on 15-16 October, with the cooperation of the American Academy of Arts and Sciences. Twenty-two participants from 9 countries held discussions on integrated technology assessment. The second meeting, held at Schloss Laxenburg on 28-29 October, involved 15 participants from 11 countries, discussing approaches to dynamizing technology.

The IIASA Energy Project held the fourth and final meeting of its study of *expanded gas usage in European markets* (17-18 October). Fifteen participants, mostly from industry, discussed gas production, consumption and trade potentials, fuel substitution, and the possible impacts of innovation on the pricing energy unit in Europe. Another focal point of the meeting concerned the impact of noncommercial realities (e.g. geopolitics, protectionism) on trade problems.

IIASA's Acid Rain Project hosted the First Executive Committee Meeting of the European Association for the Science of Air Pollution (EURASAP) at Schloss Laxenburg (30-31 October). Nine participants from 7 countries attended the meeting that aimed, firstly, to promote the idea of EURASAP as a non-governmental forum at which scientists working on European air pollution problems can discuss methods and results. The second objective was to plan the Association's inaugural meeting and colloquium on *Interregional Air Pollutant Transport*, to be held in Budapest, Hungary, on 22-24 April 1986, organized by IIASA's Acid Rain Project with the cooperation of the Hungarian Institute for Atmospheric Physics.

IIASA "Life"

U.S. officials briefed on IIASA research.

Mr. Raymond E. Bye, Director of the Office of Legislative and Public Affairs of the National Science Foundation, Mr. Richard Malow and Mr. Paul Thompson of the Committee on Appropriations of the US House of Representatives, Washington, visited IIASA on 16 August. They were accompanied by Mr. David Jackson and Mr. John Baumann of the US Embassy in Vienna, Austria. IIASA's Director Thomas H. Lee outlined the Institute's research strategy for the next three years. This was followed by reports on activities by leaders of the Environment, Population, and System and Decision Sciences Programs and Projects. Possible future collaboration between IIASA and the National Science Foundation was discussed.

Governor Celeste of Ohio with Professor Sven Lundstedt and IIASA Director T.H. Lee.

A delegation of Japanese economists conferring with Director T.H. Lee and other IIASA staff.

Delegation of Japanese economists at IIASA.

A delegation of 14 Japanese economists, organized by the Kansai Economic Research Center of Osaka and headed by Professor Chikashi Moriguchi from the Economic Research Institute of Kyoto University, visited IIASA on 9 September. They were briefed by Director Thomas H. Lee and by Professor Yoichi Kaya, Secretary of the Japan Committee for IIASA, on IIASA activities, and by Dr. Anatoli Smyshlayev, leader of the Comparative Economic Analysis Project, on IIASA's economic research. On 10 September Professor Moriguchi delivered a guest lecture on "Export-Led Growth in the Pacific Basin Economies".

Varna II Forum.

Director Thomas H. Lee and Mr. Thomas Jozseffi, from the Office of Planning and Sponsored Research, participated in the Varna II Forum "East-West Trade, Status and Prospects" from 28-30 September, which was successfully organized by the Bulgarian Government and the International Council for New Initiatives in East-West Cooperation. Some 190 leading representatives of the business world from 25 countries, both East and West, discussed the current status of East-West business relations and possible future perspectives including aspects of trade, joint ventures, financing, as well as scientific and technical cooperation. Director Lee presented IIASA's planned program on "Technology-Economy-Society", which was received with great interest, and led to intensifying and establishing contacts with representatives of the international business community.

Academician Jermen M. Gvishiani

IIASA Council Chairman appointed Deputy Chairman of GOSPLAN.

Academician Jermen M. Gvishiani, Chairman of the IIASA Council, was recently appointed Deputy chairman of the USSR State Planning Committee (GOSPLAN). A member of the USSR Academy of Sciences and of several foreign Academies, Academician Gvishiani is also Chairman of the Council of the International Research Institute for Management Sciences (IRIMS), and Director of the All-Union Research Institute for Systems Studies (VNIISI) in Moscow, USSR.

Former Director C.S. Holling honoured.

Professor C.S. Holling (Canada), Director of IIASA from 1981 to 1984, was awarded the Austrian Honorary Cross for Science and Arts, First Class. The award was presented to him by Dr. Norbert Rozsenich of the Austrian Ministry for Science and Research in recognition of his efforts to enhance IIASA's role as a center for international cooperation and exchange (4 October).

IIASA Scholar awarded honorary doctorate.

Professor Jean-Pierre Aubin, from the System and Decision Sciences Program, was awarded an honorary doctorate from the Faculty of Social Sciences of the University of Umea, Sweden, for his outstanding contribution to the development of mathematical economics, game theory, and applications of differential inclusions in the fields of social sciences, economics, and systems analysis.

Visit of Mr. Ron Berlet.

Mr. Ron Berlet, Director General of the Technology and Investment Development Bureau, Canadian Department of External Affairs, Ottawa, and a member of the Canadian Committee for IIASA, visited IIASA to acquaint himself with the current research activities (2 October).

Improving IIASA's access to INION.

Academician Vladimir A. Vinogradov, Director of the Institute of Scientific Information on Social Sciences (INION), Moscow, USSR, and Dr. Valeri V. Dashko, Deputy Head of INION's Computer Communication Department, and an IIASA alumnus, visited IIASA on 14-20 October to discuss with the IIASA management ways of improving IIASA's access to INION data bases within the framework of the agreement on information exchange signed between IIASA and INION in January 1985. This gives IIASA on-line access to bibliographical information from the data banks of INION. During his visit, Academician Vinogradov also lectured on "The Role of Scientific Information in Social Sciences and International Scientific Cooperation", and Dr. Dashko gave a talk on "INION Contribution to the Development of Telecommunication Access to the Soviet On-Line Data Bases" (15 October).

Professor Jean-Pierre Aubin

GDR Minister visits IIASA.

On the occasion of his visit to Austria, Dr. Hans Reichelt, Vice Chairman of the Council of Ministers and Minister of Environmental Protection and Water Management, German Democratic Republic, visited IIASA to learn more about IIASA's environmental research. Minister Reichelt was accompanied by officials from the GDR Ministry of Environmental Protection and Water Management, the GDR Embassy in Vienna, and representatives from the Austrian Ministries for Foreign Affairs, and Health and the Environment (22 October).

Mr. Ron Berlet, Canada, with IIASA Secretary Jean-Pierre Ayrault and Director T.H. Lee.

Minister H. Reichelt (center) and Dr. L. Kolbig (left), GDR, with Dr. S. Kaden of IIASA's Water Policies Project (right).

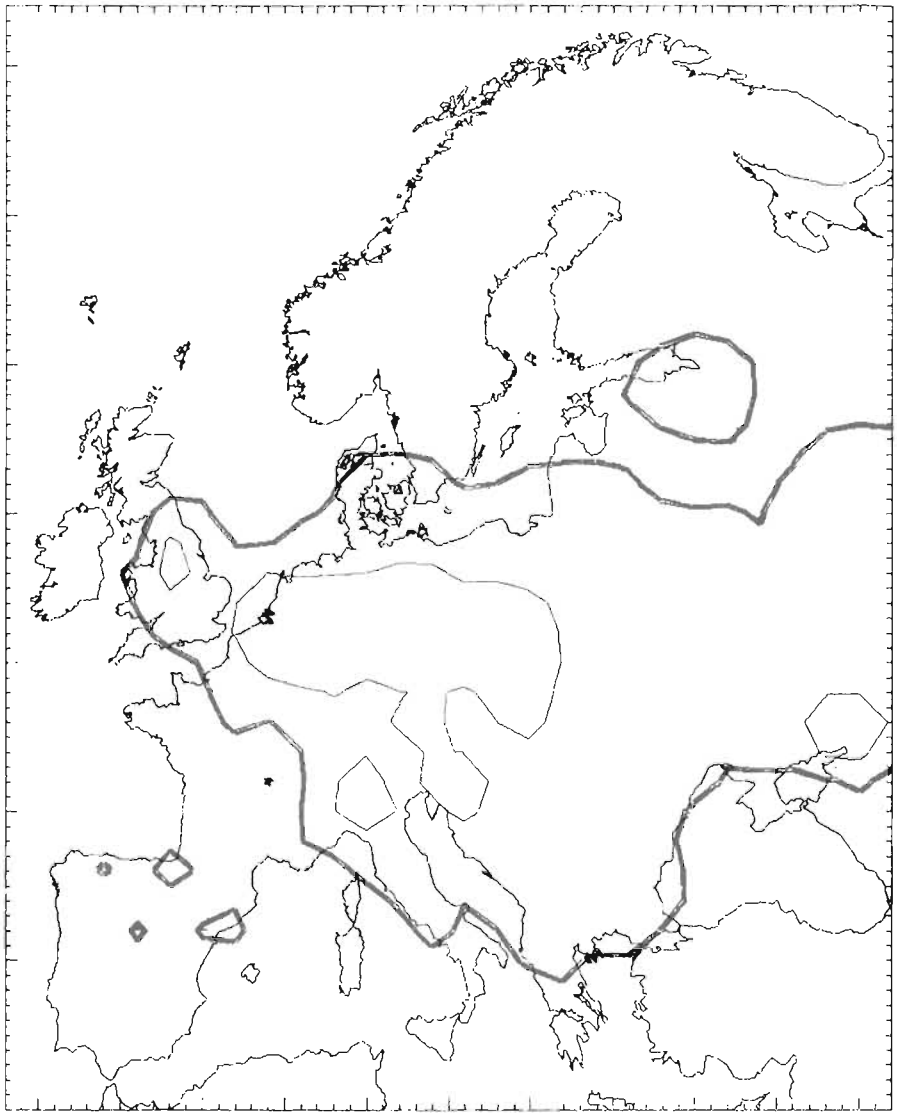
1985 Peccei Scholarships awarded.

Andrew Foster (USA), Maria Holmberg (Finland), and Rafal Serafin (Canada) were the 1985 recipients of the Peccei Scholarships. These awards have been granted since 1984 annually by IIASA to outstanding participants in the Young Scientists' Summer Program, in recognition of the dedication of the late Dr. Aurelio Peccei to the ideals of IIASA. The scholarship provides funds for a further research stay at IIASA.

Acid Rain/Continued from page 8

menting the model on a portable microcomputer. The effectiveness of the approach adopted is that all the information is graphically represented on the screen as well as in printed form. The impact of any control measure can thus readily be seen, and alternative policies easily compared, which should be of considerable assistance to those responsible for decisions and action in this field, scientists and non-scientists alike. The modular and flexible design means that the model can easily be updated as additional expert opinion and data becomes available.

There are still unknowns and uncertainties involved in the environmental acidification process, but its consequences, if unchecked, are so appalling that practical corrective action cannot wait on the elucidation of every detail of the reasons for it. The IIASA research program will be continuing at least until 1988, with the further development of RAINS as an essential aid to policy decision making. The major findings will be published in two volumes, one for the policy community, and another for the scientific community, in addition to the computer software.



Sulfur deposition (G/M2/YR) in Europe

Selected publications

L. Hordijk: *A Model for Evaluation of Acid Deposition in Europe. In: Systems Analysis and Simulation 1985 II (ed. by A. Sydow, M. Thoma and R. Vichnevetsky), Akademie-Verlag, Berlin, GDR, pp. 30-39.*

J. Alcamo, L. Hordijk, J. Kämäri, P. Kauppi, M. Posch and E. Runca: *Integrated Analysis of Acidification in Europe. In: Journal of Environmental Management (1985) 21, pp. 47-61.*

L. Hordijk: *Towards a Targetted Emission Reduction in Europe. In: Atmospheric Environment (forthcoming).*

J. Alcamo and E. Runca: *Technical Dimensions of Transboundary Air Pollution. In: Transboundary Air Pollution (ed. by C. Flintermann, B. Kwiatkowska, J.G. Lammers). Kluwer Academic Publishers, Amsterdam (in press).*

J. Alcamo, L. Hordijk, J. Kämäri, P. Kauppi, M. Posch and E. Runca: *Using Results from a Regional Air Quality Model in a Decision Making Context. In: Atmospheric Environment (forthcoming).*

A. Mäkelä: *Strategies towards Scenarios of Forest Damage due to Air Pollution.* IIASA Working Paper WP-85-12.

J. Kämäri, M. Posch and L. Kauppi: *Development of a Model Analyzing Surface Water Acidification on a Regional Scale: Application to Individual Basins in Southern Finland. In: Hydrological and Hydrogeochemical Mechanisms and Model Approaches to the Acidification of Ecological Systems (ed. by I. Johansson). Nordic Hydrological Programme, NHP Report No. 10, 1985, pp. 151-170.*

P. Kauppi, J. Kämäri, M. Posch, L. Kauppi and E. Matzner: Acidification of Forest Soils: *A Model for analyzing Impacts of Acidic Deposition in Europe – Version II.* IIASA Collaborative Paper CP-85-27.

P. Kauppi, J. Kämäri, M. Posch, L. Kauppi and E. Matzner: Acidification of Forest Soils: *Model Development and Application for Analysing Impacts of Acidic Deposition in Europe. In: Ecological Modelling (in press).*

L. Kauppi, M. Posch and J. Kämäri: *Sensitivity Analysis of a Regional Scale Soil Acidification Model.* IIASA Collaborative Paper CP-85-45.

Regional Water Policies

An IIASA research team, consisting of Dr. Sergei Orlovski (USSR, Project Leader), Dr. S. Kaden (German Democratic Republic), P. van Walsum (Netherlands) and Dr. Y. Nakamori (Japan), was the core of collaborative work that is nearing completion. This team not only coordinated the work, but also essentially developed the methodological basis, structural design of the decision support systems, and analytical procedures, and also implemented them on the IIASA VAX 11/780 computer.

But the successful work of this team would have been impossible without the direct participation in this work of the other two research groups in the German Democratic Republic and in the Netherlands. The group in the GDR included scientists from the Institute for Water Management, Berlin; Technical University of Dresden; and the Institute of Lignite Mining. The group in the Netherlands included scientists from the Institute for Land and Water Management Research (ICW), Wageningen.

To say that these groups provided a support for the IIASA Project will not fully reflect their decisive contributions to the Project, which included not only the necessary data and the basic models for the respective regional studies, but also their active participation in shaping the research strategy.

A collaborative project now nearing completion

The project also received contributions in the form of software and models from research groups from the Institutes of Automatic Control and of Environmental Engineering, both of the Warsaw Technical University, Poland, and in the Computing Center of the USSR Academy of Sciences.

In addition to these groups, a great many scientists were in permanent contact with the Project, and contributed useful ideas and criticism in personal discussions, as well as during a number of fruitful meetings and workshops held by the Project.

Intense socio-economic development in many regions of the world is putting an increasing pressure on the environment, both by consuming natural resources and by discharging pollutants that are hazardous to people and to ecosystems. A substantial proportion of these impacts takes place through regional water systems.

On the one hand, the extensive use of fertilizers and the disposal of animal wastes (manure) on arable land lead to a pollution of surface water (above all by phosphates) and groundwater (by nitrates) that affects ecosystems and water supplies for human purposes. On the other hand, the pumping of groundwater for public water supply, mine drainage, and other purposes causes a lowering of the groundwater table over a wide area. These problems are especially severe in open-pit mining areas; for example, in the GDR some 1.8 billion cubic meters annually are pumped for mine drainage, which amounts to about 20 per cent of the stable runoff of the whole country.

Apart from being a medium that is vital for socio-economic development and for the evolution of ecosystems, the regional water system is a basic medium through which local human interventions penetrate to and are "felt" in other parts of the region and also frequently beyond its boundaries.

In different regions different types of economic activity can vary in their degree of influence on the water systems. The IIASA study concentrated on two regions with intense economic activities – intense in the sense that these activities compete with each other for the use of natural resources, and also in the sense that the impacts of these activities on the environment are severe.

One of these test regions – the Southern Peel region of the Netherlands – is predominantly agricultural. The intensive agriculture in this region creates significant problems, both existing and anticipated in the future, with the deteriorating quantity and quality of groundwater resources. Some measures, maybe structural changes, should be undertaken in this region to

Photo: Votava

Water – a medium through which pollution can penetrate to distant parts of the ecosystem.

Photo: Votava

The biological quality of water is of first importance for the maintenance of life. Fish and plant life is directly affected, and the wider effects are felt throughout the ecosystem.

redirect its future development towards a more sustainable coevolution with the environment.

In the other test region of Lusatia in the GDR the major impacts are associated with the open-pit mining activities that cause major changes in groundwater and surface water regimes. But, in contrast to the Southern Peel region, the development of the mines and of the accompanying industry is predetermined by national political and economic considerations. Therefore, measures are to be considered here which can reduce the impacts of mining on natural systems as well as on other economic sectors in the region.

In the two regions considered by the Project, the multiplicity and the complex nature of the relations between water users and natural water systems on the one hand, and between water systems and natural ecosystems on the other, pose problems to authorities that are concerned with and are responsible for guiding the regional development. The complexity of these problems, and also the vast amounts of information to be considered and processed for their analysis, are the reasons for the development of new computer-based tools that can be used by regional authorities in their analysis of alternative paths of regional development.

Such a tool is a flexible decision support system that should assist the user to handle various types of information, obtain answers to multiple questions pertinent to regional concerns, and be convenient in its use. Designing two such systems for the two concrete prototype regions was a focal point of the Project's work.

As the project team see it, the process of designing a decision support system starts with a necessarily vague description of a real system and the scope of problems of concern. Its final product is a computer-implemented decision-support system designed (and tested) as a tool for the analysis of alternative solutions to those problems. Therefore, designing such a system should involve the translation of the initial formally vague description into a more logically structured and mathematically formal one allowing computer implementation. This type of translation would necessarily omit many irrelevant (and sometimes relevant) aspects of the real system and problems, but at the same time it would allow the structure of the major regional issues to be more clearly revealed, aand therefore permit their more concentrated systematic analysis.

Figuratively speaking, we can look at a region from different angles, and obtain quite different images. All these

images are, of course, true in their own senses, but what is needed is a "portrait" that is suitable and convenient for our concrete problem-oriented study, containing at the same time as little irrelevant detail as possible. Having obtained such a "portrait" that may take the form of a verbal description, diagrams, etc., we can proceed with formalizing a structure for the decision aid system that is to be designed.

This structure and its constituent mathematical models and computational procedures may be very different, depending on their planned utilization. Therefore, in addition to the above-mentioned portrait of the region we should have a more or less clear conception of the logic of the analysis that is to be performed with the use of the completed system. This concept of the analysis, in its turn, should be based on the scope of the problems in the real region under examination, because every step of such analysis is in fact obtaining answers to questions pertinent to regional problems.

Such portraying of the region together with the proposed logic of analysis forms a skeleton, to be gradually enriched with more "fleshy" mathematical models, and concrete analytical as well as computational procedures.

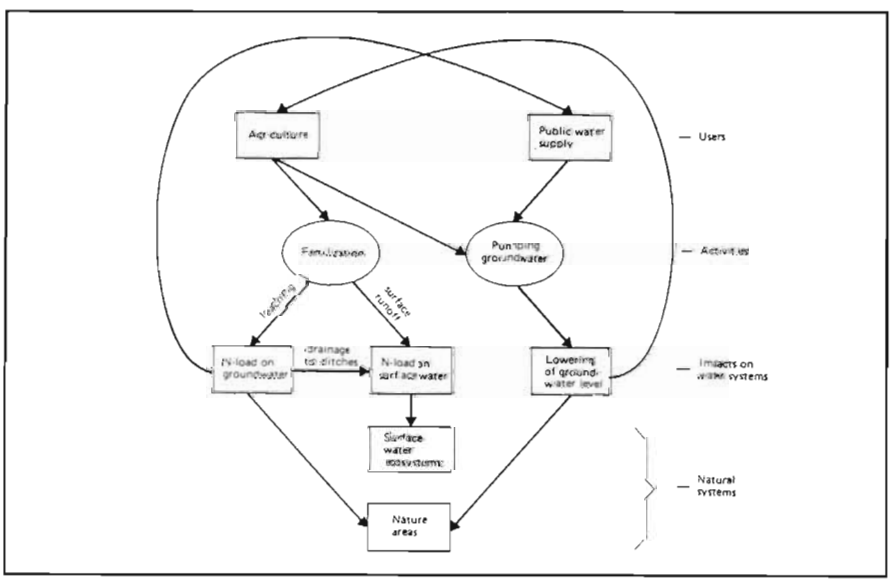
Given a concrete region, and having in mind regional environmental concerns, the following questions should first of all be clarified:

** What economic sectors in the region are making the most significant impacts on natural water systems, and through them on other parts of the environment?*

** What are the activities in these sectors that make the greatest impacts?*

Photo: Votava

Open-cast mining involves lowering the groundwater table by pumping – a process that can have far-reaching effects on the ecosystem over a considerable area.



The main impacts of human activities, using the example of a typical agricultural region. From this diagram we see what major processes, and relationships between them, should be modeled for the analysis. A diagram for a region with a sophisticated industrial base could be more complex than this example, but the basic principles remain the same.

** How, or rather through what natural processes, do these impacts take place?*

** What parts of natural systems are affected by these impacts, and what are the negative feedbacks of these impacts on the economic sectors themselves?*

The answers to all these questions are conveniently depicted in the form of an impact diagram, which is in fact the first more or less formal representation (model) of the region under study.

An impact diagram mostly portrays physical aspects relevant to the scope of regional concerns motivating the study. These concerns are focused on measures to be taken to change the existing and anticipated environmental impacts in the region. But then the question arises of who makes what changes, and why. To analyze these questions we should look into the socio-economic structure of the regional system.

The basic elements of the regional socio-economic structure are interdependent individual decision makers: e.g. farmers in an agricultural region, various regional and governmental legislative agencies, ministries or their departments, etc. All these elements have different preferences and possibilities for action, and they interact with each other in a complex way.

Continued on page 14

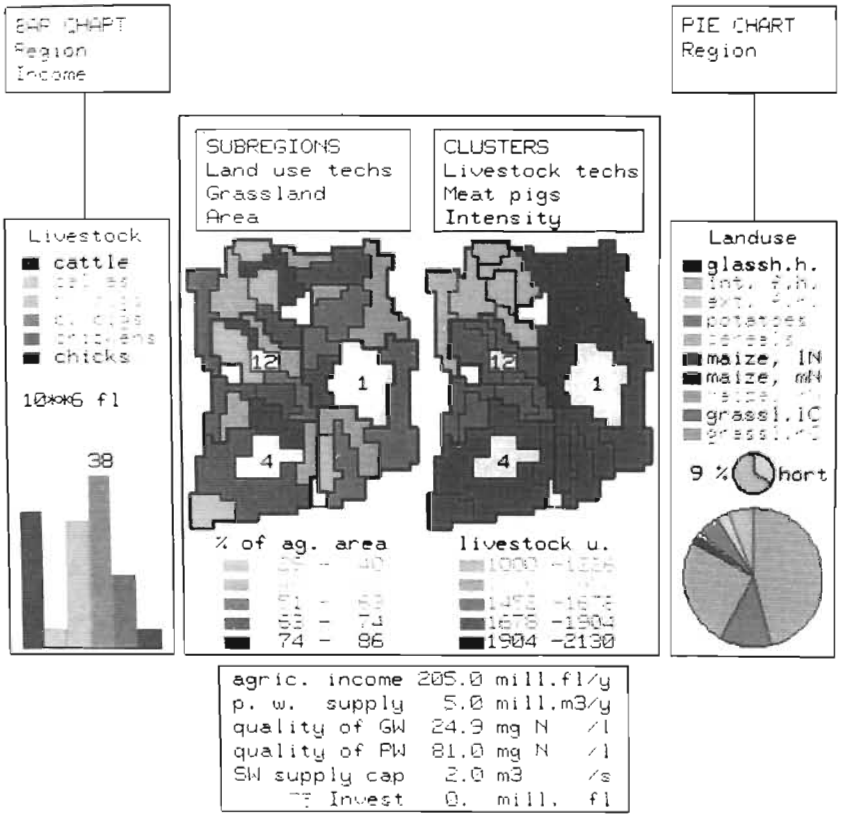
The end products

The products of the Regional Water Resources Project are two decision support systems. To be accepted and used by the decision makers, such systems must fit into the decision making reality (compatibility with common planning and decision making practice), and have to be user-friendly, reliable, robust and credible.

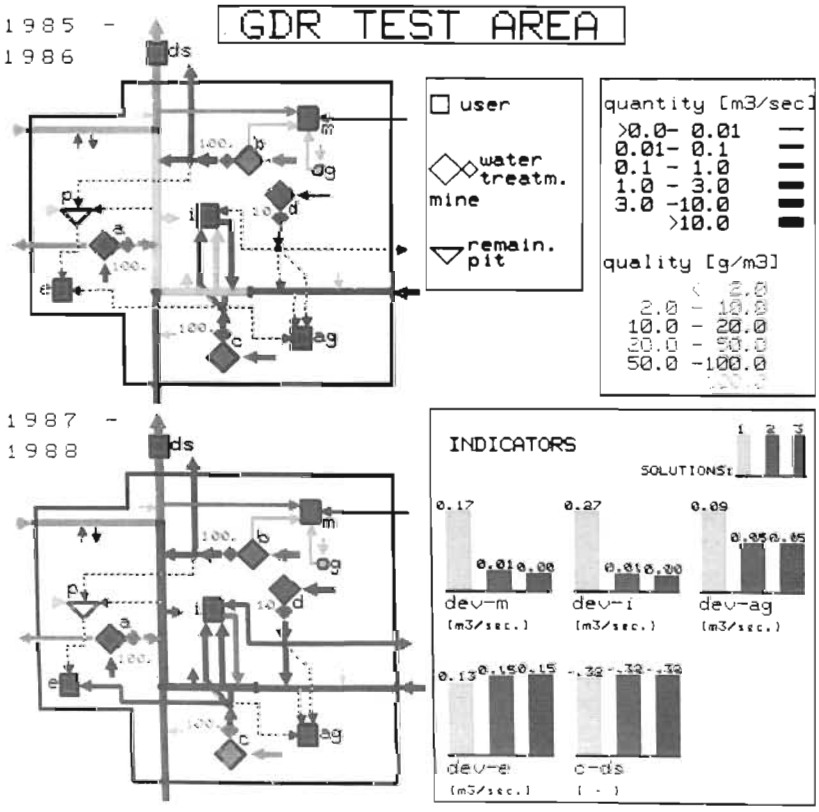
The first stage comprises the generation and analysis by computer of different scenarios. The user specifies certain "scenario requirements" pertaining to the requirements on multi-objectives for the target scenario of regional development. After obtaining an "optimized" scenario, a run can be made with second-level models in order to obtain a more accurate estimate of the scenario obtained at the first level. For easy user access and interpretation of results, interactive systems with color graphics have been developed. This makes possible the visual comparative analysis of data using colorings of subunits on a map, colored flow charts, or colored pie and bar charts. The example illustrated (in monochrome) was part of the scenario analysis procedure in one of the IIASA test areas, the Southern Peel agricultural region in the Netherlands.

The other scenario analysis example stems from the test area in the German Democratic Republic, the open-pit lignite mining region of Lusatia. For the visual display of model results in this case, a flow chart representation of the test area is used on a color monitor. The water quantity (flow) is characterized by the thickness of lines, and the water quality by the color.

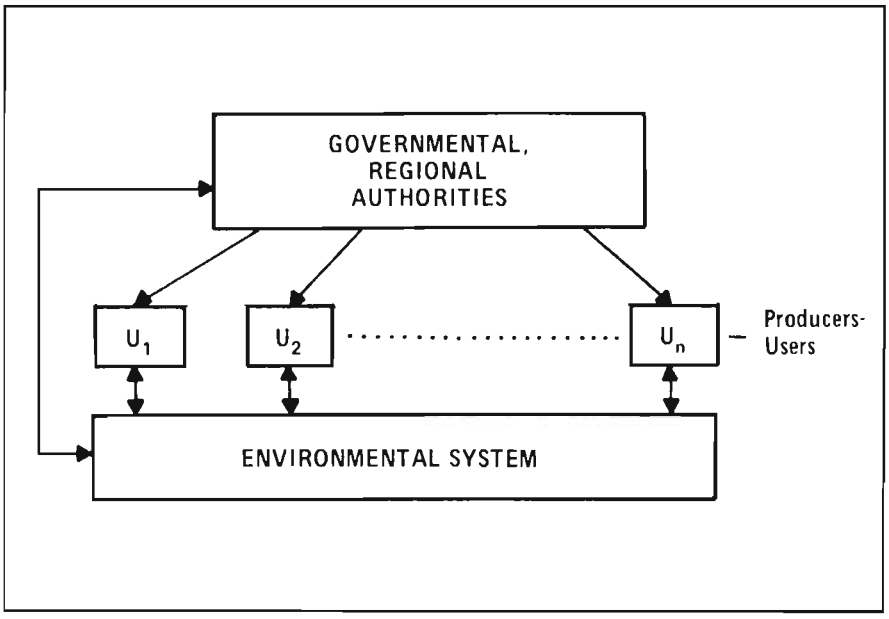
These systems have been developed in Fortran 77 for the computer VAX 11/780 with an AED-512 color Graphic system. They have a more general applicability than in the case studies for which they were developed. The procedure is concluded with the analysis of the possible policies in respect of the various scenarios which have been examined during the first stage.



A monochrome rendering of a full-colour computer graph. The scenario analysis for an agricultural region uses colored sub-units on twin maps, colored pie and bar charts.



A typical scenario analysis computer chart for an open-cast mining region. The original is fully colored. Water flow is indicated by line thickness, and water quality by the color.



How the regional hierarchical system operates. The (human) socio-economic system influences the environmental system, directly through the lower-level users (farmers, industrialists, etc.), whose actions in their turn are influenced by decisions of the upper-level policy-making authorities.

Regional water policies/**Continued from page 12**

One important aspect of the socio-economic part probably of any economically developed region is its inherently hierarchical structure. The Project considers two major classes of decision makers in this hierarchy, referred to as lower-level and upper-level decision makers.

The lower-level elements (users of the environment like farmers and mining companies) are those directly interacting with the environment, through land-use, irrigation, mine dewatering, waste disposal, etc. The major fact is that in regional systems these local interactions are often focused on local goals and are not coordinatd with each other.

On the other hand, the upper-level elements of the socio-economic subsystem (governmental, regional agencies, etc., which in total may be classified as a Regional Policy-Making Authority, or RPMA) have preferences more closely reflecting regional perspectives and the goals of different agencies and interest groups. There are also general considerations such as distribution and stability of income, the production rate, and the quality of the environment in different parts of the region.

The upper-level elements do not directly control the interactions of lower-level users with the environment, but may have varying degrees of power for influencing their behavior indirectly, using economic, legislative and other policies and mechanisms. These policies may include imposing constraints on the use of surface water and groundwater, on the amounts of fertilizers used. various economic measures like pricing, taxing, subsidizing and others (see diagram).

Our problem can now be expressed as follows: Which of these policies should the RPMA use, and to what extent should it apply them, in order to direct the regional development towards achieving a proper balance between its economic and social needs on the one hand, and the preservation of the environment on the other? The aim is to analyze legislative and economic policies under the influence of which the users (farmers, mining companies, etc.) will change their economic behaviour in the direction of a better regional environmental/economic balance. To this end what might be described as a two-stage "decomposition" approach has been adopted, with a detailed scenario analysis forming the basis for the final analysis of policies.

The scenario analysis aims at the evaluation of the possibilities of long-term regional development, based on preferences of the RPMA and in terms of the regional indicators of effectiveness. No behavioural aspects of the lower-level water users are considered at this stage, and the analysis generates, in a sense, a reference trajectory of regional development, based on tradeoffs among goals of different regional groups. This is called a reference scenario of regional development. At this stage a number of possible situations which could arise in the future can be analyzed for their implications and effects, with a view to working out policies towards them in the second stage of the analysis.

After having determined a reference scenario in the first stage, the second stage of analysis is concerned with the search for those feasible regulation policies that influence the behavior of the water users, and by doing that can direct the development of the whole system along the lines specified by the reference scenario obtained at the first stage.

One of the important aspects of the problems addressed is their multiobjective nature. Regional preferences of the RPMA reflect different economic, technological and environmental aspects. Alternative decisions that are good economically may at the same

Continuing IIASA research on water resources: Decision Support Systems for Managing Large International Rivers

Current IIASA research in the water resources field is terminating according to plan early in 1986 with the conclusion of the Regional Water Policies Project. Water resources are, however, unquestionably one of the more important objects of study within the Environment Program, and it was felt that it was an appropriate time to evaluate future work that IIASA could undertake in this area of research. The outcome is a new Project on Decision Support Systems for Managing Large International Rivers, which could be of considerable benefit to national and regional governments, not only within the countries of the IIASA member organizations, but also in Africa and other parts of the world.

time be unacceptable environmentally, and vice versa.

The role of mathematical methods and computational procedures in such situations is to assist the RPMA to select alternative planning decisions which lead to satisfactory compromises among the indicators of different natures. This necessitates the use of interactive analytical procedures through which the RPMA can take into account its concerns and preferences that are ignored in the formal models used.

The net result should be, however, that this decision support system, which is available to planners, managers and legislators for use in their own situations, will consistently provide information and guidelines of a satisfactory quality and usefulness for practitioners. The field of decision in the matter of water resources is a complex one, in which industrialists, farmers and government authorities all have their own special interests. It is clearly in all of those interests that any courses of action should be sustainable in the long term, and that, it is hoped, is not merely the aim, but also the effect, of the IIASA Water Policies Project.

Selected publications

S. Kaden and L. Luckner: *Groundwater Management in Open-Pit Lignite Mining Areas. In: Proceedings, Vol. I, International Symposium on Groundwater Research Utilization, Montreal, Canada, May 1984.*

S. Kaden: *Analysis of Regional Water Policies in Open-Pit Mining Areas – a Multicriteria Approach. In: Interactive Decision Analysis and Interpretative Computer Intelligence (ed. by A. Wierzbicki and M. Grauer). Springer-Verlag, 1984.*

S. Kaden et al.: *Water Policies: Regions with Open-Pit Lignite Mining (introduction to the IIASA study). IIASA Working Paper WP-85-04.*

S. Kaden et al.: *Decision Support Model Systems for Regional Water Policies in Open-Pit Lignite Mining Areas. In: International Journal of Mine Water, Vol. 4, No. 1, 1985.*

S. Kaden and E. Weigkricht: *MINE – a Game for the Analysis of Regional Water Policies in Open-Pit Lignite Mining Areas.* IIASA Working Paper WP-85-46.

S.A. Orlovski and P.E.V. van Walsum: *Water Policies: Regions with Intense Agriculture (introduction to the IIASA study). IIASA Working Paper WP-34-40. Also published in the Proceedings 5th World Congress: Water resources for Rural Areas and their Communities. Brussels, June 1985.*

P.E.V. van Walsum and S.A. Orlovski: *Analysis of Water Policies in Regions with Intense Agriculture. In: Mathematical Research – Systems Analysis and Simulation 1985 II, Vol. 28 (ed. by A. Sydow, M. Thoma and R. Vichnevetsky). Akademie Verlag, Berlin (GDR).*

S.A. Orlovski: *Problems of Decision Making with Fuzzy Information.* IIASA Working Paper WP-83-28.

S.A. Orlovski: *Two Approaches to Multiobjective Programming Problems with Fuzzy Parameters.* IIASA Working Paper WP-84-37.

S.A. Orlovski: *Fuzzy Information in Problems of Resources Allocation. In: Proceedings, 9th World congress of IFAC, Vol. IV, pp. 132-135, Budapest, July 1984.*

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Guest Corner

An International Fund for the Environment – a futuristic approach?

Photo: M. Wenzel-Jelinek

Dr. Kurt Steyrer was Minister for Health and Environmental Protection in the Austrian Federal Government until December 17, 1985.

Many measures in the field of environmental protection – be it, for example, the installation of desulphurization equipment or a unit for the treatment of hazardous wastes – are extremely cost-intensive.

But – taking well into account the adverse and worsening effects of environmental degradation on people, air, soil, vegetation, groundwater and aquatic ecosystems – I am convinced that all investments which can help us to minimize these effects will in the near future prove to be good investments, since they will also reduce the social costs of our economics, be it on the national or on the international level. Austria, following this philosophy at least within her national borders, established an Environment Fund in 1984.

This fund, which is operated fully in accordance with the principle of "the polluter pays", was created to provide the necessary financial basis for progressive environmental programs, especially by granting subsidies for the environmental enhancement of old installations and pilot installations.

This system, during the short period it has been in operation, has proved to be very helpful. To date, the equivalent of 49 million US dollars has been spent, thus stimulating environmentally sound investments to a total value of about 146 million dollars equivalent in various branches of our industry.

Austria, being a small and highly-industrialized country in the heart of Europe, is convinced that the field of environmental protection in particular is one of those main areas where cooperation on a multilateral basis is not only necessary, but almost inevitable.

We are convinced, further, that environmental protection is both a national and an international responsibility, and that any transboundary cooperation in this field not merely improves our environment, but should also be understood as an integral part of any policy oriented towards the necessary enhancement of peace throughout our planet.

I do not consider it too futuristic, therefore, that we should consider establishing an international fund for the ecological revival and sustainable development of our global environment – following on the idea of the Marshall Plan, which after World War II formed the most helpful and most appreciated basis for the economic revival of Western Europe.

We have only one earth, and its protection is a duty laid on all of us. Therefore, all of us are obliged to provide active support for this struggle.

The international community of states, in my opinion, should try to find ways and means of establishing coordinated financing activities in the various parts and the various systems of our world. One could consider the possibility that a small proportion of the amounts that are expended on the arms race all over the world could be dedicated to the financing – especially in the less developed countries – of environmentally sound installations, giving high priority to the replacement of old polluting installations.

Allow me in this context to quote from the recently published final report of the United Nations Group of Governmental Experts on the Relationship between Disarmament and Development:

"There can no longer be the slightest doubt that resource scarcities and ecological stresses constitute real and imminent threats to the future well-being of all peoples and nations. These challenges are fundamentally non-military, and it is imperative that they be addressed accordingly. If this is not recognised, if the international community fails to accept and persevere in the view that these challenges can only be addressed through voluntary and co-operative measures, there is a grave risk that the situation will deteriorate to the point of crisis where, even with a low possibility of success, the use of force could be seen as a way to produce results quickly enough. This is far from being a remote possibility. In recent years there has been a marked tendency in international relations to use, or threaten the use of, military force in response to the non-military challenges to security".

I am fully aware that, even taking this recommendation into account, these ideas cannot be brought to realisation from one day to the next, but I think that all of us, developed and developing countries together, should try to invest more thinking in the possibility of setting up such an International Environment Fund aimed at the protection of our human, i.e. natural environment.

Kurt Steyrer