IIASA
International Institute
for Applied Systems Analysis
A-2361 Laxenburg/Austria

OPTIONS

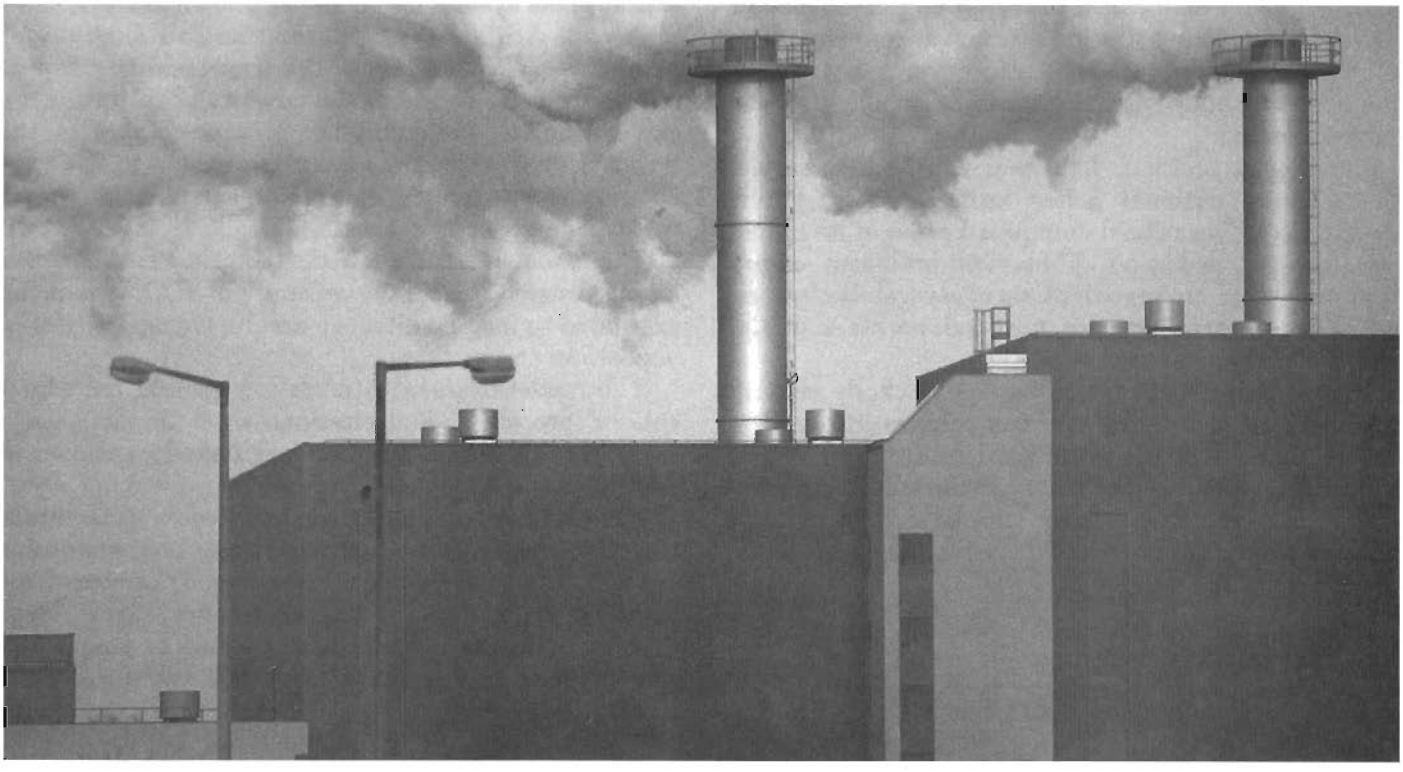

Figure 1. Emissons of sulfur and nitrogen – the first stage of a journey towards an ever-acidifying environment. IIASA's Acid Rain Project has developed a model to help deal with the problem. See story on page 2.

Decision Support Systems II

The last, double-sized issue of *Options* (1987, Nos. 3–4) introduced readers to IIASA's Decision Sciences Programs. We complete that description in this issue by focusing on the following areas of urgent concern:

- acid rain
- population growth
- human impacts on international river basins
- management of dangerous materials
- environmental effects of regional development

IIASA is particularly well suited to address these critical issues, given their transnational scope and implications. The Institute's scientists collaborate frequently and fruitfully with their own national scientific agencies, as well as state and local institutions and private business firms around the world.

The decision support systems discussed in the following pages rest on research efforts at the frontiers of systems sciences – often based on high levels of mathematical abstraction. However, the practical thrust of the Institute's work emerges in the "user-friendly" software we are developing to help policy makers and planners analyze complex, dynamic and very real problems. These practical applications are designed to yield tangible rewards to the societies that sponsor our work.

R.H. Pry, Director

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Fighting Acid Rain – It's Time for Decisions

Many Europeans believe that it is no longer enough merely to study air pollution – action is urgently needed. But what approaches should governments take? The task of policy formulation is as complex as the problem itself.

Tackling a problem like acid rain, for example, affects many national policy areas: energy, public health, the international competitiveness of its industries, forestry, and so on. Abatement measures require communication among scientists of several disciplines, just as government agencies must collaborate to implement the chosen abatement strategy.

Adding more information to the stockpile of data runs the risk of burying decision makers in numbers and opinions. IIASA's acid rain decision support system aims to organize the mass of information relating to acidification, thus easing the difficulties of both multiple communication and data overload.

The RAINS model

Over the past four years, IIASA has developed a decision support system for acid rain, known as the RAINS (Regional Acidification INformation and Simulation) model. RAINS emphasizes the transboundary aspect of the problem, so the model covers the entire European continent, including the European part of the Soviet Union. The time horizon extends to the year 2040 to enable policy makers to examine long-term consequences of control strategies.

The model currently reflects the prime role of sulfur as a precursor of acid deposition, but RAINS is being expanded to include nitrogen and its transport-related deposition and impacts.

The model deals with pollution generation, atmospheric processes, and environmental impacts, each described by submodels that are linked as shown in *Figure 2*.

Each submodel is as simple as possible to facilitate interactive use and comprehension, but maintains enough detail to capture the essential dynamics of the acidification system. This necessitates rather large time steps in the calculations (seasons or years) and large spatial aggregates (e.g., 22,500 km^2 for deposition).

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The **International Institute for Applied Systems Analysis** is a nongovernmental, multidisciplinary research institution supported by scientific organizations in sixteen countries. **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 application of IIASA's work to current problems.

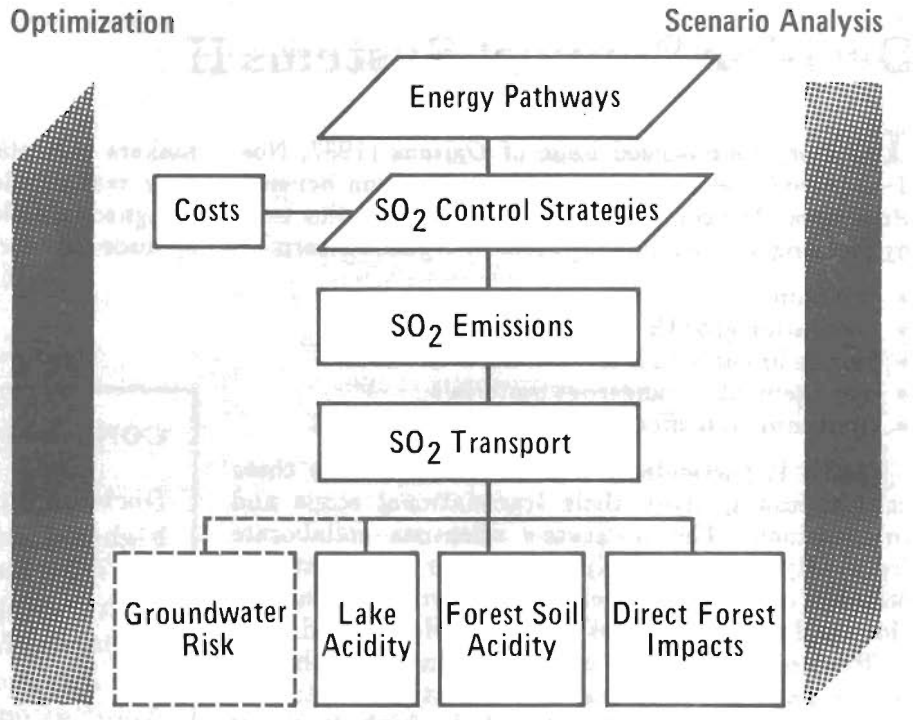

Figure 2. Structure of the RAINS model and its submodels.

Using RAINS

RAINS can perform two services for the user: scenario analysis and optimization analysis. To conduct a scenario analysis, the user moves from top to bottom through the model, as depicted in *Figure 2*, first specifying both an energy pathway and a control strategy. The implications of these inputs can then be studied.

The user has the option of examining output from any of the submodels: data on sulfur emissions, costs of control on a country basis, or maps of soil acidification or SO_2-related forest risk. The user considers this output and, on the basis of a subjective (but well-informed) evaluation, selects an alternative energy pathway and control strategy for comparison.

In optimization analysis, the user starts with specific environmental protection goals, then asks the model to work backward to determine a cost-effective approach to achieving these aims.

An example of a user-specified emission reduction strategy is the *Major Sulfur Controls* scenario, under which all countries implement strong pollution control so that by the year 2000 sulfur dioxide emissions fall to 42% of their 1980 level. This scenario calls for flue gas desulfurization in the utility and industrial sectors, and for the use of low-sulfur fuels in the domestic and transport sectors.

To illustrate optimization analysis, suppose that the aim is, at minimum cost, to limit sulfur deposition to a maximum of 5 $gm/m^2/year$, by the year 2000, everywhere in Europe; at the same time, each country would be required to cut its emissions by no less than 30% relative to the 1980 level. (We have named this the *30% Reduction* scenario.) The total emissions at the end of the century, on these assumptions, would be about the same as those in the *Major Sulfur Controls* scenario, but IIASA's preliminary calculations suggest that costs would be much lower.

As an example of RAINS' graphic output, *Figure 3* shows the results of the forest soil model for Central European countries in the years 2000 and 2040. The difference between the *Major Sulfur Controls* scenario and the *30% Reduction* scenario for all European countries (reflecting current policies) is most visible in 2040, reflecting the gradual character of soil acidification.

Tailor-made for the user

Systems analysts, environmental experts, and potential users co-designed the RAINS model system. To tailor it to users' needs, the following guidelines were adopted:

- Modular construction: Each aspect of the problem is represented by a separate compartment, which can be filled by a number of interchangeable submodels, permitting comparison of different points of view, and

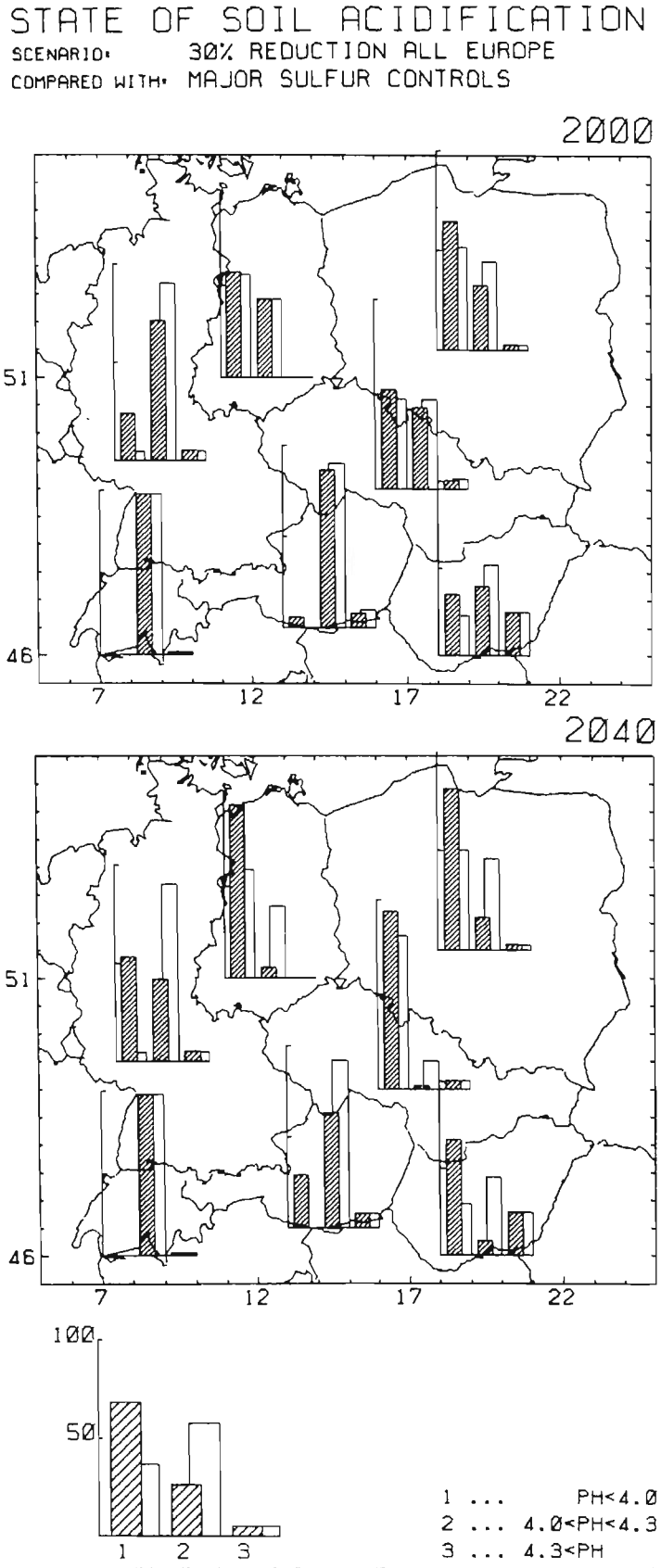

Figure 3. Distribution of Central European forest soils in pH classes for 30% Reduction *(hatched bars) and* Major Sulfur Controls *(plain bars) scenarios: (a) the year 2000; and (b) the year 2040. The bar charts at the right side of each map give the aggregated distribution of all countries shown.*

linked with other compartments.

- Simplicity: Submodels are kept as simple as possible, but, wherever possible, based on more detailed data or models. Simplicity speeds computer response and eases interactive use. In the case of acid rain, simplicity is gained by assuming a linear relationship between emissions and deposition, rather than basing the approach on nonlinear atmospheric chemistry.

- Interactive inputs and clear graphic outputs: Communication was central to the model's design, not an afterthought.

- Dynamic modeling: RAINS gives decision makers a moving picture of the problem's evolution, and its correction, over time.

Lessons from RAINS

RAINS is still being developed, but model runs have already yielded some important preliminary conclusions. One such result is a warning: current emission levels deposit more than 4 gm/m^2 total sulfur per year throughout most of Central Europe, the UK, and the USSR.

The good news is that, according to the model, a concerted SO_2 emission reduction program, as in the *Major Sulfur Controls* scenario, can cut SO_2 emissions in Europe to their 1940s' level. And a cost-optimal abatement program, significantly cheaper than the *Major Controls* scenario, would still reduce European SO_2 emissions by 58% from 1980 values. Compared with the *30% Reduction* scenario, *Major Sulfur Controls* significantly increases the "clean" area of Europe – that is, the area falling into the lower range of deposition (less than 1 $gm/m^2/year$.

The model runs show that, because of the long-term dynamics of soil and lakes, the differences between control strategies may not be particularly apparent before the end of this century. Since the ultimate goal of pollution control programs in Europe is protection of the environment, the evaluation of such strategies should take account of the longer-term effects revealed by RAINS.

Selected publications

J. Alcamo, M. Amann, J.-P. Hettelingh, M. Holmberg, L. Hordijk, J. Kämäri, L. Kauppi, P. Kauppi, G. Kornai and A. Mäkelä. Acidification in Europe: a simulation model for evaluating control strategies, *Ambio* **16**(5):232–245 (1987).

L. Hordijk. Towards a targetted emission reduction in Europe. *Atmospheric Environment* **20**(10):2053–2058 (1986).

Regional Acidification Model Available

The Regional Acidification Information and Simulation (RAINS) model, developed by the Acid Rain Project at IIASA, will be ready for distribution to interested users in early 1988. The user-friendly model is designed to simulate the effects of long-range atmospheric transport of pollutants from emitting sources on soil, lakes, and forests in Europe. The model currently deals with sulfur, but a version in preparation will include nitrogen. The modeling domain is Europe west of approximately 40° E longitude.

The model can be used interactively in two ways: given a specified scenario of energy use and pollution control, the RAINS model can predict country-scale SO_2 emissions, patterns of annual sulfur deposition, and acidification of forest soils and lakes up to the year 2040. Alternatively, given an environmental target in terms of sulfur deposition, the model can indicate the geographically optimized pattern of emission reductions that will meet the target at least cost.

The model runs most efficiently on an IBM-AT compatible personal computer equipped with a mathematical coprocessor and an EGA card for the color graphics. However, the mathematical coprocessor is not strictly needed; an XT would do as well. The Hercules and CGA graphic cards are supported by RAINS to perform monochrome graphics only. An interactive user's manual is provided by the model as well. The graphics library of RAINS is partly supported by Microsoft No-Limit. It is anticipated that most users will require an executable version. A source code version could be distributed to a limited number of users whose responsibility it would be to obtain the licenses for the Fortran compiler and the graphics library.

Prices for RAINS software are available from Dr. Roderick W. Shaw, Leader of IIASA's Acid Rain Project.

Interpreting Demographic Trends

by Dr. Douglas Wolf, Deputy Leader of IIASA's Population Program

In most, if not all, problems of planning or policy development, it is essential to know the size and composition of the population; knowing its spatial distribution may also be helpful. In problems relating to production and consumption, income distribution, or projected capital needs of health care systems, transportation systems and so on, future demands on the system are crucial. These demands are in the first instance a function of the size and characteristics – age, sex, marital status, health status, region of residence and so on – of the population.

Population change is a complex process, governed by patterns of death and childbearing at each age. The distribution of the population over space is further influenced by rates of movement from one region to another by people of various ages, as well as by rates of movement into and out of the whole country or system. The complexity of these processes makes almost inevitable the use of mathematical models to assist in the planning process. Equally, in planning it is critical to examine, wherever possible, the experience of the past to make better-educated guesses about what might be the likely direction of change in a key factor, say, the longevity of women compared to men.

In looking back at the past, the analyst is again confronted with the problem of complexity: in order to grasp the patterns in, for example, a century of information on the death rates of men, by age and year, one must be prepared to deal with literally thousands of data. A useful tool to assist in this has been developed and applied in recent years by IIASA's Population Program (POP): the shaded contour map.

The shaded (or multicolored) contour map is the counterpart in population analysis of the shaded topographical map in geography. In the typical demographic application, there are two dimensions – age and time (analogous to latitude and longitude) – and at each coordinate in the age/time dimensions there is a vertical distance, equal to the magnitude of the population rate being examined: fertility rates, or death rates, or migration rates. We can thus form a visual representation of the path over time of one or more of the determinants of population change, and from these maps arrive at numerous useful insights. This technique has been applied to birth and death data for several countries and historical periods, and has revealed numerous aspects of demographic change over time.

As noted above, the analyst's task is, on the one hand, to understand the patterns revealed by the history of demographic vital rates; and, on the other, to calculate the anticipated, future distribution of the population. This requires using a broad range of data describing the rates of population movement from one marital status to another, from one region to another, from alive to dead. One widely used technique for carrying out such projections is the multistate life table, for which a number of computational techniques and algorithms have been developed – largely at IIASA.

Most recently, an interactive computer program, based on the multistate life table approach and called the DIALOG system, was developed for the specific purpose of allowing the analyst quickly to obtain and visualize the consequences of alternative assumptions about future developments in demographic processes.

Each of these two analytic tools uses the computer to simplify the task of comprehending complex population data structures. Each is described in more detail below.

The DIALOG system

Many decisions are influenced by forecasts of population trends. As the IIASA program devoted to investigating the processes that bring about changes in the age structure of nations, and the consequences of these changes, POP has also been concerned with developing computer programs that can assist other demographers and, potentially, decision makers. One exciting product of this research is the DIALOG system.

DIALOG is a user-friendly system that allows demographic movements to be effectively analyzed. It provides an opportunity to prepare alternative scenarios, change the parameters of a demographic model during the modeling procedure, and obtain intermediate results. The system was developed by IIASA in cooperation with the All-Union Institute of Systems Studies in Moscow.

Multistate population models have recently become popular in the study of demographic transitions, such as migration, marriage, or changes in health status. However, most of the software developed to realize such models is inflexible. The programs often allow analysis of systems only when fertility, mortality, or transition coefficients do not change over time or, where this drawback has been overcome, require specialist computer training. DIALOG is different: it is highly user-friendly and offers the ability to communicate interactively with the model, making changes as required.

The system uses a simple, menu-based command language. It allows the user to control the modeling procedure, provides a variety of forms of visual display

of results, and permits flexible scenario setting. Moreover, it is designed for easy transfer from one computer to another, and representation of results can be adapted to different kinds of peripherals. Originally created for use on the VAX 11/780 mainframe, the system is now available in a PC version.

The dialogue with the system takes place through four control blocks: initialization (that is, reading the data into the system), modeling, scenario setting, and result representation. The scenario setting block gives a choice of scenarios regarding fertility, mortality, or migration. Modeling results can be represented in tabular form, by piecharts, histograms and, in a new version, three-dimensional plots.

Selected publication

S. Sherbov, A. Yashin, and V. Grechucha. *DIALOG system for modeling multidimensional demographic processes.* IIASA Working Paper WP-86-29.

LEXIS – a new kind of map

LEXIS is a computer program that generates a new kind of map – one that helps demographers in their work by representing thousands of data at a glance. The program, developed at IIASA, creates shaded contour maps of demographic surfaces.

LEXIS, which is now available for IBM-compatible PCs*, permits visualization of population surfaces, defined over age and time, offering a panoramic view of the interaction of age, period (calendar year), and cohort (e.g., birth year). LEXIS surfaces look rather like geographers' contour maps, with the difference that the colors (or shades of grey) represent not height but frequency of incidence of, say, marriage or fertility within a population or group. This kind of representation can make complex shifts in demographic patterns, over age and time, instantly visible, whereas they would otherwise be buried in a mass of statistical material.

To illustrate simply what LEXIS can do, let us take an analysis of marriage and fertility in the People's Republic of China. Data from a fertility survey of 1982 were used to create LEXIS maps. *Figure 4* represents a shaded contour map of female first-marriage rates by single year of age from 15 through 35, and by single year of time from 1950–1981. As indicated in the key, 10 levels of marriage rates are distinguished, with a contour line at 1% and additional lines from 2.5 to 20%, at 2.5% intervals. The lightest area on the map represents situations in which marriage rates were under 1%, and the darkest those in which marriage rates exceeded 20%. The rectangular patterns on the map result from that fact that the underlying data are organized in single years of age and time, while diagonals are estimated by the algorithm in the computer program.

What does the map show? The most striking pattern is the upward shift in age of first marriage. The map also demonstrates how marriage in China is concentrated within a narrow age range: high marriage rates were observed for the 16–19 age range in the early 1950s and the 20–25 age range around 1980. In addition, strong fluctuations according to historical periods are revealed by the map. Thus, during the period of hardships associated with the Great Leap Forward, 1959–1961, marriage rates fell sharply, while the recovery of 1962 brought a surge.

Other LEXIS surfaces, portraying fertility rates,

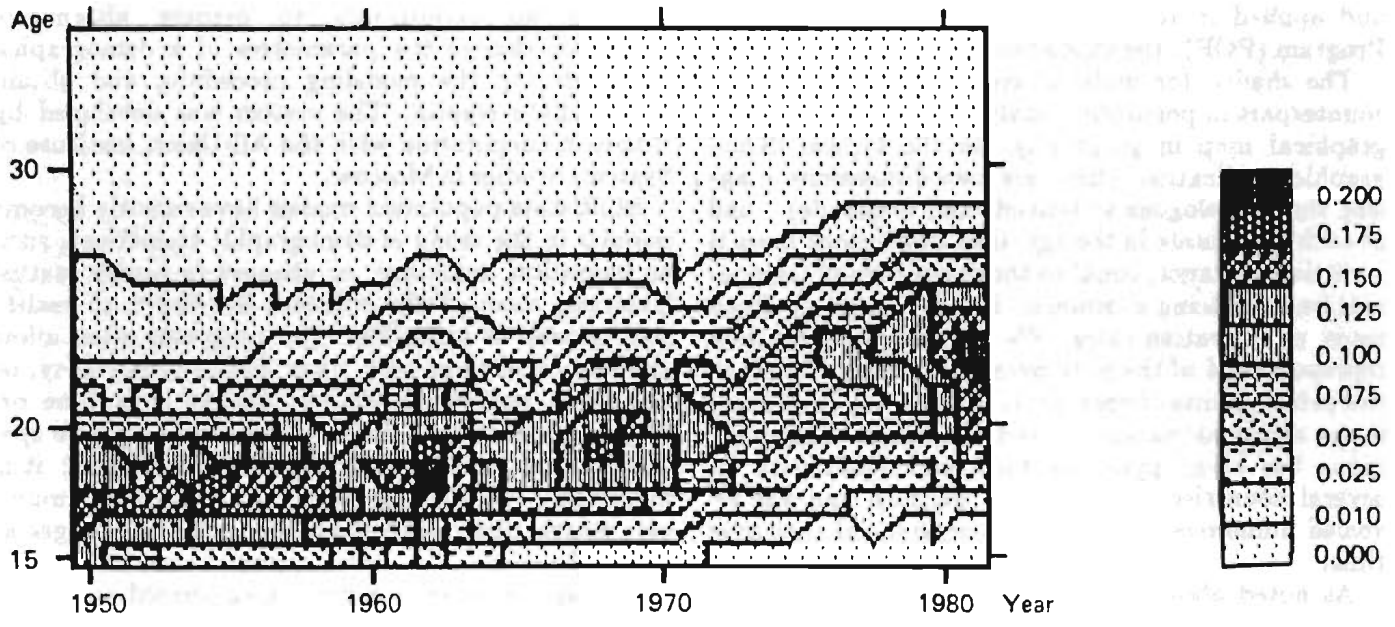

Figure 4. First marriage rates of Chinese females, aged 15-35, from 1950 to 1981.

also yield interesting conclusions. For instance, one such map summarizes the way in which a rapid decline in overall fertility was accompanied by a rise in the age range at which fertility was at a maximum, during the same period. Because the contour maps display age and time simultaneously, they can point up the effects both of short-term disturbances like the Great Leap Forward, and of long-term trends like the shifts in marriageable age and fertility.

Other examples of the use of the contour maps approach by IIASA's POP Program are recent studies of cause-specific mortality in Japan and of age-specific mortality in France and Italy. Maps used in the Japanese study represent causes of death, according to their frequency, by age and time. Thus, for instance, a contour map can illustrate the dramatic decline of tuberculosis as a cause of death; other maps show the rise of cancer and heart disease as leading mortality causes, and shifts in the age ranges at which there are high incidences of these causes of death. The Franco-Italian study uses LEXIS maps to make striking comparisons between mortality rates by age in the two countries, over time.

Selected publications

B. Gambill, A. Yashin, J. Vaupel, Z. Nanjo, and T. Shigematsu. Cause specific mortality in Japan: Contour maps approach. IIASA Working Paper WP–86–78.

J. Vaupel, A. Yashin, and B. Gambill. Thousands of data at a glance: Shaded contour maps of demographic surfaces. IIASA Research Report RR–87–16.

Zeng Yi, J.Vaupel, and A. Yashin. Marriage and fertility in China: A LEXIS-surface analysis. IIASA Working Paper WP–85–70.

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* The software, including documentation, is available from IIASA's Publications Department for US $15.00.

Managing Large International Rivers

In industrialized and developing countries alike, there is growing recognition of the increasing complexities associated with managing and using transboundary rivers. First, there are immediate problems involving externalities. Upstream development and management policies may, and often do, result in adverse economic, environmental and/or social impacts downstream. Different political entities have different, and often conflicting, interests and goals. Second, there are problems of economic and environmental sustainability. Improved procedures are needed to help governments identify politically, environmentally, and economically acceptable basin-wide development and management policies for transboundary river systems.

The need to address these related problems prompted IIASA to launch the research project entitled "Decision Support Systems for Managing Large International Rivers" (LIR). The basic objective of the project is to create a set of efficient analytical tools that can be used by river basin commissions as well as by individual riparian countries for assessing consequences of various planning and management policy options.

Software

There are two basic parts to the work:

(1) developing the computer software for managing data and analyzing policy alternatives, and
(2) applying the software to specific cases and evaluating its effectiveness.

The two proceed parallel to each other, and each benefits from the progress of the other.

A software package that is under development consists of routines through which the user can manipulate specialized data and models to predict and evaluate the consequences, over time and space, of a specific policy alternative for a specific river basin. This software is graphics-based and menu-driven.

The models and data it manipulates are themselves not part of the package referred to as the "shell". The shell is general and applicable to the models and data for different river basins. The project objective is that the shell should be easy to use and understand by those close to actual river basin negotiations and decision making. It should be available where such negotiations and decision making is taking place, and at a reasonable cost. Hence, the decision to implement the software on a PC-AT compatible microcomputer.

Shell users should be able to simulate alternative proposals for developing or managing a river system, even where such proposals include management practices and facilities that change significantly over time. The shell will also allow users, in constructing simulations, to show data and models from a number of different original sources, and thereby to test different assumptions underlying competing forecasts of how any given development proposal will work out in the future.

Two versions of the shell are being developed. They are distinguished by different levels of detail. The

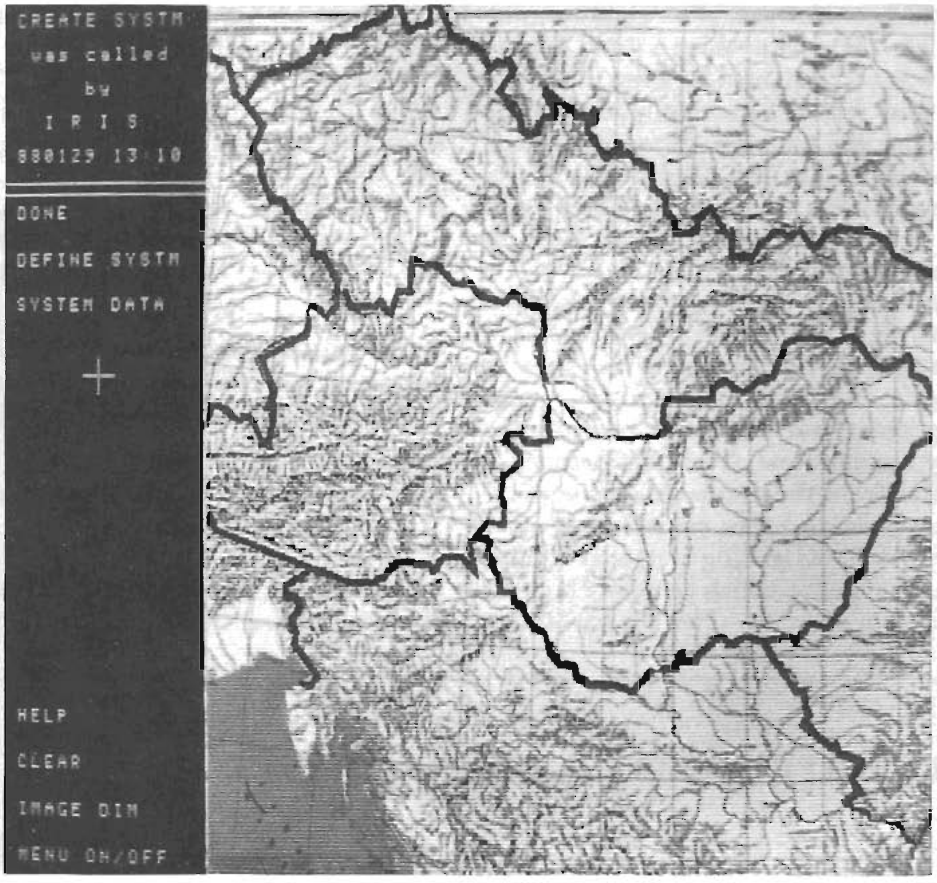


Figure 5. Computer graphical display is used not only to provide users with information presented in a graphical form, like the Western Danube Basin map, shown on the right part of the screen, but also allows users to control program execution through menus, as is shown on the left part of the screen.

more detailed version of the shell is nearly completed. The graphics output includes transparent color overlays on maps (part of the geographic information system capabilities within the shell) and hence requires a special color board and high-quality display monitor attached to the PC-AT microcomputer.

A simpler version of the shell is being developed to be compatible with the more common EGA 16-color monitor.

Application and evaluation

Once the shell is complete, we can begin incorporating the data and associated models applicable to two principal case studies – the Danube and Zambezi – and other river systems of interest to specific collaborators.

Modifications and improvements of decision support systems created for each river system will continue to be made during the entire project as we receive the advice and criticism of our colleagues and of our collaborators with direct policy interest in specific applications.

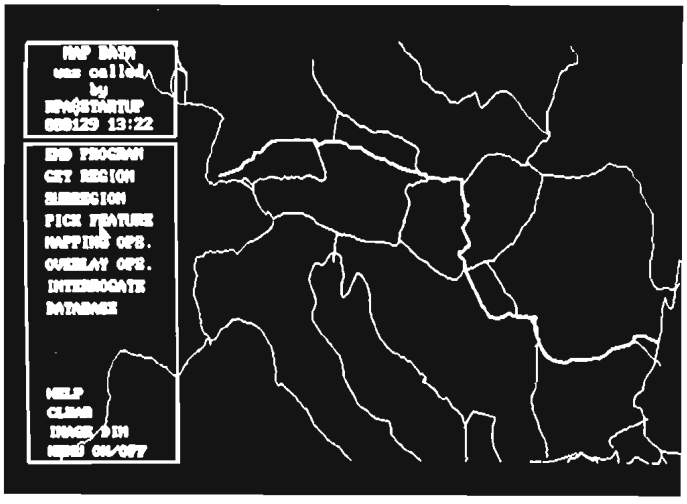


Figure 6. To make DSS software more widely applicable, another version of the software package is under development, to be implemented with the popular 16-color EGA graphics card. In this version of the package, all basic features that ensure interactive user-friendly operation are preserved, but fewer details may be displayed. The graphical display can be overlaid with additional information presented in text form.

The Advanced Computer Applications Project

The Advanced Computer Applications (ACA) Project integrates several completely externally funded research projects in the field of model-based decision support and applied artificial intelligence (AI). The products are software systems implemented at client institutions, as well as methodological contributions.

ACA seeks to build a bridge between the increasing volume and complexity of information relevant to large sociotechnical and environmental systems, on the one hand, and the information needs of planners and policy makers, on the other. It does this by integrating methods and approaches of operations research and applied systems analysis with elements of AI and advanced information and computer technology. The software tools are designed to provide planners and policy makers with direct and interactive access to a large volume of information and powerful methods of scientific analysis.

ACA's highly modular systems combine several high-level languages such as C, LISP, Prolog, FORTRAN 77 and Pascal. Custom-configured software is implemented on dedicated, high-resolution color graphics workstations.

The studies entail intensive collaboration with various institutions including: the Academy of Sciences of the GDR; the Academy of Mining and Metallurgy, Cracow, Poland; the University of Colorado at Boulder, USA; and both the US Department of the Interior and the US Environmental Protection Agency. Among the studies under way are projects relating to regional development, industrial structure, groundwater management and management of hazardous substances and industrial risk.

Managing natural resources, hazardous substances, and industrial risk

Technological, economic, environmental, and sociopolitical factors must all be considered in making decisions about hazardous substances and industries; and the information required comes from a broad range of disciplines. An effective decision support system will support, but not replace, human expertise and judgment, while also drawing on available scientific techniques.

In 1985, ACA worked for the Commission of the European Communities' Joint Research Centre (JRC), Ispra, Italy, on a project to support comprehensive risk management. The aim was to develop and implement integrated software tools, using AI concepts coupled with more traditional applied systems analysis and operations research methods. On the basis of the prototype installed in 1986, a pilot system called IRIMS (Ispra Risk Management Support) is now operational.

In a related project, implementing many of the concepts of IRIMS, a graphics-based, intelligent interface for a large fault-tree analysis and consequence modeling system is being developed for the Dutch Ministry for Housing, Physical Planning and the Environment. This project addresses the production, transportation, and use of chlorine in the Netherlands (see *Figure 7* and *Figure 1* on the cover page of *Options* issue 1987, 3–4).

A recent industrial client is Sandoz. A site-specific set of models for industrial safety analysis, treating heavy gas dispersion scenarios, is currently under development. The software will allow concentration distributions in time and space to be estimated and displayed graphically, based on interactively defined user input.

Another ongoing project, in collaboration with the University of Colorado at Boulder, is that of designing a decision support system for natural resources management. The sponsors are the US Bureau of Reclamation of the US Department of the Interior, the US Environmental Protection Agency and the US Geological Survey. The creation of tools for hazardous waste and water resources management – in particular, surface water pollution control and groundwater engineering – is the objective of this project (see *Figure 8*).

The approach

ACA's approach is founded on information management and model-based decision support. The computer is seen as a vehicle not just for analysis, but for communication, learning, and experimentation.

The central concept underlying ACA's software for managing hazardous substances and industrial risk is that of a team of experts with a systems analyst orchestrating their tasks. The systems analyst is represented by the user interface, while the experts are the models and the knowledge/data bases.

The system is designed as a hybrid, embedding AI techniques in the object-oriented overall design and problem representation. The user interface includes elements of expert systems technology, such as natural language parsing, rule-based input checking and error correction. *Help* and *explain* functions are implemented throughout the system. It is menu-driven, the basic elements being the interactive user interface, a task scheduler or control program, and a problem generator that assists in defining scenarios. Traditional numerical data processing is supplemented by symbolic elements, rules, and heuristics in the various forms of knowledge representation.

A scenario is represented by a set of process-oriented models that can be used in simulation or optimization modes. An evaluation and comparison module evaluates scenarios according to the criteria specified, and assists in organizing the results from several scenarios. The system uses a graphic display and report generator, which offers a variety of display styles and formats.

Most of these elements are linked so that, for instance, a scenario analysis will usually entail several data/knowledge base queries. The user is offered policy choices at each stage, and the system must, on request, "explain" where a result comes from and how it was derived.

Some application examples

The systems used at JRC and in the Netherlands already integrate several data bases, numerous simulation and optimization models, and specific decision support tools.

The simulation models of the production system can be configured to describe the life cycle of hazardous substances. The simulation system includes the industrial production sector, use and market, waste management, transportation, and effects on man and the environment.

The data bases and models can be driven through the interactive graphics interfaces to assist in the assessment of dangerous substances and industrial risks.

The Shanxi regional case study

The ACA Project is assisting regional planners coordinate the development of Shanxi Province, People's Republic of China.

Within the context of a regional case study, a prototype expert system is being developed for use by the provincial government. The two-year study, which began in July 1986, is funded by the Central and Shanxi Province Science and Technology Commissions, and is being carried out in collaboration with Chinese academic, industrial, and governmental institutions.

Shanxi Province, which lies southwest of Beijing, is one of China's industrial powerhouses, sharing the country's rapid economic growth. Shanxi's main resource is coal, and its mines are of vital importance for China's coal-based economy as a whole. Coal is the foundation of local power generation, chemicals, steel, transportation, heavy engineering, and light industries such as textiles. All these activities are expected to expand, and new sectors are to be introduced.

The question for Shanxi is how to plan for integrated industrial development centered on coal, and meet its obligations to the rest of the country, without straining its resources and the environment. Shanxi is obligated to supply the rest of China with an annual 320–350 million tons of coal and 30 terawatt hours of electricity by the year 2000; and its projected annual growth rate for the rest of this century is 7.2%. The

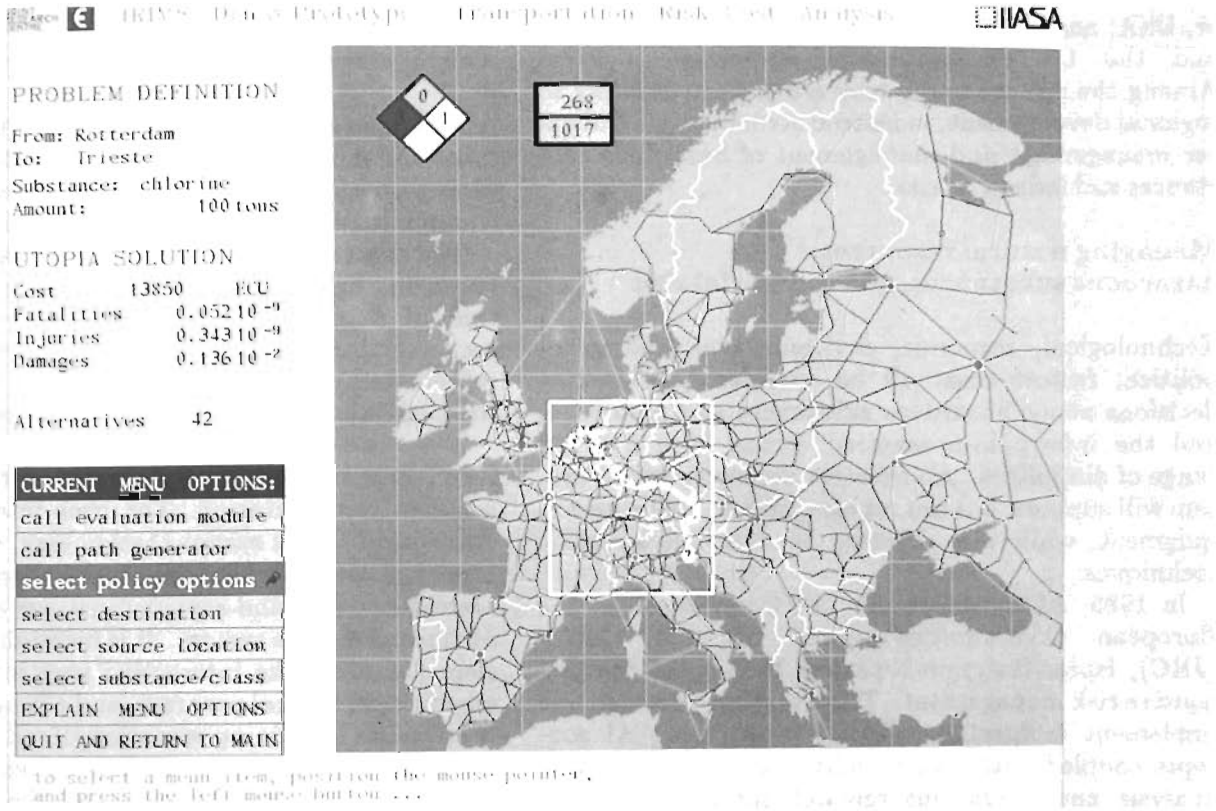


Figure 7. The transportation risk/cost analysis model.

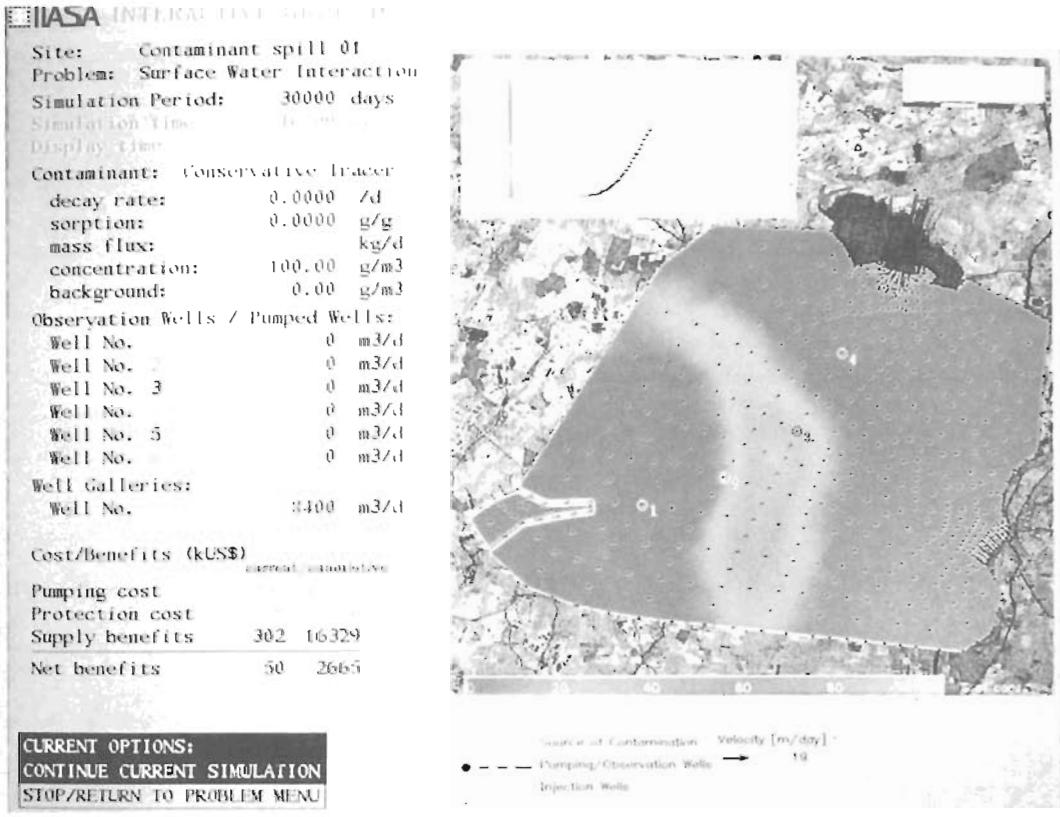


Figure 8. The groundwater quality model.

study aims to help in achieving balanced, sustainable development, within the constraints of limited capital, water resources, transportation network, environmental degradation, and the available industrial labor force.

ACA is helping Shanxi's planners and decision makers to develop an advanced computer system to help design and evaluate alternative development policies. This involves handling a vast and diverse store of information, and simultaneous consideration of numerous interrelationships and impacts.

Such information must be made accessible in a useful format. The system therefore includes an intelligent user interface, an information system, a model system, and a decision support system. The DSS will assist in the evaluation of modeling results, and provide tools for the selection of optimal alternatives with interactively defined preferences and aspirations.

From an implementation point of view, the system consists of three layers: the macroeconomic and strategic planning level, the sectoral and intersectoral level, and, finally, the data bases. For the user, however, these levels are hidden by the problem-oriented interface structure.

At the macroeconomic level, the system includes classical I/O models and an economic development planning symbolic simulator. In the simulator, macroeconomic objects are represented as heterarchically grouped frames communicating via a common message distribution system. Each frame consists of a number of slots containing descriptive information as well as rules and descriptions of the input–output behavior of the object represented. The user interface has several levels of external control, representing state, provincial, and market interests (see *Figures 9* and *10*).

The sectoral level is represented by models describing coal-based, carbochemical, and energy-intensive industries. All other sectors are being integrated at the levels of the symbolic simulator and input–output models. Intersectoral models describe water resources, water quality, and air pollution.

Data bases are being developed to cover macroeconomic summary data, industrial areas and production sites, transportation networks, water resources and climate, geographic background, land use, and population.

A system as large and complex as a province requires several layers of abstraction to enable the observer to conceptualize a given element, such as the coal mining sector, in its context. On the other hand, many features are best understood at the level of personal experience, e.g., an individual mine. The system therefore allows lower-level elements to be described, then generalizes the results by analogy.

The Shanxi regional case study is still being developed, but the system already promises a great range of useful methods and insights, presented in a variety of forms that assist intuitive understanding.

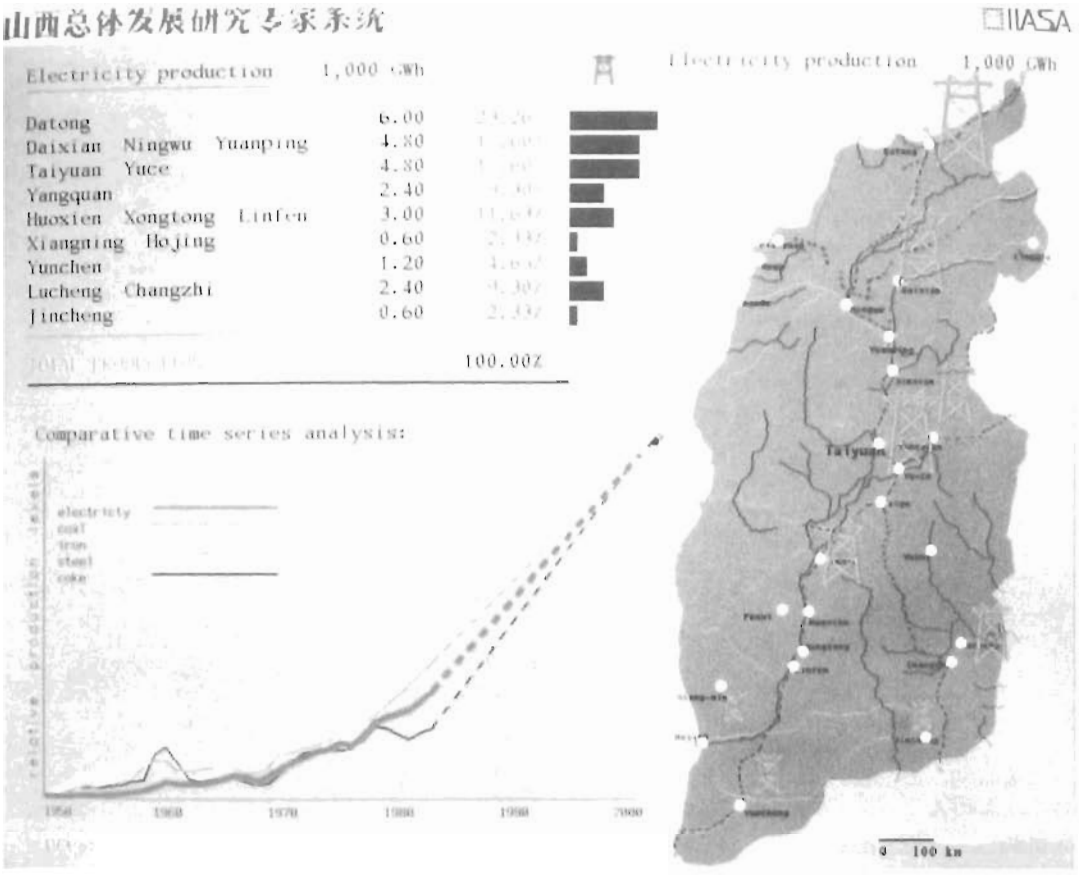


Figure 9. Industrial locations data base: display of major sites in Shanxi Province.

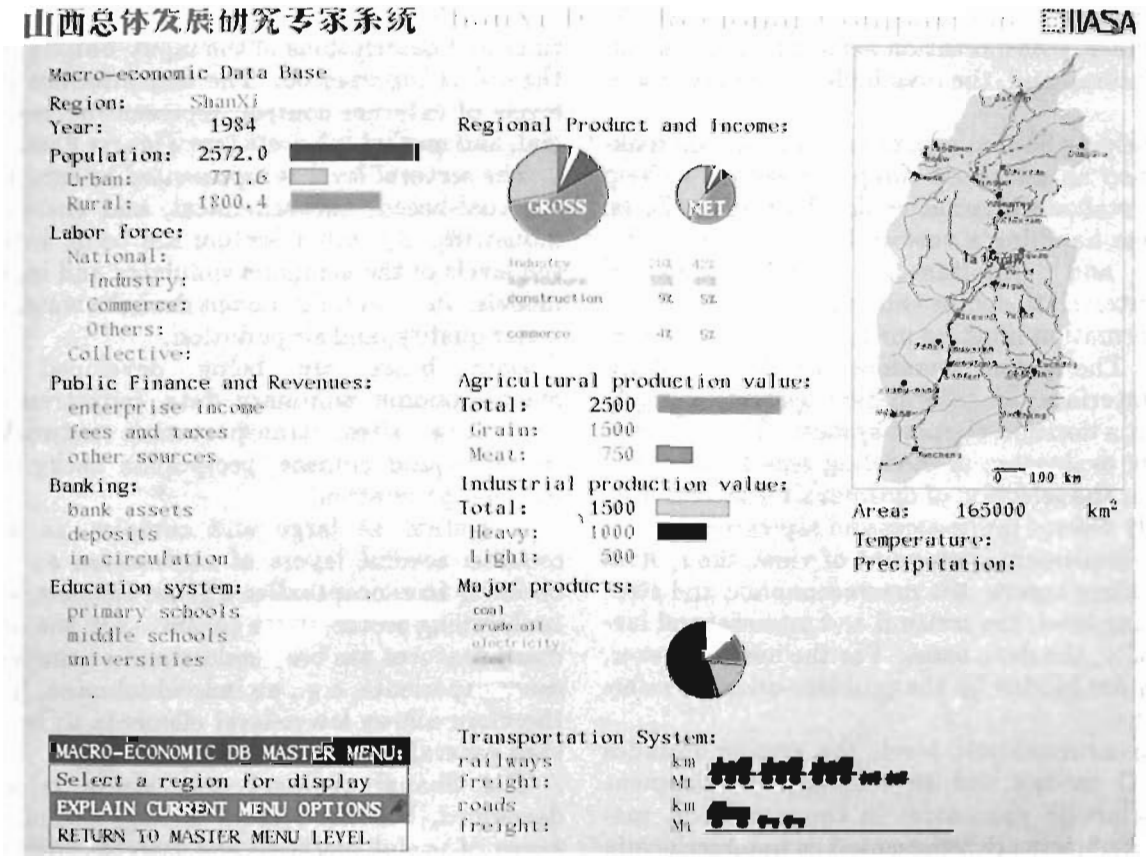


Figure 10. Interregional comparison: Shanxi Province.

News from the Institute

IIASA Council Meeting

The 30th meeting of the IIASA Council, chaired by *Academician Vladimir S. Mikhalevich*, was held on 19 and 20 November. The Council approved IIASA's Activity Plan and Budget for 1988, as presented by *Director Robert H. Pry*. Following the recommendation of Director Pry, the Council also approved the nomination of *Professors Alexander Kurzhanski* (USSR), Leader of IIASA's System and Decision Sciences Program, and *Robert E. Munn* (Canada), Leader of the Environment Program, as Deputy Directors of the Institute. It was further decided to hold the Third IIASA Conference in Laxenburg, 14–15 June 1988. In recognition of their important contributions to IIASA, the Council awarded the title of IIASA Honorary Scholars to the former Director *Professor Thomas H. Lee* and the departing Secretary to IIASA *Mr. Jean-Pierre Ayrault*. The Council also welcomed a new member: *Dr. Peter E. de Janosi*, of the US Committee for IIASA, who succeeded *Professor Howard Raiffa*. Dr. de Janosi, formerly the Chairman of IIASA's System and Decision Sciences Program (1977–1979), is Vice President of the Russell Sage Foundation in New York.

Professor Alexander Kurzhanski

Developments in Collaborative Research

The United Nations Environment Program (UNEP) recently signed a contract with IIASA in connection with the Decision Support Systems for Managing Large International Rivers Project. IIASA has been developing the initial versions of user-friendly microcomputer programs that can be used in training programs to identify and evaluate environmentally sound water- and land-related development plans and projects. At the same time, UNEP has been developing methodological guidelines for integrating environmental considerations into decision making. The main short-term objective of the UNEP-supported project is to help governments *select* the best environmentally sound alternatives in planning and managing water resources in larger international water systems by providing a sound decision system. The long-term objective is to assist governments, particularly in developing regions, to *manage* in an environmentally sound manner their surface and groundwater resources in international inland water systems. It is expected that the project will yield a package of computer programs and manuals, results of the application of the developed methods in two international river basins – one in Africa (the Zambezi) and another in a developed region (the Danube) – and training of at least 10 professionals from the African region.

A collaborative three-year agreement was signed between IIASA's Biosphere Project and the Institute of Geography of the Academy of Sciences of the USSR in Moscow, contributing to IIASA's study on the *Future Environments for Europe: Some Implications of Alternative Development Paths*. According to the agreement, Soviet scientists will provide assistance in the areas of historical and future developments in economic activities in the USSR, and the

Professor Robert E. Munn

effects of these activities on the environment. The agreement also provides for the exchange of scientists between the two institutions.

IIASA's Population and Environment Programs have been awarded grants by the Alfred P. Sloan Foundation in New York, USA. The objectives of the Population project on *Studies of Household Composition Among the Elderly* are: (1) to better understand the process by which family members come to co-reside with the elderly; and (2) to examine trends for the future by generating projections for a range of countries, taking into account changing patterns of fertility, marriage, divorce, cohabitation, life expectancy, and other demographic characteristics. The second project, on *Ecologically Sustainable Development of the Biosphere* (recipient of a previous Sloan grant), is a major effort to understand the nature of future changes in global vegetation and land use, and, through development of mathematical models and their application, to anticipate future, significant collisions between economic development and environmental limits.

IIASA and the V. Glushkov Institute of Cybernetics of the Ukrainian Academy of Sciences in Kiev, USSR, signed a two-year research agreement to enhance collaboration between the two institutions in the development of systems analytic methods, with applications to modeling the environment and energy systems. Special attention will be given to joint efforts in the design of decision support systems, based on the techniques of multiobjective decision analysis. The proposed topics of collaboration will involve cooperative development, standardization, and transfer of mutually compatible models and software.

In collaboration with the Center for Advanced Decision Support for Water and Environmental Systems of the University of Colorado (CU) in Boulder, USA, and sponsored through CU by the US Bureau of Reclamation, the US Environmental Protection Agency, and the US Geological Survey, a new project on *Intelligent Decision Support for Natural Resources Management* has been started by IIASA's Advanced Computer Applications Project. The two major tasks of the first project phase are to develop: (1) an integrated software system for ecological risk assessment, in particular for the analysis of pesticide application scenarios and their impact on aquatic systems; and (2) an interactive groundwater quality management system, including a computer-aided model design component and a knowledge-based problem generator, designed for use within the framework of the Federal Superfund program for cleaning up toxic waste sites.

The Laboratory of Systems Analysis and Management of the Karl Marx Higher Institute of Economics in Sofia, Bulgaria, renewed the study agreement on *Methodology and Software for Interactive Decision Support*. This study, undertaken within IIASA's System and Decision Sciences Program, includes such topics as methodology of man–machine interfaces for decision support systems, interactive tools for model analysis, and creating new software for decision support.

IIASA's Acid Rain Project has been awarded a contract from the Dutch Ministry for Public Housing, Physical Planning and Environment to extend the capability of the RAINS model to deal with the long-range atmospheric transport and acidifying effects of nitrogen compounds. IIASA has already developed internationally recognized expertise in modeling acidification in Europe due to sulfur emissions, but awareness is steadily increasing of the need to control emissions of ammonia and oxides of nitrogen (NO_x) as well. The contract, which will run from January 1988 to June 1989, will be used to complete a 1980 NO_x emission inventory for Europe, incorporate into the RAINS model cost functions for controlling NO_x emissions, and construct an ammonia emission and atmospheric transport model. The work will involve hiring an additional IIASA scientist and organizing a task-force meeting on NO_x control costs.

A three-year collaboration agreement was signed between the Central Economic and Mathematical Institute (CEMI) of the Academy of Sciences of the USSR and IIASA's System and Decision Sciences and Technology–Economy–Society Programs. Signatories were *Director Robert H. Pry* and *Professor Valeri L. Makarov*, Director of CEMI. Aims of the agreement are to enhance CEMI's practical participation in IIASA's research activities and to initiate research work at CEMI on identical themes. The main areas of collaboration include methodology and models, expert systems, and analysis and forecasting of technological progress.

IIASA's Advanced Computer Applications Project has signed a collaborative agreement with the GDR Academy of Sciences for enhancing a Technology Data Base for the Integrated Regional Development Study of Shanxi Province, PRC. The agreement runs until 31 May 1988. The work will be carried out by the Institute of Chemical Technology of the GDR Academy of Sciences, and will include validation, extensions, and improvements to the industrial technologies data base (for the PDAS and MAED models) used in the Chinese case study, *Expert Systems for Integrated Regional Development: A Case Study of Shanxi Province, People's Republic of China.*

An agreement for scientific cooperation was signed between the All-Union Research Institute for Scientific and Technological Development (VNIIEPRANT), USSR, and IIASA's Technology–Economy–Society Program. Themes of the collaboration are the analysis of socio-economic factors of computerized technologies diffusion, and development of methods for technological forecasting and estimation of modern technologies' impact on economic growth and structural changes.

IIASA's Environment Program has received a contract from Atomic Energy of Canada Limited (AECL) to review a draft report by AECL on an atmospheric model to estimate the concentration and deposition of radionuclides being emitted from a nuclear fuel waste disposal site in the granitic area of the northern part of the Province of Ontario. The report is one of a series produced by AECL on models of the movement of radionuclides through the

soil, surface water, the atmosphere, and the food chain, the purpose of which is to assess the risk to human health from nuclear fuel waste disposal. The multidisciplinary team, led by *Professor Robert E. Munn* and *Dr. Roderick W. Shaw* of the Environment Program, is expected to finish the assessment by the end of this month.

A one-year collaboration agreement was signed between the Polish Academy of Sciences and IIASA. Specialists at the Institute of Econometrics and Statistics of Lodz University will collaborate in the construction of a linked system of Input–Output INFORUM-type models for the CMEA countries, for application in IIASA's Computer Integrated Manufacturing and New Logistics Technologies activities. This system will be used for studies of the socioeconomic impacts of new manufacturing and logistic technologies in different countries.

Scientific Meetings

The Institute of Agricultural Economics of the Academy of Agricultural Sciences of the GDR, the Academy of Sciences of the GDR, and IIASA jointly organized the *International Workshop on Computer-Aided Instruments for the Elaboration of Strategic Solutions for Complex Processes in Agriculture*, held in Schwerin, GDR, 7–12 September 1987. Forty-seven specialists from 12 countries attended the meeting. The deliberations concentrated on the use of computer systems at different levels of agricultural production and management, but interesting ideas were also put forward regarding future IIASA activities in the area of food and agriculture. It was suggested that IIASA should coordinate any future food and agriculture activities with the existing Technology–Economy–Society and Environment Programs. One of many points made was that no easy-to-use procedures yet exist for identifying the environmentally tolerable limits of agroproduction: usually, production is maximized and environmental impact is dealt with secondarily. Concrete examples illustrated that computer-aided monitoring can play an important role here. This technique can directly integrate environmental impact into the process of agricultural production. Papers presented at the meeting will be published in condensed form.

Under the auspices of the President of Finland, *Dr. Mauno Koivisto*, the Finnish Institute of Management, in cooperation with IIASA, organized the *East–West Meeting on Management Development for Joint Ventures*, held in Helsinki, 12–14 October 1987. The main objectives of this meeting were to identify issues, delineate concrete solutions, and discuss management development for East–West joint ventures. After the presentations, the discussion emphasized the new demands on economies, and especially on managers, created by joint ventures. To satisfy these new demands, the 40 participants from 17 countries proposed several concrete measures: (1) to encourage cooperation between the existing institutions; (2) to continue the series of East–West meetings; (3) to establish an East–West Secretariat on Management Development; and (4) to create special programs for participants from East and West, with the idea of establishing an East–West Institute for Comparative International Management Development. Continuous cooperation between high-level representatives from Eastern and Western countries in the area of management and management development for joint ventures was considered important. It was recommended that the next meeting be held in Budapest, Hungary, in spring 1988.

Thirty-four specialists from 11 countries attended the *Task Force Meeting on Integrated Energy Systems (IES): Technical and Economic–Ecological Aspects of Siting New Energy Technologies*, held in Sopron, Hungary, 12–14 October 1987, organized jointly by IIASA and the Hungarian Committee for Applied Systems Analysis. In addition to presentations of 27 papers on problems of the technological development of IES; economic, environmental, and safety aspects of IES; and problems of modeling of IES and risk assessment, discussions were held on the assessment of perspectives for new energy technologies development.

Over 300 participants from 25 countries attended the *Smart Card 2000 International Meeting* on the future of integrated circuit cards, hosted by IIASA, 19–20 October 1987. Sponsored by the International Federation for Information Processing, the Austrian Smart Card Association, the International Association for Cryptologic Research, and the Institute of Electrical and Electronics Engineers, this was the first event of its kind with global participation, focusing on emerging technologies and the application possibilities they open, with the aim of bringing together from around the world those engaged in developing these various new devices, systems, and applications, as well as representatives of potential user organizations. Among the topics discussed were: (1) present and future technologies; (2) electronic stock exchange; (3) smart card banking, (4) digital signature-capable cards; and (5) multifunction/multiapplication cards. The final conference proceedings are to be published by North-Holland Publishers.

The *International Workshop on Methodology and Software for Interactive Decision Support Systems*, which took place in Albena, Bulgaria, 19–23 October 1987, was attended by 80 scientists from 15 countries. Organized jointly by IIASA and the Bulgarian National Committee for Applied Systems Analysis and Management, and cosponsored by several Bulgarian scientific and industrial institutions, this was the third IIASA meeting of its kind and constituted a follow-up to earlier meetings held in Sopron, Hungary, 16–26 August, 1984, and Wartburg, Eisenach, GDR, 17–22 November, 1985. The participants exchanged information about current developments and trends in interactive decision support systems. In addition to the demonstration of the 17 software packages for decision support, 50 papers were presented, and a roundtable discussion on decision support systems (DSS) versus expert systems was also organized. A separate session was devoted to discussion of the international comparative study in DSS coordinated by IIASA's System and Decision Sciences Program. The meeting was considered to be the official opening of this activity. Various Bulgarian newspapers reported on the workshop. The proceedings will be published by Springer-Verlag.

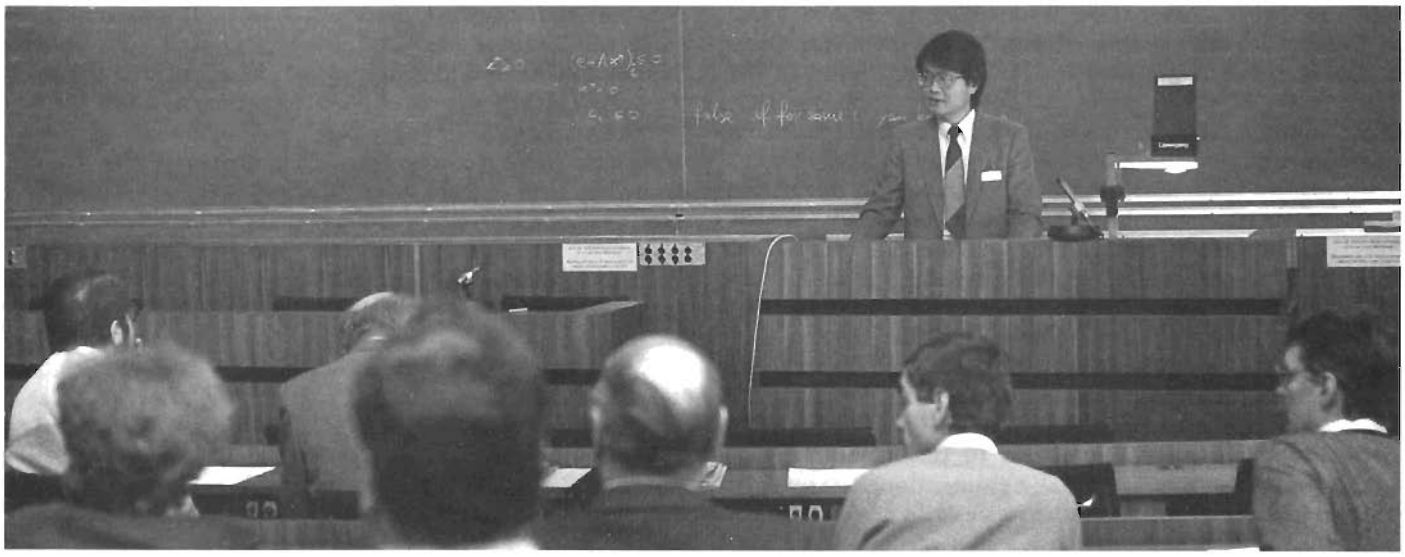
As part of Clark University's centennial celebration, the Graduate School of Geography, the World Resources Institute, IIASA's Biosphere Project, and several foundations and government agencies sponsored the *International Symposium on the Earth as Transformed by Human Action*, held in Worcester, Massachusetts, USA, 24–31 October 1987. This meeting was designed as the sequel to a similar conference, held at Princeton University in 1955, which itself was a reconsideration of the thoughts first expressed by *George P. Marsh* in a book published in 1864, entitled: "The Earth as Modified by Human Action". The Clark University sessions featured 40 invited papers and about 90 participants from 17 countries, addressing changes in the "states" and "flows" of the earth's environment, transformations on a regional scale in the form of case studies, and social processes directly linked to transformation. The contributed papers will be published in a book.

Internationally consistent safety standards are needed; and, generally, man-made sources contribute relatively little contamination when compared with natural sources – these were the main conclusions of over 200 scientists, industrial managers, and policy makers from 28 Eastern and Western countries and several international agencies who attended the *International Conference on Radionuclides in the Food Chain*, held at the Laxenburg Conference Center, 2–5 November 1987. Organized jointly by the International Life Sciences Institute and IIASA, this meeting provided an opportunity to discuss various factors involved in the analysis and management of radioactivity in the food chain from the vantage point of experts from various disciplines. The data and conclusions of this conference will contribute to the development of international guidelines for establishing safety standards. The proceedings will be published by Springer-Verlag.

With the assistance of the Hungarian Committee for Applied Systems Analysis, IIASA's Population Program organized a *Workshop on Demographic Microsimulation*, held in Budapest, Hungary, 30 November–1 December 1987. The objectives of the meeting were to bring together researchers using microsimulation techniques to share their findings, and to discuss various problems and their potential solution in an informal setting. Over 35 researchers from 14 countries and two international organizations discussed: (1) the distinction between micro- and macrosimulation models; (2) differences between empirically derived models and those based on theoretical formulations and generated data; (3) the availability of appropriate data for model building; and (4) the lessons learned from several existing large-scale microsimulation models. Twenty papers were presented, together with the demonstrations of three microcomputer microsimulation programs.

Thirty-five scientists from 16 countries attended the *Workshop on Selected Topics in Biomathematics*, held in Laxenburg, 30 November–4 December 1987. Organized by IIASA's System and Decision Sciences Program (SDS), and cosponsored by the Austrian Federal Ministry of Science and Research and the Austrian Science Foundation, this was the fourth IIASA meeting of its kind. In past years, SDS has developed cooperative networks on such topics as immunology, epidemiology, population genetics, mathematical ecology, molecular evolution, neural networks, and physiological models. The aim of the workshop was to bring together scientists working in these fields, who often use closely related methods, to discuss recent mathematical developments. The proceedings are to be published.

A delegation of Italian managers being briefed on IIASA



Workshop on Selected Topics in Biomathematics, 30 November 4 December

In cooperation with the International Society for Inventory Research, the New Logistics Technologies Project of IIASA's Technology–Economy–Society Program organized a *Workshop on New Logistics Technologies*, held in Bük, Hungary, 1–3 December 1987. Among the 39 researchers and policy makers from 13 countries who participated were *Mr. Vladimir Fukan*, Deputy Minister of Transport of Czechoslovakia, and *Mr. Dirk Gödhart*, Managing Director, Corporate Forwarding, Philips International, the Netherlands. There were 36 presentations viewing logistics, i.e., transport, distribution, and storage, from various scientific disciplines. It was concluded that there are large discrepancies in logistic performance among nations, which are mainly due to technical and organizational differences, and that logistic innovations and infrastructures play a substantial, growing, and partly new role in economic growth and structural change. Furthermore, these new opportunities have not yet been fully understood by the scientific community or implemented in transport, industry, or trade policies and company strategies. Research teams in several countries prepared extensive National Reports on logistic structures, strategies, and prospects. It is planned to publish summaries of these reports, together with cross-national analyses, forecasts on the evolution of new logistic technologies, and analyses of their socioeconomic impacts, in an IIASA book, as well as in scientific journals.

The International Atomic Energy Agency (IAEA) and IIASA sponsored an *Expert Meeting on Human Error Probabilities*, held in Laxenburg, 7–11 December 1987. Fifteen experts in human factors research and probabilistic risk assessment from eight countries met to prepare a report, which will serve as a preparatory document for IAEA's program to better integrate human error probabilities into their safety evaluation procedures. A draft report, prepared during the meeting, will be reviewed and published early in 1988. Probable follow-up of this exercise will be a three-day workshop in Laxenburg, jointly organized by IAEA, the Joint Research Center of the Commission of the European Communities in Ispra, Italy, and IIASA, in November–December 1988.

Miscellaneous

At its 23rd meeting, the General Committee of the International Council of Scientific Unions (ICSU) accepted IIASA's application to become an *Associate International Non-Governmental Organization*. As the first such Associate Organization, IIASA can look forward to enhancing its cooperation with members of the ICSU family, and, in particular, contributing to the newly launched ICSU "International Geosphere–Biosphere Program: A Study of Global Change".

Mr. Mihail Ter-Mikhaelian (USSR) was the 1987 recipient of the Peccei Scholarship for his work in the Environmental Monitoring Research Area on Forest Dynamics Modeling. This award has been granted annually by IIASA since 1984 to outstanding participants in the Young Scientists' Summer Program, in recognition of the late *Dr. Aurelio Peccei's* dedication to the ideals of IIASA. The scholarship provides funds for a further research stay at IIASA.

Eighteen forestry experts from the Federation of Quebec Wood Producers in Montreal, Quebec, Canada, visited IIASA to get acquainted with current research activities and meet with members of the Forest Study of the Biosphere Project. The group was accompanied by *Dr. Hartmut Gossow*, Dean, and *Dr. Peter Schwarzbauer*, of the Forestry Faculty of the University of Agriculture in Vienna, Austria. (8 September 1987)

A delegation of Italian managers, from cooperative companies in the area of Modena, visited IIASA to get acquainted with current research activities and to learn about the Institute's techniques of modeling and forecasting. The group was headed by *Dr. Augusto Morello*, President of the Italian Association of Marketing in Milan. (28–29 September 1987)

Professor Felix I. Peregudov, First Deputy Minister for Higher and Secondary Specialized Education of the USSR in Moscow, and *Professor Felix P. Tarasenko*, Head of the Department of Cybernetics at Tomsk State University, USSR, visited IIASA to get to know current research activities and to discuss possible collaboration. On 28 October, Professor Tarasenko delivered a lecture entitled "Some Contributions in System Methodology". On 29 October, Professor Peregudov delivered a lecture on "Problems of Reconstructing Higher Education in the USSR". (23–30 October 1987)

On the initiative of the Central Institute for Cybernetics and Information Processes of the GDR Academy of Sciences, five members of IIASA's Acid Rain Project were invited to an "IIASA Day", held in Berlin, and gave a demonstration of the Regional Acidification INformation and Simulation (RAINS) model to an audience of 25 scientists from the environmental protection agency and various other meteorological and forestry institutes in the GDR. The demonstration generated a lengthy discussion afterwards. (2 November 1987)

A delegation of Czechoslovak officials, headed by *Dr. Jaromir Obzina*, Deputy Prime Minister, Member of Parliament, and Chairman of the State Committee for Technology and Investments in Prague, visited IIASA to be briefed on current research activities. Dr. Obzina was accompanied by, among others, *Dr. František Brom*, Vice Chairman, and *Dr. Václav Jerman*, Head of the Secretariat, of the State Committee for Technology and Investments; *Dr. Bohumil Jelen*, Head of the Secretariat of the Presidium of the Czechoslovak government; and *Dr. Stanislav Havel*, Chairman of the Czechoslovak Atomic Energy Commission. (3 November 1987)

Dr. Jaromir Obzina

Within the framework of a series of lectures entitled "Computers in Decision Support", the Hungarian Committee for Applied Systems Analysis and the Computer and Automation Research Institute of the Hungarian Academy of Sciences organized an "IIASA Day", held in Budapest. IIASA scientists presented the research activities of the Population Program, and the Acid Rain and Advanced Computer Applications Projects, accompanied by several demonstrations. Attending the event were many Hungarian experts from different institutions, who expressed much interest in closer cooperation with IIASA. (10 November 1987)

In order to highlight the activities of IIASA's System and Decision Sciences (SDS) Program, as well as related research in the Netherlands, the Foundation IIASA–Netherlands and the Mathematical Center organized a symposium on SDS, held in Amsterdam, and attended by 30 scientists from Dutch universities and scientific institutions. IIASA's Deputy Director *Professor Alexander Kurzhanski*, Leader of SDS, and *Dr. Andrzej Lewandowski*, Leader of the Methodology of Decision Analysis Project, and four other scientists from Dutch collaborating institutions delivered lectures. The symposium was preceded by a meeting of the Foundation IIASA–Netherlands Committee, where Professor Kurzhanski and Dr. Lewandowski described current and planned SDS research. (12–13 November 1987)

On 4 December 1987, the US Midwest Association for IIASA held its first Board meeting hosted by Board member *Mr. Willis S. White, Jr.*, Chief Executive Officer of the American Electric Power Service Corporation in Columbus, Ohio. Other members of the Board who attended the first meeting were *Dr. Chester Cooper*, member of Resources for the Future and an IIASA Honorary Scholar, *Dr. Peter de Janosi*, Vice President of the Russell Sage Foundation and US Representative on the IIASA Council, *Mrs. Jean S. Lundstedt*, Secretary of the Board, *Dr. Sven B. Lundstedt*, Founder of the Association, Chairperson of the Board and Ameritech Research Professor at the Ohio State University, *Dr. Thomas H. Moss*, Vice Chairperson of the Board and Dean of Research and Graduate Studies at Case Western Reserve University, and *Dr. Howard Raiffa*, Founding Director of IIASA and the Ramsey Professor of Managerial Economics at Harvard Business School. The Association was created to enhance awareness of IIASA's global research programs.

In connection with IIASA's 15th Anniversary, the Bulgarian National Committee for Applied Systems Analysis and Management organized a series of events in 1987, united in a special program called "IIASA Days in Bulgaria". The sixth and final stage of the program was a meeting between IIASA's Director *Dr. Robert H. Pry* and the heads of top level governmental institutions, held in Sofia, 6–9 December. During his visit, Dr. Pry delivered two lectures on "Manufacturing in the Future" and "IIASA: The Director's Perspective", and discussed with Bulgarian managers and specialists problems of mutual interest and possibilities of future cooperation with IIASA.

A delegation of US officials, headed by *Professor Francis A. McDonough*, Commissioner for Information Management at the US General Services Administration in Washington, DC, visited IIASA to obtain information on current research activities. Prof. McDonough was accompanied by *Professor Donald Marchant*, Director of the Institute for Information Management, Technology, and Policy, College of Business Administration of the University of South Carolina in Columbia; *Professor Tom Davis*, General Manager of SCG in Florida; and *Professor Klaus W. Otten*, from the Department of Management Consultancy, Information Systems, and Technology of the University of California at Berkeley. The delegation was accompanied by *Professor Otto Simmler*, Head, and *Mr. Fritz Summer*, of the Information Policy Department of the Austrian Federal Chancellery in Vienna. (9 December 1987)

Members of the International Expert Group for the preparation of the feasibility study of a possible World Institute for Space Studies of the United Nations University (UNU) visited IIASA's Directorate for discussions on possible cooperation. The group consisted of *Professor Hubert Curien*, former French Minister of Research and currently President of the Scientific Committee of the French Ministry of Defense in Paris; *Dr. Johannes Ortner*, Managing Director of the Austrian Solar and Space Agency in Vienna; *Professor Yash Pal*, Scientific Advisor to the Government of India in New Delhi; and *Mr. Edward Ploman*, a consultant to the UNU, Paris, France. (14 December 1987)

Recent Publications

Books

Economic–Ecological Modeling. L.C. Braat and W.F.J. van Lierop, editors. North–Holland, Amsterdam, New York, Oxford, Tokyo. ISBN 0–444–70298–9. 329 pp.

Risk Management and Hazardous Waste: Implementation and the Dialectics of Credibility. B. Wynne. Springer-Verlag, Berlin, Heidelberg, New York, London, Paris, Tokyo. ISBN 0–387–18243–8. 447 pp.

Dynamical Systems and Environmental Models. H.G. Bothe, W. Ebeling, A.B. Kurzhanski, and M. Peschel, editors. Proceedings of an International Workshop cosponsored by IIASA and the Academy of Sciences of the GDR, held in the Wartburg Castle, Eisenach, GDR, 17–21 March, 1986. Akademie-Verlag, Berlin. ISBN 3–05–500334–9.

Model-Oriented Data Analysis. V. Fedorov and H. Läuter, editors. Proceedings of an IIASA Workshop on Data Analysis, held at Eisenach, GDR, 9–13 March, 1987. Springer-Verlag, Berlin, Heidelberg, New York, London, Paris, Tokyo. ISBN 3–540–18596–8, ISBN 0–387–18596–8.

These books are available from your regular supplier and the publisher.

Scientific Reports

Perestroyka: Recent Developments in Restructuring the Soviet Economy. A. Aganbegyan. Dr. Bruno Kreisky Lecture Series, No. 3. 11 pp. US $5.00.

RR–87–17. *Transport Consequences of New Logistics Technologies.* S. Wandel and R. Hellberg. Reprinted with permission of the World Congress, Inc., from their book of presentations from the Second World Congress of Production and Inventory Control, held in Geneva, Switzerland, 7–9 April, 1987. 14 pp. US $5.00.

RR–87–18. *Predicting Lake Acidification* and *Regionalization of Predictions: Two Conference Papers.* J. Kämäri and M. Posch. 26 pp. US $5.00.

RR–87–19. *Manufacturing and Human Labor as Information Processes.* R.U. Ayres. 59 pp. US $7.00.

RR–87–20. *Interregional Air Pollutant Transport: The Linearity Question.* J. Alcamo, H. ApSimon, and P. Builtjes, editors. 101 pp. US $10.00.

RR–87–21. *Singularity Theory for Nonlinear Optimization Problems.* J.L. Casti. Reprinted from Applied Mathematics and Computation, Vol. 23(1987). 26 pp. US $5.00.

RR–87–22. *Manufacturing as a System-Determined Science.* J.L. Casti. Reprinted from Technological Forecasting and Social Change, Vol. 31(1987). 18 pp. US $5.00.

RR–87–23. *A Framework for Error Analysis of a Long-Range Transport Model with Emphasis on Parameter Uncertainty.* J. Alcamo and J. Bartnicki. Reprinted from Atmospheric Environment, Vol. 21(1987). 12 pp. US $5.00.

These publications are available from the IIASA Publications Department.

Forthcoming IIASA Books

The following summaries describe major IIASA books being published by Kluwer Academic Publishers, P.O. Box 322, 3300 AH Dordrecht, The Netherlands. All four books will be available during the course of this year. Contact the publisher or IIASA's Publications Department for further information on these and other forthcoming IIASA books.

The Impact of Climatic Variations on Agriculture edited by *M.L. Parry, T.R. Carter and N.T. Konijn.*

Volume 1: Assessment in Cool Temperate and Cold Regions

Volume 2: Assessments in Semi-Arid Regions

These two volumes report detailed results from the international project on "The Impact of Climatic Variations on Agriculture", funded jointly by the UN Environment Programme and the International Institute for Applied Systems Analysis, with added support from the United Nations University.

Volume 1 reports results from five case studies in cool temperate and cold regions and Volume 2 from six case studies in semi-arid regions. Each case study brought together climatologists, agronomists, agricultural economists and regional and national planners. In all, more than 70 scientists were involved in the project.

The studies trace the complex linkages between climate-related impacts as they cascade through biophysical, economic and social systems. They adopt a hierarchy of models of systems and perform experiments with this hierarchy for a number of climatic scenarios of short-term and long-term climatic changes. Three sets of models simulate in turn the climatic change, the first-order impacts on crop yields or livestock productions, and the second-order responses of the wider agricultural and socioeconomic sectors. Although there is much uncertainty still attached to estimates of long-term climatic changes and effects, it is possible, by considering credible future scenarios, to identify a range of probable climate-induced effects on food production, as well as suitable adjustments to agricultural and supporting activities to manage the associated risks.

Toward Free Trade in Agriculture by *K. Parikh, G. Fischer, K. Frohberg and O. Gulbrandsen.*

While malnutrition and hunger are endemic in many countries, the world's granaries are bursting with nearly 400 million tons of surplus grain. For rational domestic reasons, national governments collectively spend upward of $120 billion a year perpetuating excess production, compounding the problem of what to do with the surplus. Something now has to be done to bring sanity to the world food situation – the only question is what?

This book deals in a quantitative way with the impact of removal of distortions in agricultural trade. It reports the findings of a major IIASA study on the likely outcomes for different countries of a range of trade liberalization scenarios. The analysis is based on results obtained using the linked system of national models, the BLS (see the book described immediately below).

Linked National Models: A Tool for International Food Policy Analysis by *G. Fischer, K. Frohberg, M. Keyzer and K. Parikh.*

This book focuses on the use of Applied General Equilibrium (AGE) analysis to build a set of empirically estimated national models for policy analysis in the fields of food and agriculture. It further considers the linkage of these separate, national models to produce a global system, the Basic Linked System (BLS), which is also of the AGE type, in which the behavioral responses of consumers and producers are kept consistent with microeconomic theory. Both the national models and the BLS were developed by analysts of IIASA's Food and Agriculture Program (FAP) with the help of an international network of collaborating institutions.

The book gives an overview of AGE models in economic analysis, a detailed mathematical description, economic specifications and empirical estimates of the BLS, as well as summary statistics and elasticities.

The BLS was used for policy analysis to study impacts of agricultural trade liberalization (see book above) as well as to explore policies to deal with hunger in the world (to be presented in a forthcoming book).

Sustainable Development in Agriculture edited by *J.K. Parikh.*

This book focuses on the interactions between resources, technologies, and environment in agricultural systems and on their consequences for long-term agricultural development.

Specifically, the issues addressed are: (1) How should we estimate biological potentials of a given region? (2) How do certain technological options, resource limitations, and environmental consequences of cultivation affect each other? (3) How does one design a production plan (what to grow, how to grow it) for a region that ensures sustainability of production? (4) What are the additional costs of production, if soil productivity (and this can be operationally defined) has to be preserved?

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