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International Institute for Applied Systems Analysis

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Inside

Focus on Global Change

IIASA BOOKS

Mountain World in Danger
S. Nilsson and D. Pitt

This book discusses the potential problems caused by the changing climate in the high mountains and forests of Europe. Published by Earthscan Publications Ltd., London, in association with Alp Action.
ISBN 1-85383-118-2

European Forest Decline:
The Effects of Air Pollutants and Suggested Remedial Policies
S. Nilsson, Editor

The papers presented in this book deal with the latest scientific information on the causes and effects or air pollution, the extent of forest decline, and projections on future developments and socioeconomic consequences. A joint IIASA/Royal Swedish Academy of Agriculture and Forestry InterAction Council publication.

Future Forest Resources of Western and Eastern Europe
S. Nilsson, O. Sallnäs and P. Duinker

This book records the detailed results of a four-year study of the effects of air pollutants, ineffective silvicultural practices, and forest policies in 24 European countries, and provides definitive information for development of forest policy. Published by Parthenon Publishing Ltd., Camforth
ISBN 1-85070-424-4

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IIASA is an international research institution which draws on the scientific and financial resources of member organizations to address problems of global significance.

Used worldwide, IIASA's results and products have established IIASA as a frontrunner in applying systems analysis to the examination of international issues.

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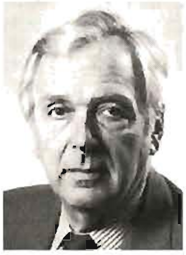
EDITORIAL



The increasingly popular term "global change" embraces a host of complex processes affecting the Earth and the people on it. Trying to study any one of these global phenomena – population growth and urbanization, the spread of new technologies and the Third Industrial Revolution, shifts from central planning to market economies, patterns of energy use and their effects on climate, to name a few – is a daunting task. Trying to study the interactions among many of these processes, as we at IIASA attempt to do, compounds the effort enormously. But this effort must be made if we are ever to achieve an overview, no matter how imperfect, of how people and societies live and interact with one another, and with their environment.

Encouraging this difficult debate is part of the brief of the UN Conference on Environment and Development, to be held in Rio de Janeiro next June. We wish the Conference Secretariat well in this challenging endeavor. Already, it has succeeded in forcing many institutions and governments to take stock of their knowledge – and lack of knowledge – of the forces reshaping societies and their relationships with the natural world.

At the request of the Secretariat, a team of IIASA researchers explored the applications of systems analysis to the issues of environment and development. A summary of the team's report begins on the next page. Other articles in this issue of *Options* also relate to processes of global change, but it is by no means a comprehensive survey of the Institute's work on these themes.

Indeed, IIASA scholars were studying the processes of global change long before the term became popular. Examples of such study include major projects in the 1970s and 1980s on energy, food and agriculture, sustainable development of the biosphere, global vegetation modeling, and the integration of Central and Eastern European nations into the global economy.

Recent issues of *Options* have reported on work regarding regional acidification, economic transitions, and the paths of toxic chemicals through the industrial economy. Future issues will report on current projects involving energy use, food and agriculture, and population shifts, all of which bear directly on processes of global change.

Peter E. de Jánosi
Director

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Cover photomontage: a farmer ploughing and a nuclear powerplant in Gremingen, Germany.

FEATURE

Environment, Development, and Systems Analysis

In 1990 Maurice Strong, Secretary-General of the UN Conference on Environment and Development, to be held in Rio de Janeiro, Brazil, next June, asked IIASA to examine the usefulness of systems analysis in identifying key linkages among population, environment, and development.

A team comprising Roderick Shaw, Gilberto Gallopín, Paul Weaver, and Sture Öberg looked at some of the causes of unsustainable development, developed conceptual models, and examined cases of the application of systems analysis to the issue.

What follows is a précis of their report to the UNCED Secretariat.

Our starting point is the official recognition by the UN that we face one of the biggest threats in our history, that we are on a course that could result in massive disruptions of people, cultures, and planetary ecology.

The human cost of the failure of development – hunger, starvation, illiteracy, homelessness – is staggering. Environmental failures – loss of species, the spread of deserts, acidification, climatic change, ozone depletion, pollution – threaten the global support systems on which all life depends.

The purpose of our report is *not* to further define sustainable development. We worked within the spirit of the definition expressed by the 1987 report of the World Commission on Environment and Development, better known as the Brundtland Report. This definition has been endorsed by the UN. Rather, our objectives are the following:

In general:

• Examine the usefulness of systems analysis (in its broadest sense) in helping to formulate and implement policies towards sustainable development.

In particular:

• Stress the importance of taking a holistic view in examining issues of environment and development so as not to overlook important linkages.

• Examine the root causes of unsustainable development, considering the activities of both rich and poor.

• Develop conceptual models of environment and development that could help identify problem linkages and potential solutions (pages 6-7).

• Identify characteristics of sustainable development and the challenges that they pose for systems analysis.

• Through case studies, demonstrate how systems analysis may help us meet these challenges.

The premises on which our work was based are as follows:

• Many aspects of development in both the North and the South are not sustainable.

• The aim of development should be: i) to enhance the quality of people's lives, materially and non-materially, and ii) to lessen disparities across social groups, regions, and generations.

• Our relations with the environment are more complex and interlinked than ever; a change in one part of the socio-ecological system may ripple through it and cause unexpected changes in others.

• Sustainable development should ideally promote resilience in socio-ecological systems at all scales, from the local village to the globe.

• Decision-makers should strive to look at broader contexts and longer time frames. **Even a simplified but holistic overview can be more useful as a guide to development than a highly detailed knowledge that covers only parts of the problem.**

We acknowledge that some of these premises are debatable, and indeed are being debated in the literature more fully than we are able to do.

Tools available for systems analysis

Models are the central tools of systems and policy analysis. They come in a great variety, ranging from simple conceptual models to elaborate mathematical structures that challenge the capacity of the largest super-computers.

Conceptual models are essential in the initial analysis of a problem. Their formulation requires insight, judgment and imagination about essential elements of a system and the chains of influences, feedbacks and inter-dependencies. Conceptual models can store information about intangibles such as motivations and values. But it is difficult for them to track and store information on many interlocking factors — this is a task better performed by formalized models.

Formalized models are based on conceptual models, but the linkages among elements are expressed more formally, usually (but not always) as mathematical relationships. Beyond a certain point, it is usually necessary to computerize them.

Computerized mathematical models of large dynamic socio-ecological systems have had a checkered record, partly because of naive expectations about their ability to make detailed and precise predictions. Yet they remain a valuable tool for examining complex systems. The greatest value of such models may lie in their ability to force the analyst to look at complex systems (in our case, socio-ecological systems) as a whole, to clarify the important elements and linkages, to point to how the system may be most critically bounded, and to examine the *relative* merits of various strategies.

Models, particularly quantitative models, need to be able to receive information and to store the results of their analyses. **Information bases** are systems for storing, retrieving and displaying information, usually with a computer. Data bases may also combine information mathematically and display it on a grid. Such a data base is called a **Geographical Information System**. A GIS can display environmental data such as height above sea level or buffering capacity against acidic deposition, or human and economic information such as population density or per capita income.

Gaming, role-playing, expert systems and the **Delphi approach** are not so much tools *per se* as ways of using tools, particularly when quantitative information is lacking.

Our report focuses on the use of models and data bases.

People and nature: linkages and conceptual models

The notion of linkages is an essential part of systems analysis, where a "system" is defined by Webster's dictionary as a *"regularly interacting or interdependent group of items forming a unified whole"*. A **linkage** is, in general, some kind of relation between two or more elements of the system. The elements may be physical entities, concepts,

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Negotiations on Global Change

The Project on the Processes of International Negotiation (PIN) has several studies underway that bear directly on the processes of global change. For the Secretariat of the UN Conference on Environment and Development (UNCED), PIN is analyzing the dynamics of prenegotiation leading to the conference in Rio de Janeiro. The project is evaluating how key issues are being defined, linked, and reframed during the early stages of the debate and the implications of these definitions for agreement or stalemate at the conference. It is also tracing the dynamics of coalition formation among nations and how these groupings make certain outcomes likely. The focus is on financial resource issues and the global action plan, Agenda 21.

The PIN Project is also supporting the UN Institute for Training and Research in developing a set of courses on the process and substance of international environment-development negotiations. The aim is to enhance the capacity of delegations from developing nations to participate as equals in such negotiations with their counterparts from industrialized countries.

In 1992 a book titled *International Environmental Negotiation* will be published. The book analyzes how agreements were sought in bilateral and multilateral conferences on ozone depletion, global warming, the transport of hazardous materials, acid rain, sea pollution, inland water pollution, desertification, biological diversity, and nuclear pollution.

Another PIN study assesses negotiations concerning rivers and water rights. This research, partially funded by the UN Educational, Scientific, and Cultural Organization, targets the impact of cultural factors — assumptions about the nature of the world, verbal and nonverbal communication, and key aspects of behavior — on the way the negotiation process is perceived, conducted, and concluded in such disputes. A book about this research will be completed in 1992.

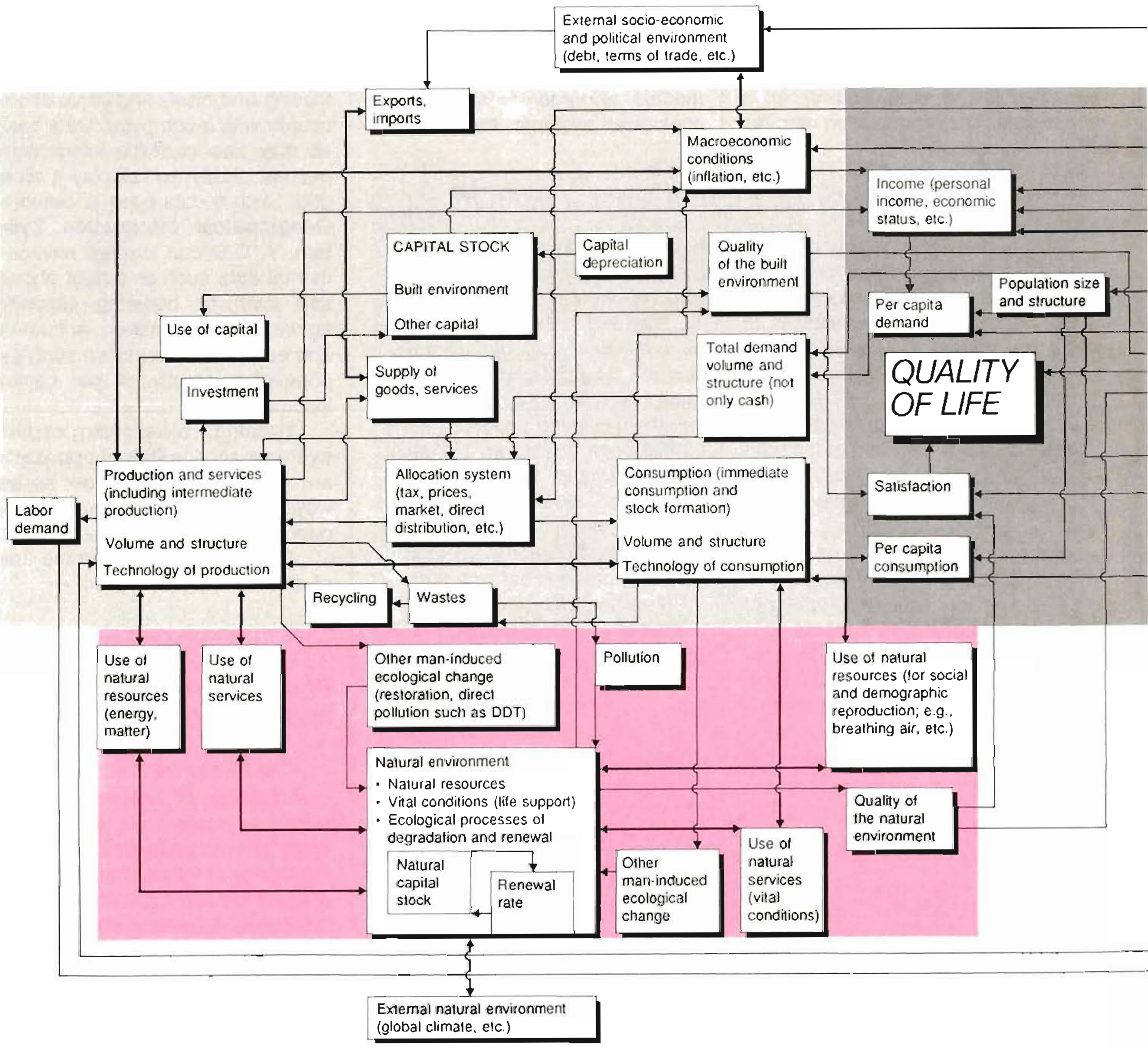
Bertram Spector

Conceptualizing the System

As part of our report we developed a family of conceptual models of varying complexity of **socio-ecological systems**, which we defined as any system composed of a societal (or human) component and an ecological (or biophysical) component. This definition embraces anything from a single household to the system comprising the whole of humanity and the ecosphere.

The basic criteria for the conceptual models were that they:

- Include only the factors considered most relevant to the society–nature nexus.
- Include factors and relations that could be used not only to explain problems, but as entry points for solutions.
- Have a conceptual framework or systemic causal structure that was *neutral* and *universal*, applicable to market as well as non-market economies, to developing as well as developed countries, and to problems associated with poverty as well as overconsumption.



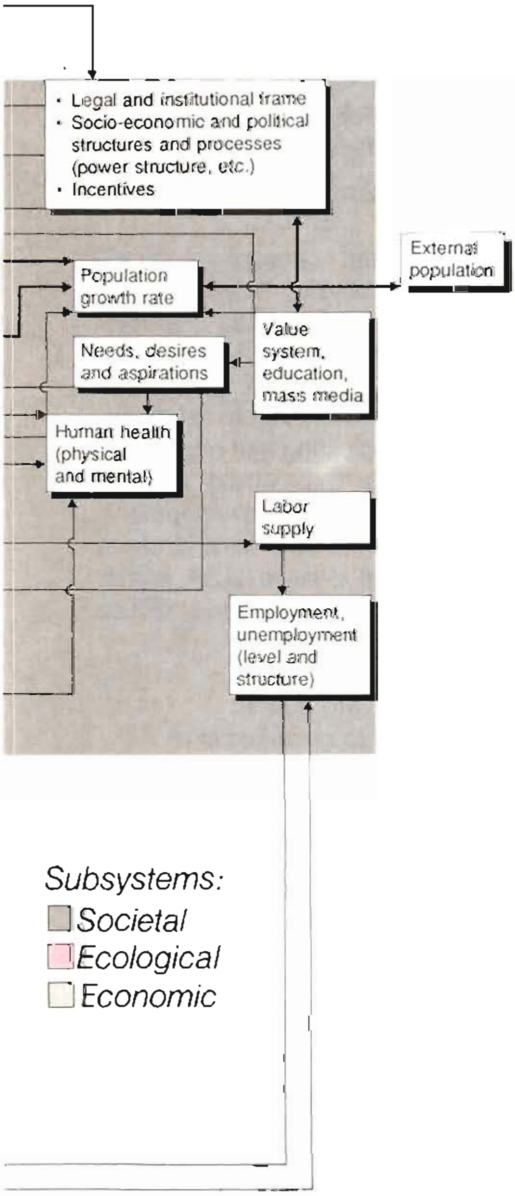
• Able to represent socio-ecological systems at all scales, from the local to the global.

• Capable of representing issues to be discussed at UNCED.

All models included three main subsystems: societal, ecological, and economic.

The **societal subsystem** included not only demographic aspects (population size, structure, growth rate, etc.), but also per capita demand, and the social organization (meaning the social, cultural, political, and legal situation structure, including power relationships). Together, total population size, per capita demand, and social organization were considered to determine the total demand of goods and services on the economy.

As stated earlier, quality of life was considered the ultimate goal of development. The level and variation of quality of life among the members of a given society determines the societal requirements that must be fulfilled in order to satisfy the needs and desires of its members, and partly determines the pattern or strategy of development of the society.



The **ecological subsystem** was considered to be the basic provider of natural (renewable and non-renewable) resources, of basic ecological functions such as waste assimilation, and of life-support functions affecting humans and other organisms (climatic and hydrological regulation, etc.). Managed ecological systems such as agricultural lands and managed forests were included in this subsystem.

For the purpose of our analyses, resources were defined as material or energy inputs to economic processes.

Two particularly relevant attributes of the ecological subsystem were considered to be the renewal rates of its constituents and its robustness or vulnerability. Both can be affected by human activities. The former determines the natural or managed productivity—the rate at which the natural "goods and services" can be provided or replaced—and the latter the capacity of the subsystem to continue providing those goods and services, or to suffer deep behavioral or structural ecosystemic changes.

The **economic subsystem** was considered to impinge on the ecological subsystem mainly through the processes of production and consumption, mediated by the technology that is used. The scale or volume of production and consumption was considered to be central to the relationship. Consumption was defined to include not only commercial products, but also natural goods and services, such as air for breathing and fuelwood for cooking.

The built, man-made environment represents part of the accumulated capital stock generated by investments, but it was included as a central factor in our conceptual models mainly because its quality, together with the quality of the natural environment, directly affects the health and satisfaction of the population and hence the quality of life of its members.

On all scales except the global, exports and imports of economic and non-economic items (materials, energy, or information) could exist in our models and could be very significant in economic and ecologic terms (exporting pollution, externalizing environmental costs, etc.).

Finally, our conceptual models took into consideration planetary-scale "megaprocesses" that are likely to induce profound changes, such as population growth and urbanization, climatic warming, and the current technoeconomic wave or Third Industrial Revolution. Megaprocesses include phenomena as diverse as cultural homogenization, economic restructuring, socio-economic polarization, the waning of nation-states, the increase in the North–South gap, the expansion of democratic regimes, dispersion of species, diseases, and pathogens, pollution of the seas and depletion of the ozone layer. The potential for change arises not only through the intrinsic characteristics of these processes, but also from the interactions among them. □

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subsystems, or mathematical entities such as variables.

Linkages vary just as widely. They may be physical flows of matter and energy (perhaps the easiest linkages to conceptualize), as when a pollutant moves from the source through the biosphere, up the food chain and back to people; or they may represent causal influences between elements, such as the correlation between education of women and the size of families.

The existence of many linkages among the elements of a complex system implies that a change in some part may reverberate through the system, eventually triggering changes in other components. This may occur in ways that are not immediately obvious, especially if one is examining, because of a narrow jurisdictional or scientific specialty, only part of the system.

In dealing with complex systems, we must be aware that solutions to problems often lie in non-obvious linkages. Otherwise, we run the risk of treating symptoms rather than root causes.

The chances of discovering the key linkages are greatest when as much of the system as possible is included in the search. Yet this runs counter to the modern trend towards specialization of knowledge. In view of the complexity of the environment/development nexus, the chances of sustainable development are not great if we adopt narrow approaches.

Using linkages to foster sustainability, restoring important linkages to the system, and even creating new linkages is not necessarily more difficult than the sectoral approaches that are usually applied. An intersectoral approach can bring not only scientific and technical benefits but political ones as well, especially for negotiators. By bringing more sectors under scrutiny, a system-wide analysis can open new options; benefits for one party in one sector can more readily be traded with benefits for another party in another sector.

Water Resources

In 1990 the Second World Climate Conference noted that: "Among the most important impacts of climate change will be its effects on the hydrological cycle and water management systems, and, through these, on socio-economic systems." IIASA is addressing some of the disturbing questions raised by climate change, and by other aspects of global change.

A monograph tentatively titled *Water Resources in the Face of Climatic and Hydrological Uncertainty*, to be published in 1992, will review the current state of knowledge on the subject and analyze some of the future implications. It will also discuss several case studies, from the Delaware River Basin to the Kariba Hydropower System in the Zambezi River Basin. The book will include contributions by researchers in 10 countries.

In 1991 the project developed a meso-scale hydrological model based on stochastic storage and its application to sensitivity and water balance impact studies. The methodology was tested for a number of river catchments in Europe and Africa, and will be tested in more detail on river basins in Central Europe.

Further studies in 1992 will focus on questions of climate change and water demand management, particularly in developing countries. The growing populations in many developing countries have increased their vulnerability to any problems that might be brought about by climate change. A higher population usually means increased domestic and industrial pollution, and higher demand for water for irrigation. The result is often a decreased quantity and deteriorating quality of water.

An additional study involving the Young Scientists' Summer Program will look at how the "life" of lakes may be influenced by climate change. This study will initially consider changes in ice cover, thermal stratification, and the inorganic carbon household.

The long-term objective of the studies is to contribute to a determination of those countries and regions that are most at risk from climate change.

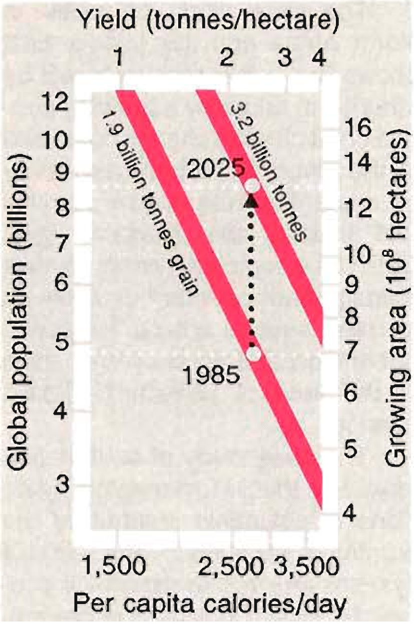
László Somlyódy

Meeting the challenge: case studies using systems analysis

A number of applications of systems analysis, using mainly models ("operationalized" versions of parts of the conceptual model on pages 6-7) and data bases are examined with respect to their usefulness in indicating and implementing policies that would support more sustainable development. These case studies, most of them involving work done at IIASA, center on four basic needs: food, water, energy and materials.

a) Strategic and holistic approaches to sustainable development

The case studies show that the human needs for food, water, energy and assimilative capacity for wastes are inter-related. The growing of food of course depends on water, but it can also compete for hydrocarbons needed to manufacture fertilizers and fuels; fuels are in turn used to manufacture and transport food. Patterns of energy use can also affect food; growing conditions may be affected by the climatic changes that may result from the emission of greenhouse

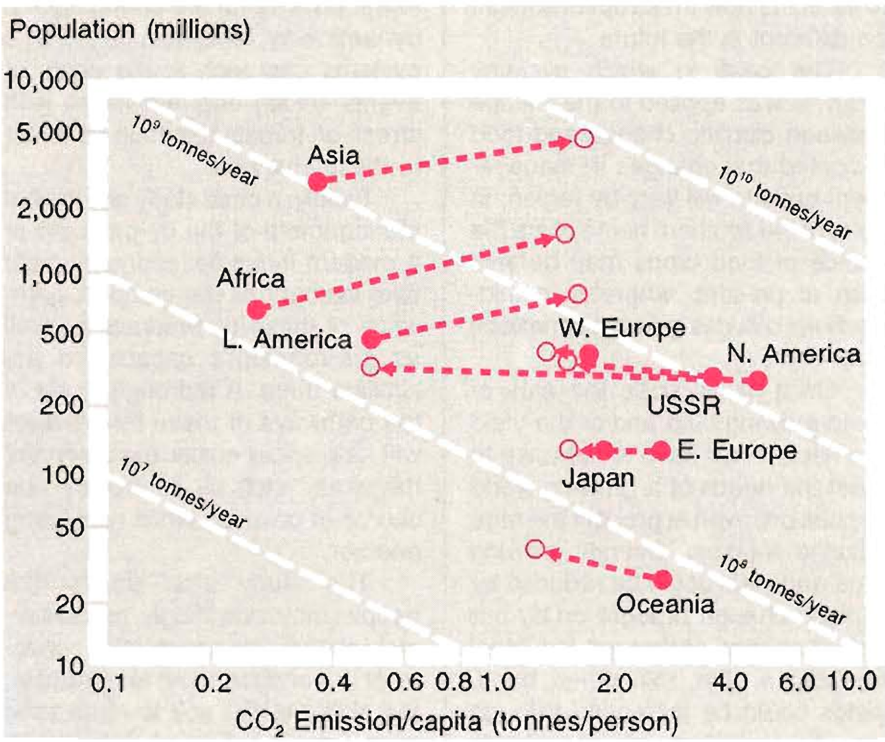


Relationships among world population, average per capita calorie consumption, cereal growing area, and average cereal yield. The diagonal lines depict combinations of population and consumption requiring cereal harvests of 1.9 billion and 3.2 billion tonnes, and also the combinations of growing area and yield needed to produce those harvests.

gases. Efforts to counter climatic change through reforestation (a method of recapturing carbon released to the atmosphere) could decrease the potential growing area for crops. Such measures should be restricted to lands unsuitable for agriculture.

Turning to water, the case studies examine how changes in water supply could affect, not only food production, but other uses of water such as the generation of hydro-electric power. Water supply is directly and indirectly related to patterns of energy use; burning of fossil fuels releases greenhouse gases that could generate climatic change.

Demand for water is a product of population change and water use per capita. The latter in turn is dependent on the technology that is used, especially for agriculture, and the willingness and ability of the population, through education and training, to use these technologies.



Filled dots represent per capita CO_2 emissions by region in 1985; empty dots represent emission targets in 2025, if per capita emissions were allocated equitably to keep atmospheric CO_2 emissions concentrations below 620 ppm. Diagonal lines represent combinations of population and per capita emissions producing total emissions of 10^7 – 10^{10} tonnes per year. Adapted from Y. Fujii, IIASA Working Paper WP-90-55 (summarized in Options December 90).

Our use of the environment as an assimilator of industrial wastes could affect our food and water supply through toxification. An application of a systems approach to industrial products can help us avoid costly mistakes. The case studies give an example in which banning cadmium in consumer products would not necessarily reduce the amounts of cadmium circulating in our cities, soils, air, and water, but merely re-route it.

In summary, systems analysis through the use of relatively simple models can alert us to important interlinkages. These models need not be highly quantitative to be useful, as shown in the example of qualitative systems analysis applied to the water management of the Salto Grande Dam on the Uruguay River.

b) Staying within the carrying capacity of the biosphere

The case studies show that the ecological carrying capacity of a given region must be examined in terms of specific demands on the environment, that is, in terms of food or water or assimilative capacities of wastes, or, better, in terms of those factors which are the most ecologically constrained. Carrying capacity can sometimes be defined as a relatively fixed quantity, as in the example given of the "critical loads" (or maximum ecologically safe rate of deposition) for acidic pollutants. But it is not usually a fixed number in terms of population, for several reasons.

First, as the case studies show, the application of different technologies can change the productivity of food and water, and hence raise a region's carrying capacity. For example, naturally renewed water sources could be supplemented by desalination of sea water. As indicated by the general conceptual models prepared for this report, the application of new production technologies is linked to the economy of a region,

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the existence of an education system to train operators, and the appropriate social and economic incentives.

Second, per capita demand for food, water, energy, and assimilation of wastes, as illustrated in the conceptual models, is linked to needs and desires, which in turn are influenced by values and education, income and affluence.

Third, unsustainable practices can be supported in a particular region by shifting demands beyond the regional environment's carrying capacity to other regions, as in the case of transboundary air pollution. In effect, such practices "export" unsustainability.

c) Sharing resources in an equitable and efficient way

The three cases examined in the report showed that it is essential to account for linkages among geographical regions and among generations if our resources are to be used efficiently and equitably. Management decisions which take into account only a limited part of the system run the risk of being inefficient or even harmful.

One of the cases, the Food Information System, shows that many developing countries now depend heavily on imports of animal protein from the developed world. Radical reductions of livestock in the developed world might in the short run seriously effect the food supply of many people in the developing world.

The case study of the application of systems analysis to acidification in Europe shows that, while helpful, it would be inefficient to reduce acid emissions further in countries that have already invested heavily in emission control. A more cost-effective solution would be to pool financial resources and to spend them in neighboring countries that have so far invested little in controls; both sides come out with cleaner air and less acidification of soils and lakes.

The report also addresses the problems inherent in an equitable allocation among the world's people — past, present, and future — of emissions of long-life greenhouse gases. The analysis suggested that, at least in the short term, devices such as tradeable emission allocations may be useful in sharing allocations and in providing the less developed countries with financial resources for development. In the long run, however, more energy-efficient technologies must be developed and adopted in all countries.

d) Continuous management of a dynamic system

It is certain that the characteristics of our socio-ecological system will change in the future, and our options for management of resources such as food, water and the disposal of wastes will change with them. Systems analysis can be used to examine how these options might be different in the future.

The case in which systems analysis was applied to the linkage between climatic change and food indicated that changes in management options will vary by region; in parts of the southern hemisphere the choice of food crops may be less than at present, whereas in mid-northern latitudes growing conditions may improve.

On a global scale the area of grain-growing land and/or the yield per hectare will have to increase to meet the needs of a growing world population, even at present average calorific intakes. Overall growing area and yield could be reduced by climatic change brought on by our use of energy, or through industrial toxification. On the other hand, yields could be increased through the dissemination of appropriate technology, which, as the general conceptual models indicate, is linked to availability of capital and operational skills.

The case study on water in North Africa and the Middle East shows that water resources will be strained in future by a growing population; a climatic change could add to the strain. A second case study on managing water supply showed that treating the Zambesi River Basin as a regional system reveals management options that allow us to meet several criteria for power generation and flood control, even in the face of projected climatic change.

The case study of acidification indicates that, in managing emissions of pollutants created by the burning of fossil fuels, one can use systems analysis to determine ecologically-based indicators of change. The study on forest decline in Europe shows how to use the volume of commercial wood receiving harmful levels of acid deposition as both a target for management policies and as an indicator of the success of those policies. Forest resources and the acid-carrying capacity of the forest ecosystem are changing in a dynamic way; indicators based on a systems approach to the chain of events linking acid emissions with stress on forests can help us adapt to these changes.

Finally, a case study shows that management of the by-products of a modern industrial economy must take account of the complex pathways of these by-products as well as environment's capacity to assimilate them. A thorough study of the pathways of these by-products will help avoid costly management mistakes, such as controlling one source of pollution while neglecting another.

The study also shows that people may unwittingly or deliberately change the assimilative capacity of the environment; for example, the ability of the soil to store toxic metals may be diminished by acidification. A systems approach offers us the opportunity to understand and manage these factors in an integrated, dynamic way. ■

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Population, Environment, and Development

A Case Study on Mauritius

by Wolfgang Lutz

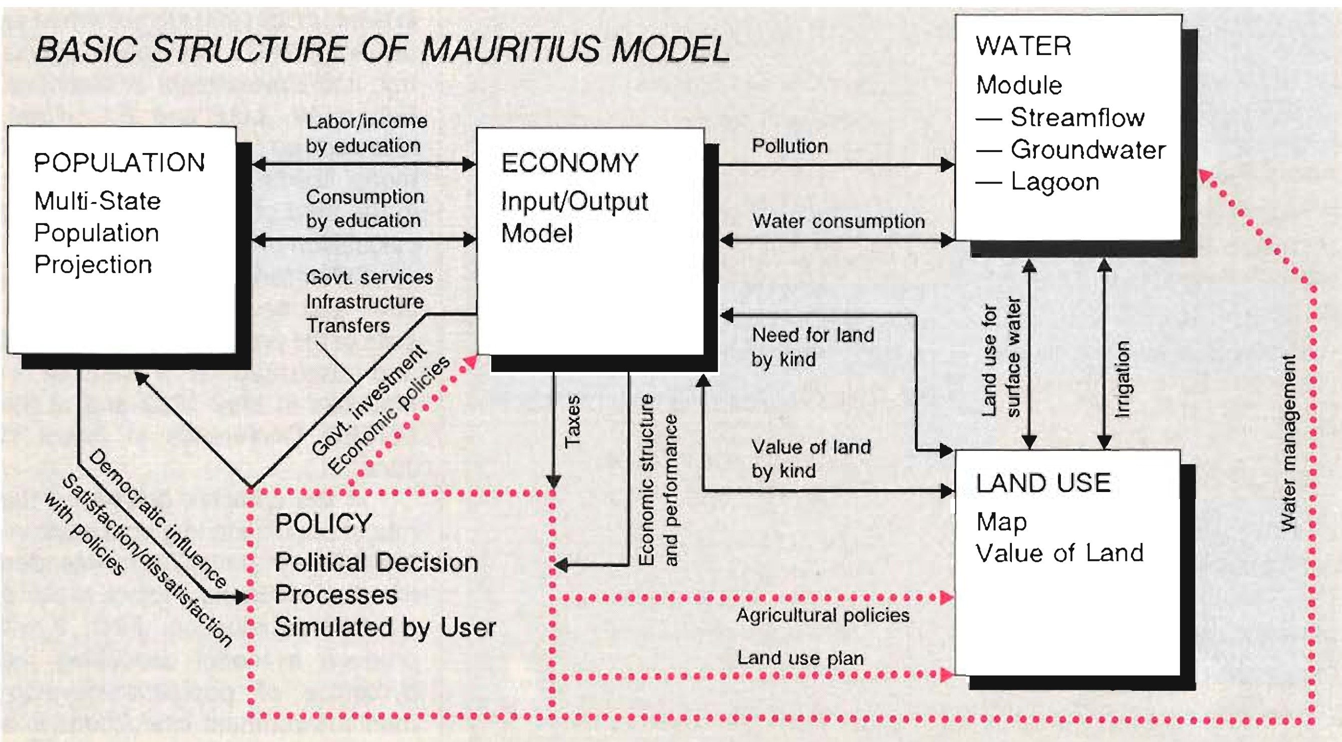
Population has long been discussed as a major factor in international development, but only recently has the issue of population — especially the impact of rapid population growth — been at the center of scientific and political controversies over who and what is to blame for environmental problems. Since 1989 the number of international scientific meetings on population and environment has increased exponentially, as has the number of publications: an inter-library search for combinations of the words 'population' and 'environment' gives few titles before 1989 and a rapid increase thereafter.

The present debate is controversial because the causal linkages between changes in population size and structure and changes in the environment are far from being direct and constant over time and space. Only in minor ways does the sheer number of people directly affect the environment (such as CO_2 emissions by human breathing). The major human impacts on the natural environment depend on prevailing technologies, soils and climate as well as patterns of culture and consumption.

These factors vary greatly from one region to another, and from one state of development to another. With respect to environmental impacts, a North African village has little in common with a North American village of the same population.

Mauritius offers an ideal case study to address these issues on a manageable scale. The study is being carried out by IIASA's Population and Sustainable Development Project in collaboration with the University of Mauritius, the Mauritian Ministry of Economic Planning and Development, and the new Ministry of the Environment. The project is funded by the UN Fund for Population Activities.

Work started in spring 1990 and is expected to end in August 1992.



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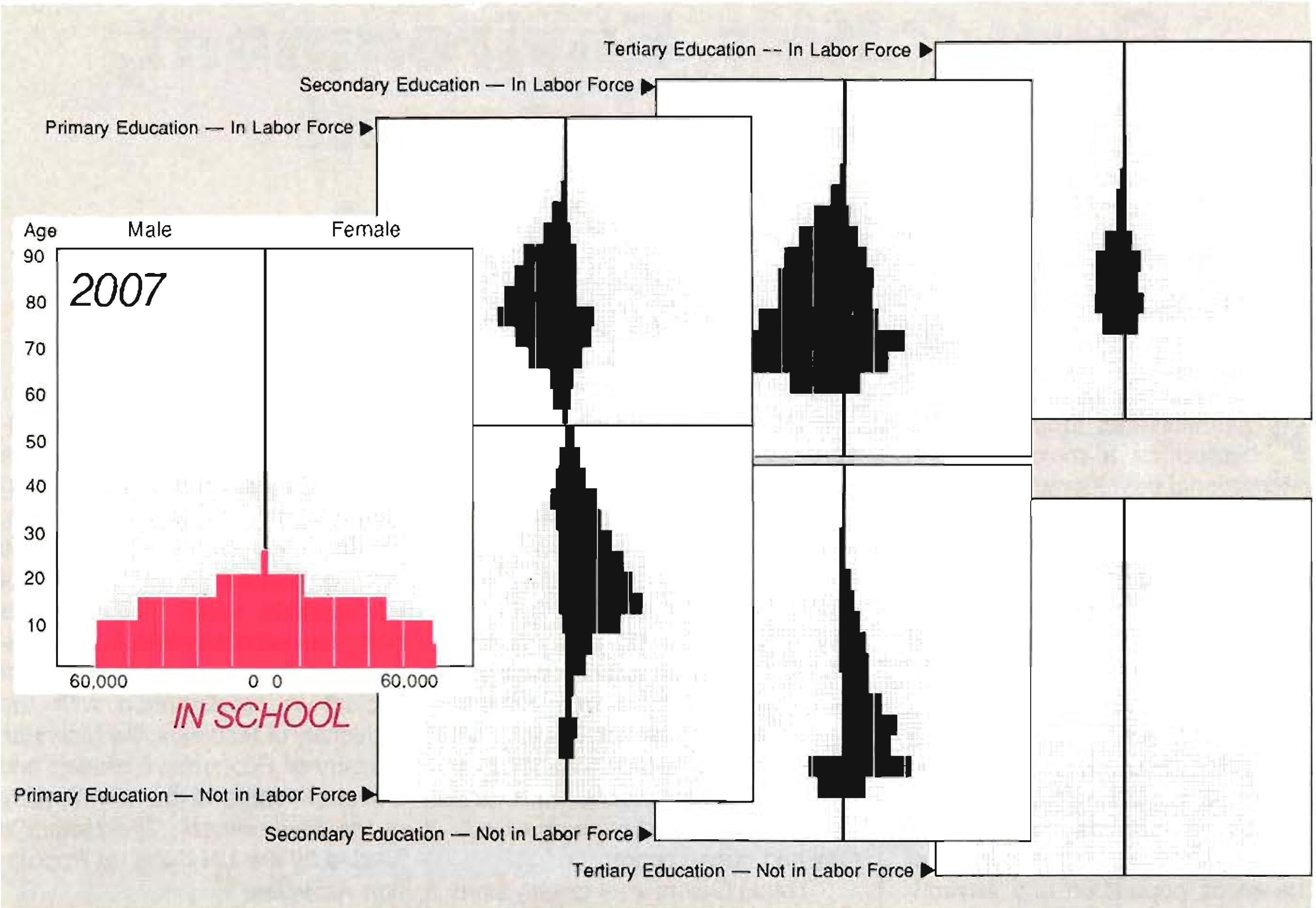


Basic Data on Mauritius

Geography/Environment

Size of island: 1852 km^2
Urban use: 14 percent
Sugar cane fields: 45 percent

Annual Rainfall: 2100 mm

Annual Evaporation: 1700 mm

Volcanic soils; large underground water resources

Fertilizer/ha 1986: 236 kg

Daily biological oxygen demand production: 60 tons (minimum 80 percent untreated)

Population (1990 data)

Size: 1,056,660

Annual Growth Rate: 1 percent

Total Fertility Rate: 2.3 percent

Ratio (0-14)/(15-64) year-olds: 0.46

Ratio (65+)/(15-64) year-olds: 0.17

Life expectancy: 67 years

Economy (1987 data)

Total GNP: $1.5 billion

GNP/cap: $1490

Annual growth rate: 8.4 percent

Foreign debt to GNP: 4.3 percent

Share of Agriculture in GNP:
15 percent
Sugar cane in agriculture:
83 percent

Share of industry in GNP:
33 percent
Textile exports in industry:
35 percent

Share of services in GNP:
53 percent
Tourism in services (hotels and restaurants):
6 percent

Tourist arrivals: 207,570

It began with a first phase of definition and data assembly (proceedings of a task force meeting held at IIASA in September 1990 are published as IIASA CP-91-01: *Population, Economy, and Environment in Mauritius.* Editors W. Lutz and F.L. Toth), followed by a second phase of model building. The project is now in the third phase of definition and calculation of alternative scenarios.

Other tangible results will be a book and several reports. The results of the project will be presented and discussed at a seminar in Mauritius in May 1992 and at the UNCED Conference in Brazil in June.

In the complex debate on the role of population in global environmental degradation, it is intended that the Mauritius Project make a two-fold contribution. First, it will produce a model describing the dynamics of population/development/environment interactions in a model which can be used by Mauritian authorities and scientists to consider and evaluate alternate paths of development. Already, government officials are using the laborforce part of the model in policy planning.

Second, the model is designed to be general enough to give students of population/environment interactions a clearer view of how linkages may be specified quantitatively and how changes in one sector affect other sectors. In other words, the model will be useful not only for Mauritius, but as a teaching tool for the international community of scientists and students.

Philosophy of the Model

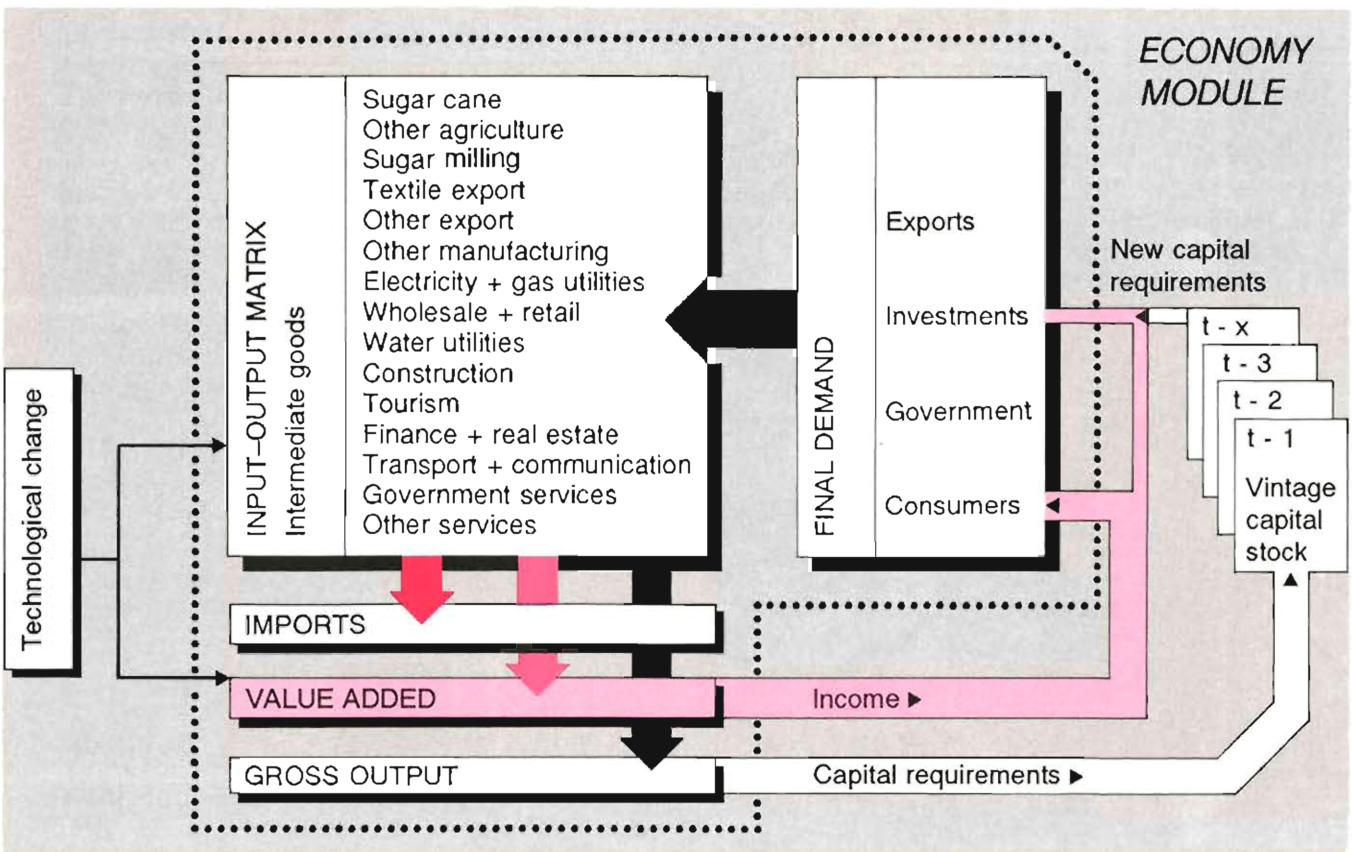
The Mauritius model has four components which are interlinked in various ways: the population module, the economy module, and two environmental modules covering water dynamics and land use (page 11). Air pollution is not considered in this study because it is irrelevant — steady winds immediately blow all pollution over the vast Indian Ocean.

A fifth entity within the model is the policy module. Here, information from all parts of the model is registered and certain pressures are exerted that lead to reactions via public policy, either in the form of legal regulations or of direct government investment. It was decided that the complex feedback loops running through this policy module should not be "hard-wired," or pre-specified; instead the user can specify reaction through computer-aided scenario setting.

Throughout the model the general approach was to hard-wire only immediate, unambiguous interdependencies between population, economic, and environmental modules. All other connections could be defined by the user. For example, regarding population change we felt that neither fertility nor mortality could be made directly dependent on certain economic or environmental characteristics, because the conclusion from the body of literature on these questions is that there is no unambiguous association that would allow the definition of a specific function.

The model is set up to run scenarios from 1990 to 2050 in five-year intervals. A special feature, however, will enable the user to run scenarios starting in 1960 and compare the actual trend over the past 30 years to hypothetical alternative trends.

Mauritius experienced an extremely rapid fertility decline in the late 1960s and is now beyond the demographic transition. Because most other less-developed countries are still in earlier phases of this process, it may be very instructive to simulate what impact continued high fertility would have had on Mauritius. Using this model it may be possible to disentangle the effects of fertility decline and of economic restructuring on the actual development of Mauritius.



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Population Module

The population module can be used either as part of the whole system or separately to generate population projections by sex, age, educational status and labor force participation. It is a multi-state population projection model with seven specified states (page 12). The projection is done in five-year steps and assumptions have to be made concerning status-specific fertility, mortality, and migration rates, as well as the rates of transition between the states (for example, the transition for 30–35 year old women with secondary education into or out of the labor force).

The present rates of transition will be given to the user in a predefined baseline scenario. The system's graphical tools make it easy for the user to make other assumptions concerning the intensity and age pattern of transitions or the timing of any changes.

The population module influences the economy module through labor supply by educational groups and through consumption, which is correlated to education.

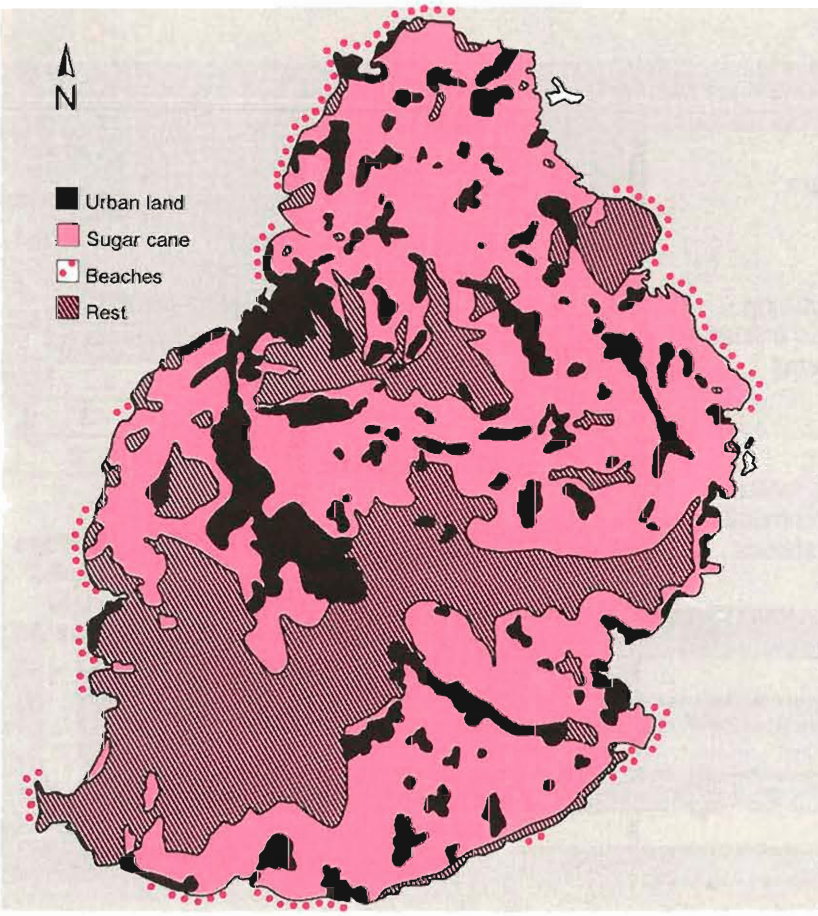
The momentum of population growth ensures that population size and structure in the near future are to a large extent predetermined by the existing age structure. For this reason the Mauritian population is still growing by more than one percent per year, due to the relatively high numbers of people of childbearing age born during the high-fertility years of the 1950s and '60s. Continuation of present fertility and mortality levels would in the long term imply a constancy, if not a shrinking, of the population.

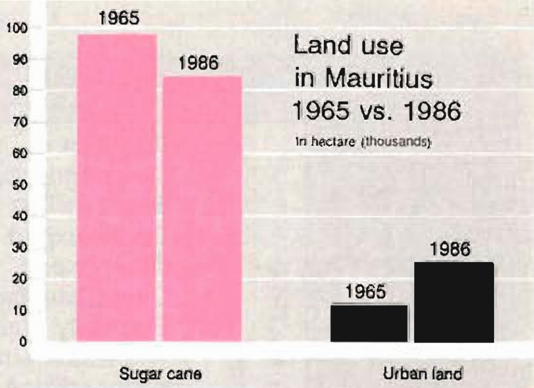
Economy Module

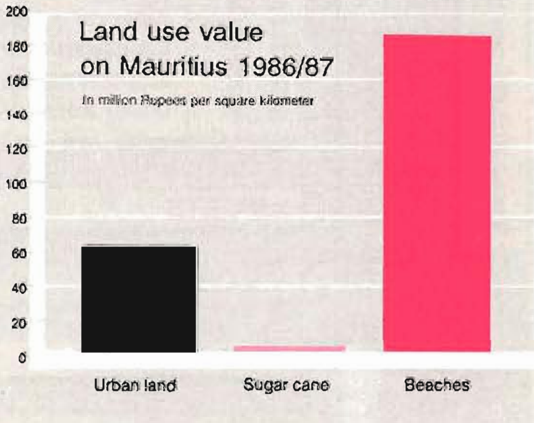
The economy is represented by a demand-driven, input–output model (page 13). International trade is exogenous and to be specified by the user. Government expenditure is a function of population size and age structure and a user-provided profile of per-capita expenditure. Household demand and investment demand are endogenous. Prices are fixed and only material flows are considered. Investments are the result of total demand for capital and the vintage capital stock. Foreign investments are user defined.

An equilibrium is calculated for every five-year time period, with some characteristics carried over from the previous period. The structure of the economy can be influenced by changing final demand. A procedure has been developed to change the matrix of technical coefficients by gradually phasing in new sets of coefficients.

In calculating the equilibrium for each period several economic constraints are considered: household







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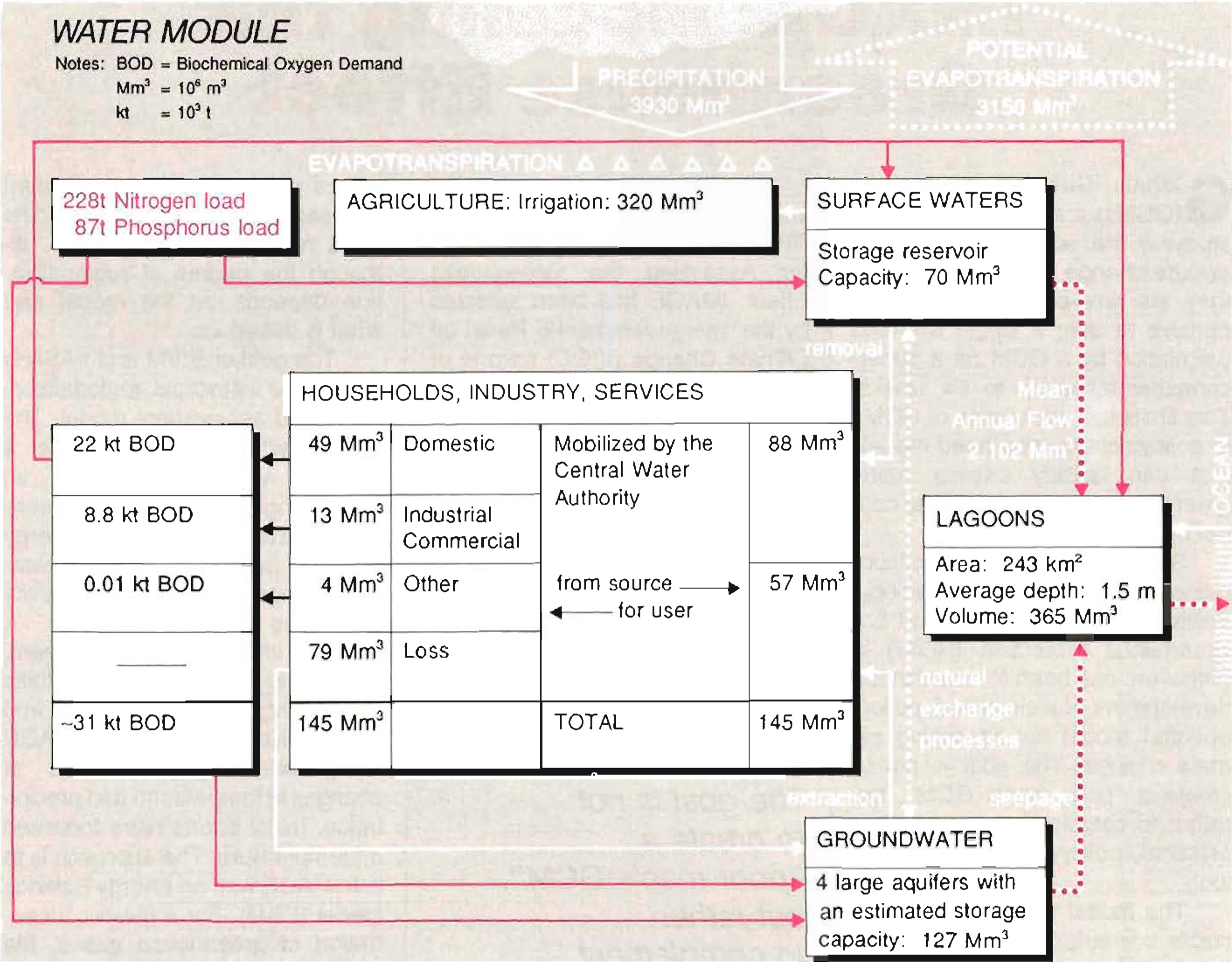

income must equal expenditure plus savings; savings plus foreign investments equal investments; government spending equals income plus deficit. Environmental constraints such as land use and water availability are being included in the calculations.

Land-use Module

A map of the island of Mauritius (page 14) distinguishes among four major types of land use: urban use, sugar cane, other use including other agriculture, and beaches. Between 1965 and 1986 urban land almost doubled, mostly at the expense of sugar cane land. Due to a higher intensity in sugar cane growing, however, total sugar output also increased during that period. Beaches were given a separate category, even though they comprise a small proportion of the total area, because they are central to the tourist industry and the Mauritian economy.

The land-use module reconciles competition by different users and puts constraints on the economic and environmental modules, working through a common geographic information system. Both the limits of land availability and the value of land are considered. In a competition for land under the baseline scenario, the higher-value use wins out; for example, urban land over sugar cane fields. The user, however, can stipulate land-use policies and calculate the economic consequences.

Water Module

Three water systems are considered separately: surface water (stream flow), ground water, and the lagoons. The figure on this page shows the basic connections between these systems, with quantitative information about the extent of water exchange. As can be seen from the chart, water quality depends both on the pollution vector, which is provided by the economic module, and the amount of water available to dissolve pollutants. The user can then set water quality standards and test the implications of certain policies on the water dynamics system as it is linked to population, the economy and land use. ■

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IMAGE: Modeling the Greenhouse Effect

Global Circulation Models (GCMs) are essential tools for studying the scientific aspects of climate change and its effects, but they are time-consuming and expensive to use; a single scenario calculation by a GCM on a supercomputer takes up to six weeks. This limits the usefulness of GCMs to policymakers, who need models that can quickly assess many greenhouse-gas scenarios and control options.

Since 1990 IIASA, in collaboration with the Netherlands National Institute for Public Health and Environmental Protection (RIVM) in Bilthoven, has been involved in the development of a simplified, policy-oriented model for assessing climate change. The goal is not to create a "poor man's GCM", but rather to complement them with a practical, policy-oriented modeling tool.

The model will be able to calculate scenarios within minutes or hours, rather than weeks, using only a personal computer. An added advantage of its simplicity, by comparison with GCMs, is that it can be easily integrated with other models that project the ecological impacts of climate change, such as changes to vegetation.

Even with complex GCMs there is great uncertainty over their regional estimates of the effects of climate change; given the same scenario of greenhouse gases, GCMs tend to produce roughly similar global averages, but for any given region often project widely differing values of temperature and precipitation. As regional estimates by GCMs become more reliable, the simplified model being developed at IIASA and RIVM can be tuned to take advantage of their results.

The starting point is an existing integrated model developed at RIVM, called the Integrated Model for Assessing the Greenhouse Effect. IMAGE has been selected by the Intergovernmental Panel on Climate Change (IPCC) as one of two standard tools to assess the impacts of climatic change, as opposed to GCMs, which are intended primarily for basic research. The IPCC is already using analyses from preliminary versions of IMAGE, and the European Community plans to do so in future.

> *"The goal is not to create a "poor man's GCM", but rather to complement pure research tools with a practical, policy-oriented model."*

The IPCC is placing increasing emphasis on the use of time-dependent impact models that are linked with energy-emission accounting frameworks and models that predict, in a time-dependent fashion, important variables such as atmospheric concentrations of greenhouse gases, temperature and precipitation.

At present IMAGE only partially meets these criteria. It is time-dependent but gives only global values of changes in temperature and sea-level rise. Impact models need regionalized projections, although the degree of regionalization depends on the model and what is assesses.

The goal of RIVM and IIASA is to produce a practical, regionalized, integrated assessment model. The model will eventually include a modified version of IMAGE, an accounting framework for greenhouse gases generated by energy use and models of global vegetation change and forest productivity developed at IIASA.

The international IIASA team, comprising Roderick Shaw, Matthias Jonas, Krzysztof Olendrzynski, and Jaroslav Krabec, will modify IMAGE to provide regional values of changes in temperature and precipitation. Initial efforts have focussed on temperature. The approach is to link IMAGE with an Energy Balance Model (EBM). For a given concentration of greenhouse gases, the EBM will calculate what equilibrium temperature will result, considering both the balance of short-wave radiative energy from the sun and infra-red radiative energy from various layers in the atmosphere and from the earth's surface. The horizontal transport of heat by wind systems will also be taken into account.

Late in 1991 a preliminary one-dimensional (latitudinal) but time-dependent version of an EBM had been formulated. As described in a collaborative paper by Jonas, Olendrzynski, and their collaborator at RIVM, Michel den Elzen, the preliminary model calculates temperature change in latitude bands of 10 degrees. One result is shown in the accompanying figure: for IPCC Scenario A ("business as usual"), the average temperature

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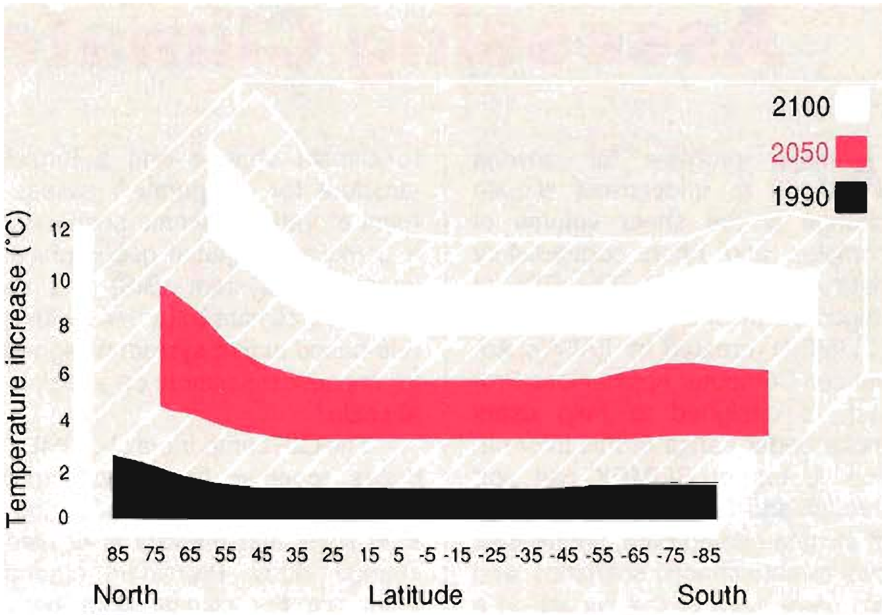
in a given 10-degree latitude band increases with time and, generally, with latitude in both hemispheres, with the greatest increases near the North Pole.

It should be stressed that these are the results of a very preliminary version of the model. They do not include the time lags caused by the deep ocean, and are therefore too high. RIVM is developing a deep-ocean component of the model.

In 1992, a two-dimensional EBM will be developed and a representation of ice and meridional and vertical heat fluxes will be developed. Work will also be expanded to enable estimates of precipitation changes with latitude. Detailed box structures of land, ocean, and atmosphere will be gradually incorporated. In late 1992 and 1993 the modified IMAGE will be linked with models of ecological effects such as IIASA's Biosphere Model and Timber Assessment Model.

Work is proceeding in parallel at IIASA to provide regional values of temperature and precipitation change. Two research assistants, Katharina Fleischmann and Uta Nitschke, began this work in the summer of 1991. Taking a relatively empirical approach, they laid the analytical groundwork for combining the time-dependent temperature changes provided by IMAGE with the global maps provided by GCMs. Again, they are tuning their approach to the results of GCMs. This work will continue in 1992.



Preliminary projections of temperature increases, by latitude, calculated by the Energy Balance Model developed for IMAGE. Projections are based on IPCC scenario A ("business as usual").

Roderick Shaw, Matthias Jonas, and Krzysztof Olendrzynski

Biosphere Dynamics - *Position Announcement*

One of the major unknowns associated with ongoing global environmental change is its effect on vegetation distribution and structure. IIASA currently occupies an international position in vegetation modeling and intends to maintain this position. The Institute's global vegetation model, developed during 1988-90 in the Biosphere Dynamics Project, was accepted as a 'Flag Concept' by the International Geosphere–Biosphere Programme's Global Change and Terrestrial Ecosystems Project.

The main objective of the Biosphere Dynamics Project is to develop the existing static global vegetation biome model into a dynamic transitional model by including processes on short time scales, incorporating land-use aspects, and regionally validating the biome model, taking into account the influence of soil quality in the model. The work is not restricted to the direct effects of climate, but encompasses other important human impacts, including deforestation, burning, grazing, and agriculture.

The Biosphere Dynamics Project is currently without a leader. Applicants for the post must have a Ph.D. in field biology, ecology, or a closely related field and a strong publication record. Other requirements are a demonstrated interest in global ecological research; experience in ecological modeling at or above the community level; experience in the management of research groups; an excellent command of written and spoken scientific English; and proven fund-raising capabilities.

The dates of the appointment are negotiable, but should begin in 1992, preferably in the spring, with an initial contract for two years. The salary, exempt from taxation in Austria, is based upon experience. Applications should be made to IIASA Director Peter E. de Jánosi, together with a letter giving a statement of interests, a curriculum vitae, two relevant publications, and the names of three reference persons and their addresses and telephone and fax numbers, where available.

Further information is available on request from IIASA.

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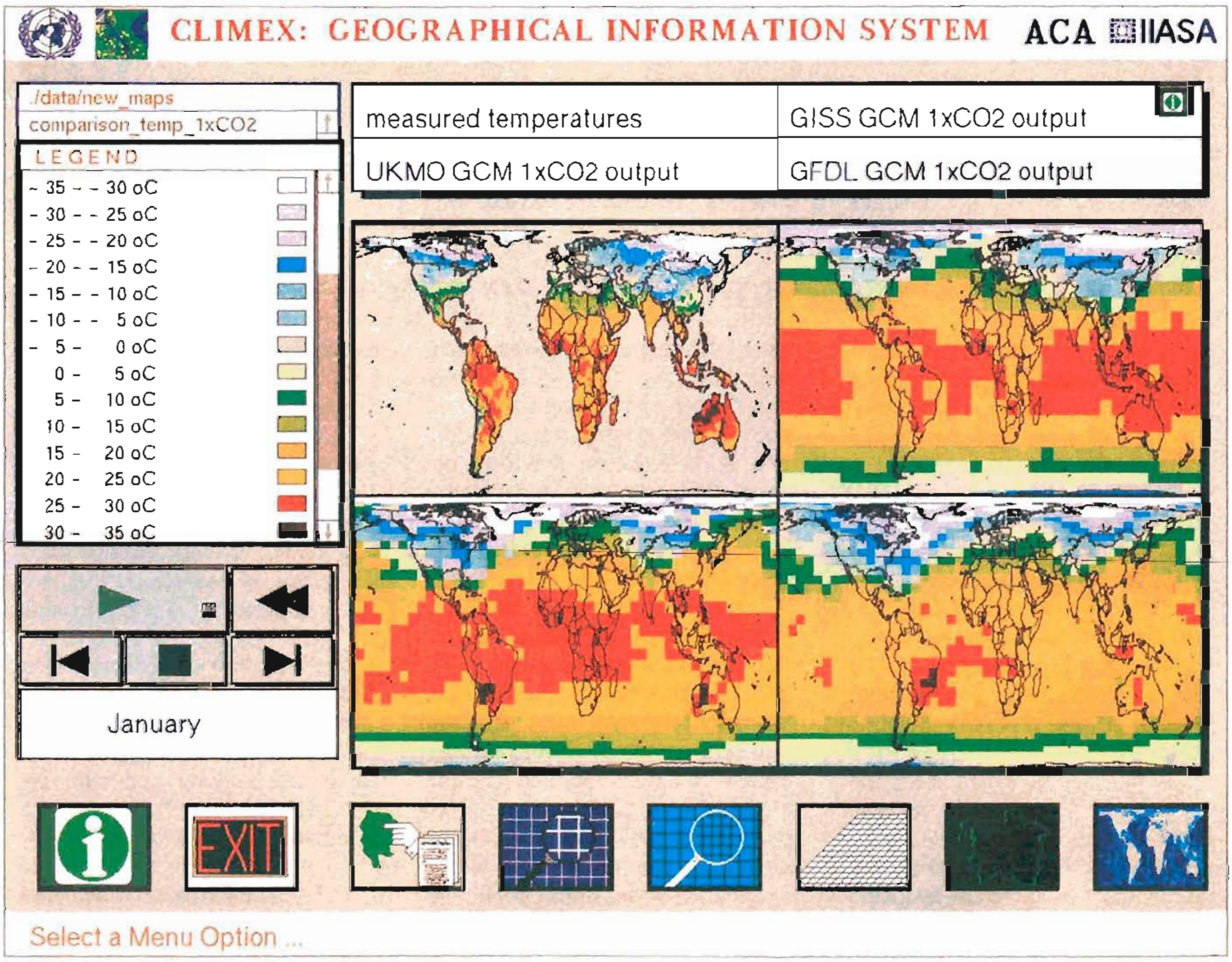
Assessing Climate Change

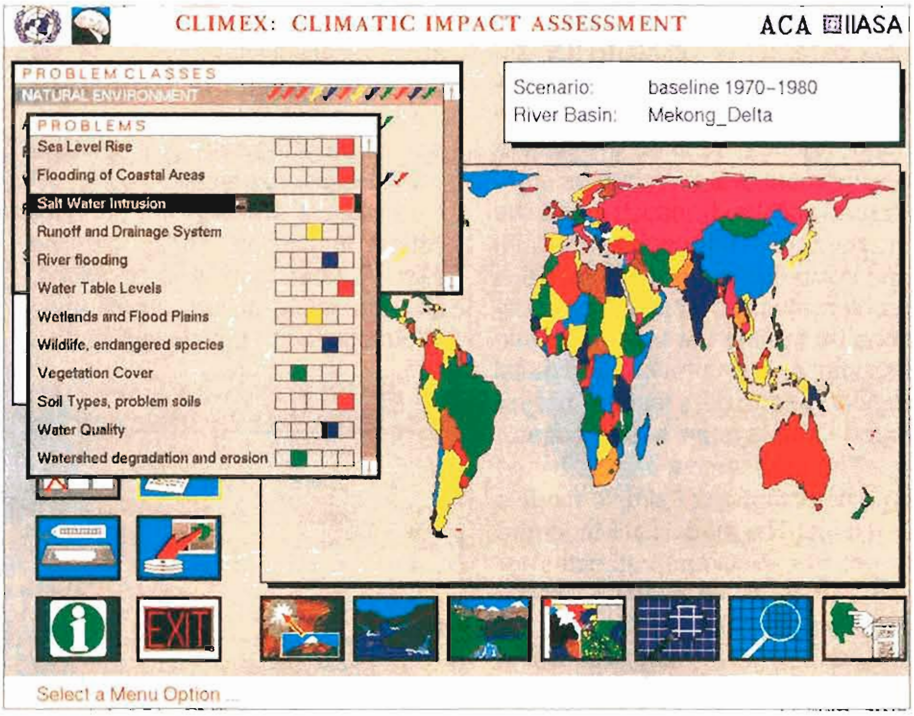
A major problem for anyone trying to understand climate change is the sheer volume of complex and often contradictory data on the subject. The Climate Impact Assessment Expert System (CLIMEX), created by IIASA's Advanced Computer Applications Project, is designed to help users make better sense of this information. Users of CLIMEX can sort through and compare vast amounts of climate-related data, create their own climate change scenarios, and get some idea of the impact on a given region.

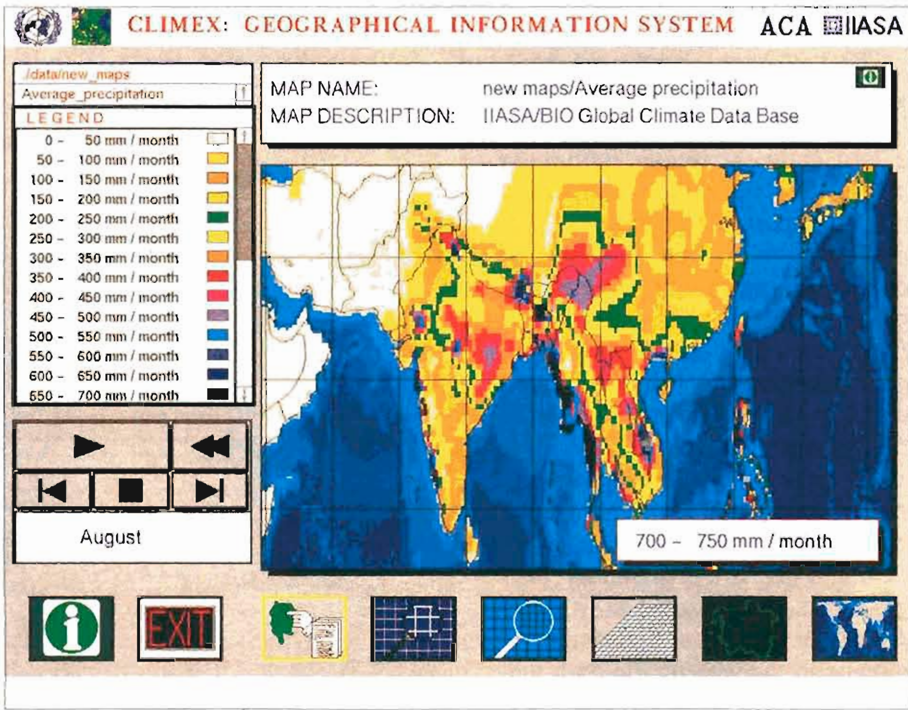
CLIMEX is both a repository of often disparate information related to climate change and a formal structure for comparative assessment of various climate scenarios. It combines a global geographical information system (GIS) and an extensive climate data base with a rule-based expert system designed for impact assessment on a regional scale.

The GIS component of CLIMEX draws together information from many different sources that is global in scale and relevant to climate change study. Prominent among them are the climate data base developed by IIASA's Biosphere Project; data sets and results from the project's Biome Model, which projects the effects of climate shifts on vegetation and carbon fluxes; and data and results from the Food and Agriculture Project's Basic Linked System, which combines 35 national and/or regional models to form a global agroeconomic model. The data base structure is open: additional data sets and maps can easily be added.

Current background data in CLIMEX include basic topographic data such as elevation, the world soil map of the UN Food and Agriculture Organization (FAO), and data on historical, current, and forecast population from the UN, by country. Vegetation maps based on







the Olson and Holdridge vegetation classification schemes are also included. Basic climate variables, including temperature, precipitation, and cloudiness from IIASA's climate data base, are provided as monthly average data sets (bottom). Satellite-derived climate data, such as surface temperatures from NIMBUS, are also available.

Complementing this background and base-line climate data, GCM projections of climate assuming one and two times current atmospheric CO_2 concentrations are available. Currently, the model includes outputs from GCMs created by the Goddard Institute for Space Studies and the General Fluid Dynamics Laboratory, both in the USA, and the United Kingdom Meteorological Office.

With CLIMEX all these data sets can be viewed as topical maps and, where appropriate, can be animated as a time-series of monthly values, or, in the case of the population data, in five-year intervals. For the climate data base, the system also allows the user to retrieve and display data from individual stations from the map, and display them as a set of histograms (page 20, top).

Up to four maps can be displayed simultaneously for comparison. This is particularly instructive when comparing GCM projections with the observed climate data, or contrasting differences between the GCMs or the models and data with other potential explanatory variables, such as elevation (page 18).

The display system of the GIS provides several tools and features that help in the visual interpretation of the data sets. For example, values or labels can be read back directly from the maps by pointing at the feature of interest, arbitrary zooming is supported, and national boundaries can be displayed as a line overlay for orientation. A color editor allows the user to define the color composition of a map set for better contrast and visibility. For example, on the elevation map a certain elevation band can be highlighted or given a high-contrast color.

The data sets of the global GIS, while of interest in themselves, are designed to provide input to CLIMEX's analysis component. The user first selects a region, such as a major river basin, then selects or defines a climate scenario. This can be based on a GCM scenario or be created by the user, specifying, for example, an absolute or relative increase in temperature and precipitation, a specified rise in sea level, etc. The system applies the modifiers to base-line information from IIASA's climate data base to generate a new climate scenario.

The assessment then uses a

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system of checklists that guide the user to a set of problems for assessment (pages 19, top; 20, bottom). Problems are grouped into major themes, such as the natural environment, water resources, agriculture and food, industry and the energy sector, or population, health and socio-economic impacts. Each problem involves a number of questions that refine the basic scenario assumptions or provide additional region-specific data that are not yet found in the system's data bases.

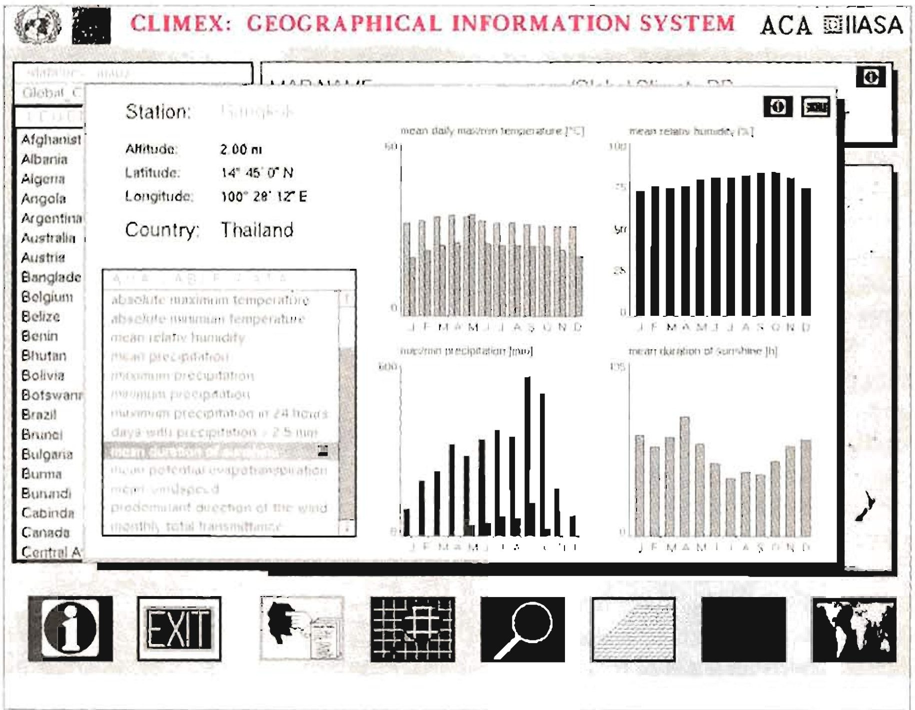
The assessment itself is based on a combination of simple models and rules. The models are triggered to provide individual estimates for key variables; for example, irrigation water demand based on a set of FAO estimation methods. Using a distributed parallel computing scheme, they are run as an integrated part of the expert system inference mechanism.

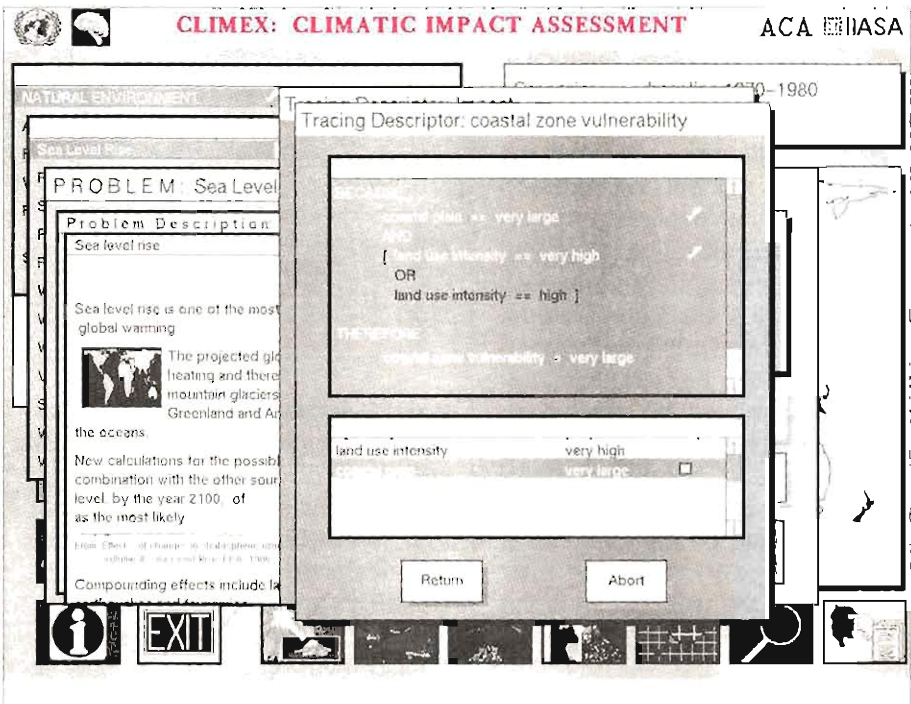
The inference itself uses near-natural language rules that can handle both numerical and symbolic data. Data are retrieved from the GIS, the various data bases, or put in by the user. The symbolic analysis uses rules that are derived from the literature and from domain experts. These rules, sometimes using alternative chains of reasoning depending on the information available, lead to an assessment of the initial problem on a qualitative scale, for example, between insignificant and major. Any conclusion of the system can be further questioned. Using an explanatory *Why* option, the system explains, step by step, its reasoning and displays the rules used, as well as the data utilized. All of the concepts used can be further linked to a "hypertex" system that provides an interactive glossary and background information that offers useful contextual information for the assessment procedure.

The expert system's formalism provides rigor and flexibility at the same time. Each and any conclusion must be based on a set of well-defined precursors and their well-defined interdependence. This enforces intellectual discipline. At the same time, the near-natural language and rich set of operators provided by the rule syntax offers considerable expressive power. All the system's workings are open for critical inspection. Rules can be easily understood and modified, and the menu-driven tutorial style of dialogue with the system makes it very user friendly.

The same idea of ease of use, direct accessibility, and ease of understanding is behind the visualization in the GIS component. Together they build a powerful set of tools that can help to make better sense of complex data in the area of climate change research.

Kurt Fedra





NEW PROJECTS

Technology Development and Transfer

The Tokyo Electric Power Company, Inc., and IIASA signed this two-year research agreement to assess the technical feasibility of new energy technologies and their viability in Europe, with the emphasis on inter- and intra-regional cooperation and technology transfer. (Contact: *Nebojša Nakićenović*, IIASA)

Soil Acidification and Emission Reductions

Members of the Transboundary Air Pollution Project will assist the Coordination Center for Effects (CCE) at the National Institute for Public Health and Environmental Protection (RIVM) in the Netherlands to implement dynamic soil modeling by providing updated input data files for the SMART dynamic soil model, and will also assist in installing the new version of the dynamic RAINS soil model at CCE. (Contact: *Markus Amann*, IIASA)

Life-cycle Analysis Model

IIASA has signed a memorandum of understanding with the University of Economics of Vienna to transfer the rights to use the life-cycle analysis model, operating systems and database, and their related source codes. (Contact: *Sten Nilsson*, IIASA)

Anthropogenic Air Pollutants in Urban Areas

Under a memorandum of understanding, signed with the UN Environment Programme, IIASA will study the feasibility of developing a software package to enable technical staff, particularly in less developed countries, to establish, compile, and/or estimate emissions of anthropogenic air pollutants in urban areas. The software would allow for the estimation of emissions if limited statistical information and technical expertise is available. (Contact: *Markus Amann*, IIASA)

Comparison of Pollution Control Models

Under a nine-month contract with the Commission of the European Communities in Brussels, IIASA will make dynamic comparisons of four European integrated assessment models. The study also includes a discussion of the feasibility of integrating submodels, principles, postulates, theoretical or other approaches of various models into a Multipurpose European Model. (Contact: *Markus Amann*, IIASA)

Water Management in the Vah River Basin

The Water Research Institute (VUVH) of Bratislava, CSFR, and IIASA have signed an 18-month collaboration agreement in cooperation with the Vah River Basin Authority. The objectives of the project are: integrated evaluation of information available for quantity, quality, and pollution loads; preparation of a pollution inventory; evaluation of pollution sources and quality of groundwater; assessment of quantity and quality problems using models, as well as evaluation of future scenarios and the effectiveness of control measures; revision of the systems of monitoring and water quality classification; and recommendation for future policy. (page 8) (Contact: *László Somlyódy*, IIASA)

CONFERENCES

User-oriented Methodology and Techniques of Decision Analysis and Support, Warsaw, Poland, 9–13 September.

IIASA's System and Decision Sciences Program, in cooperation with the Institute of Automatic Control of the Warsaw University of Technology and the Systems Research Institute of the Polish Academy of Sciences, organized this workshop, supported by the Polish Ministry of Education. Over 70 scientists from 14 countries discussed: principles of parameterization of decision analytical models; user-oriented methods of dealing with uncertainty; programming algorithms for decision support systems; special preprocessors of mathematical methods for decision analysis; and developments in interactive computer graphics for decision support systems. (Contact: *Marek Makowski*, IIASA)

Systems Analysis Techniques for International Negotiation, Laxenburg, Austria, 9–10 October.

This conference investigated why techniques to analyze negotiations have not been applied in practice and to discuss ways of facilitating their use. A second objective was to set a research agenda for the Processes of International Negotiation Project that could contribute to closing the gap between practitioners and scientists. Specialists reported on current research on game theory, cognitive mapping, statistical analysis, multicriteria and multi-objective optimization, mathematical modeling, and decision support systems. (page 5) (Contact: *Bertram Spector*, IIASA)

Implementation of the World Climate Program–Water Project A.2, Laxenburg, Austria, 23–25 October.

IIASA's Water Resources Project and the World Meteorological Organization organized this meeting to evaluate and discuss the implementation of the WCP-Water Project (A.2) on analyzing long-time series of hydrological data with respect to climate variability. (Contact: *László Somlyódy*, IIASA)

Recycling of Paper Products, Laxenburg, Austria, 14 November.

Twenty industrial representatives were given a detailed description of the IDEA Life-Cycle Model, followed by the results of a feasibility study undertaken by

CONFERENCES

IIASA's Forest Resources Project. (Contact: *Sten Nilsson*, IIASA)

ASCEND 21: The International Conference on an Agenda of Science for Environment and Development in the 21st Century, Vienna, Austria, 24–29 November.

Organized by the International Council of Scientific Unions, IIASA, and other nongovernmental organizations, this conference was a unique exercise, both through its focus on development, and because of its inclusion of scientists from many disciplines (natural, social, engineering, and health sciences). Some 250 experts from around the world discussed scientific aspects of environment and development and proposed a scientific agenda for the next 10 to 20 years. The conference was part of the scientific support for the UN Conference on Environment and Development. (Contact: *Elisabeth Krippl*, IIASA)

Aspects of A Convention to Control Climate Change, Laxenburg, Austria, 28 November.

The Tata Energy Research Institute (TERI) of New Delhi, India, the Stockholm Environment Institute (SEI), Sweden, and IIASA's Environmentally Compatible Energy Strategies Project organized this workshop, coinciding with the ASCEND meeting in Vienna. The purpose was to review the progress of the short-term TERI study, prepared for the UNCED process, and to initiate a longer-term joint study by TERI, SEI, and IIASA to assess emission allocation schemes. (Contact: *Leo Schrattenholzer*, IIASA)

CORINAIR Training Workshop for Hexagonale and PHARE Countries (16–18 December) and Emission Inventory for the Hexagonale Countries (18–19 December), Laxenburg, Austria.

Twenty-five participants from ten countries attended these two events, organized jointly by the European Environmental Agency, the PHARE Program of the Commission of the European Communities, and IIASA. The objective was to undertake on-line tutorial and training for CORINAIR software, and discuss progress on the Hexagonale emission inventories and IIASA's role in coordinating these inventories. A special session was devoted to emissions from road transport. (Contact: *Markus Amann*, IIASA)

Forthcoming Conferences

The following conferences will be sponsored or cosponsored by IIASA:

March 3–5, 1992: Implications of Mass Migration in Europe, Vienna, Austria. (Contact: *Sture Öberg*, IIASA)

April 21–8 May, 1992: Global Change and Environmental Considerations for Energy System Development, Miramare-Trieste, Italy. (Contact: ICTP, P.O. Box 586, I-34100 Trieste, Italy)

May 12–13, 1992: IIASA '92: An International Conference on the Challenges to Systems Analysis in the Nineties and Beyond, Laxenburg, Austria. (Contact: *Claudia Heilig-Staindl*, IIASA)

June 22–24, 1992: Advances in Decision Support Systems, Laxenburg, Austria. (Contact: *Marek Makowski*, IIASA)

June 24–26, 1992: Support Systems for Decision and Negotiation Processes, Warsaw, Poland. (Contact: *Zbigniew Nahorski*, DNS '92, Systems Research Institute, Polish Academy of Sciences, Newelska 6, PL-01 447 Warsaw)

October 1992: Intelligent Decision Support Systems. (Contact: *Marek Makowski*, IIASA)

November 26–27, 1992: Applications of Decision Support Systems, Tokyo. (Contact: *Marek Makowski*, IIASA)

NEWS

In Memoriam

Alexander P. Iastrebov (Russia), a researcher with the IIASA Craft of Systems Analysis Project from 1977 until 1983, died 27 December 1991.

Appointments

Yuri Ermoliev (Ukraine), Head of the Department of Mathematical Methods of Operations Research at the Institute of Cybernetics of the Ukrainian Academy of Sciences in Kiev, has joined the Social and Environmental Dimensions of Technology Project.

Serguei U. Glaziev (Russia), from the Central Economic and Mathematical Institute in Moscow, has joined the Economic Transition and Integration Project.

Jaroslav Krabec (CSFR), from the Institute of Physics of the Atmosphere at the CSFR Academy of Sciences in Prague, has joined the Global Environment Security Project.

Mikhail Marinichev (Russia), from the Institute of World Economy in Moscow, has joined the Economic Transition and Integration Project.

Yoichi Nishimura (Japan), from the Nuclear Power Section of the Tokyo Electric Power Company, has joined the Environmentally Compatible Energy Strategies Project.

Chibo Onyeji (Nigeria), from the Center for Advanced Decision Support for Water and Environmental Systems of the University of Colorado in Boulder, USA, has joined the Advanced Computer Applications Project.

Astrid Rautengarten (Germany), from the Technical University of Dresden, has joined the Global Environment Security Project.

Maarten van't Riet (Netherlands), from the Center for World Food Studies of the Free University of Amsterdam, has joined the Food and Agriculture Project.

Awards

At its 38th meeting, 14–15 November 1991, the IIASA Council passed a resolution conferring the title of IIASA Honorary Scholar on the departing Deputy

NEWS

Director **Bo Döös**. The Council also welcomed the appointment of **Nathan Keyfitz**, Leader of the Population Program, as the new IIASA Deputy Director.

At the Board of Trustees Meeting of the International Federation of Institutes for Advanced Study, held in Wuppertal, Germany, 11–13 November 1991, IIASA Director **Peter de Jánosi** was elected to the Executive Committee.

IIASA's Peccei Scholarship is awarded for outstanding participation in the annual Young Scientists' Summer Program. The 1991 Peccei recipients are, left to right, ***Elena N. Boulanger*** *(USSR), from the Institute of Control Sciences of the Academy of Sciences of the USSR in Moscow;* ***Wolfgang Keller*** *(Germany), from Yale University in New Haven, Connecticut, USA; and* ***Amanda Wolf*** *(USA), from the University of Maryland in College Park, Maryland, USA.*

Position Announcement Optimization Research

The goal of IIASA's optimization studies is to develop procedures and mathematical frameworks that allow model builders to deal with uncertainties without unjudicious simplification. The focus of research will be the interplay between data collection processes and the search for a solution. Other work will involve improving solution techniques for stochastic optimization problems. Techniques involved include theories of epi-convergence, random sets, large deviations and variational analysis, and statistical asymptotic analysis.

Areas of research include: numerical methods in stochastic optimization; the control and optimization of discrete-event systems, development of theoretical tools and their testing on applied projects at IIASA and elsewhere.

Applicants should have a Ph.D. in operation research, applied mathematics or computer sciences, knowledge of FORTRAN, C, and PASCAL, and experience in decision making and decision support systems. Experience in programming in the MS-DOS environment, working with UNIX, and in the design of optimization algorithms, data bases, user interfaces, and information systems is also required. They must be fluent in English.

The initial contract will be for one year, starting around July, 1992, with salary based on experience. Applications should be made by 15 April to IIASA Director Peter E. de Jánosi, including a curriculum vitae, two relevant publications, and the names of three reference persons, their addresses and telephone and telefax numbers.

PUBLICATIONS

IIASA Books

The following books are now available from your regular book supplier or direct from the publisher.

Mountain World in Danger: Climate Change in the Forests and Mountains of Europe. S. Nilsson, D. Pitt. Earthscan Publications Ltd., London. ISBN 1-85383-118-2.

Computer Integrated Manufacturing, Volume 2: The Past, the Present and the Future. R.U. Ayres, M.E. Merchant, J. Ranta. Chapman and Hall, London/New York/Tokyo. ISBN 0-412-40450-8.

Computer Integrated Management, Volume 3: Models, Case Studies and Forecasts of Diffusion. R.U. Ayres, I. Tchijov, W. Haywood. Chapman and Hall, London/New York/Tokyo. ISBN 0-412-40460-5.

Computer Integrated Management, Volume 4: Economic and Social Impacts. R.U. Ayres, R. Dobrinski, K. Uno, E. Zuskovitch. Chapman and Hall, London/New York/Tokyo. ISBN 0-412-40470-2

What Is To Be Done? Proposals for the Soviet Transition to the Market. M.J. Peck, T.J. Richardson, Editors. Yale University Press, New Haven/London. ISBN 0-300-05466-1.

IIASA Reports

The following reports are available from Robert McInnes, IIASA Publications Department, for the amounts indicated.

Hunger: Beyond the Reach of the Invisible Hand. G. Fischer, K.K. Frohberg, M.A. Keyzer, K.S. Parikh, W. Tims. October 1991. RR-91-15. US $20.

Environmental Issues Requiring International Action. B.R. Döös. October 1991. RR-91-16. US $10.

Long Waves, Technology Diffusion, and Substitution. A. Grübler, N. Nakićenović. October 1991. Reprinted from *Review* XIV(2):313-342. Spring 1991. RR-91-17. US $10.

The IIASA Database for Mean Monthly Values of Temperature, Precipitation, and Cloudiness on a Global Terrestrial Grid. R. Leemans, W.P. Cramer. November 1991. RR-91-18. US $10.

Expert Systems for Environmental Screening. An Application in the Lower Mekong Basin. K. Fedra, L. Winkelbauer, V.R. Pantulu. November 1991. RR-91-19. US $20.

Selecting a Flexible Manufacturing System using Multiple Criteria Analysis. A. Stam, M. Kuula. December 1991. Reprinted from *International Journal of Production Research*, 29(4): 803-820. RR-91-20. US $5.

◆ Capital Cities of NMO Countries

IIASA

International Institute for Applied Systems Analysis

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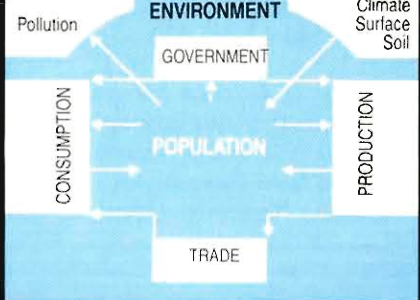
The International Institute for Applied Systems Analysis is an international, nongovernmental research institution sponsored by scientific organizations from 15 countries. IIASA's objective is to bring together scientists from various countries and disciplines to conduct research in a setting that is non-political and scientifically rigorous. It aims to provide policy-oriented research results that deal with issues transcending national boundaries. Resident scientists at IIASA coordinate research projects, working in collaboration with worldwide networks of researchers, policymakers, and research organizations.

Population /Environment Interactions



RESEARCH

Recent projects include studies on global climate change, computer modelling of global vegetation, heavy metal pollution, acid rain, forest decline, economic transitions from central planning to open markets, the social and economic implications of population change, processes of international negotiations, and the theory and methods of systems analysis. IIASA applies the tools and techniques of systems analysis to these and other issues of global importance.

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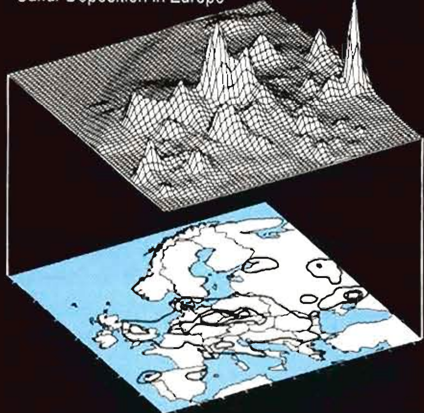
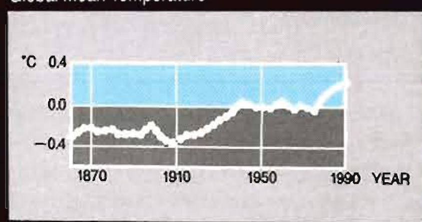


Global Mean Temperature



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IIASA was founded in 1972 on the initiative of the USA and the USSR, and now also includes eleven European countries, Canada, and Japan. IIASA has member organizations in the following countries: Austria, Bulgaria, Canada, the Czech and Slovak Federal Republic, Finland, France, Germany, Hungary, Italy, Japan, the Netherlands, Poland, the Russian Federation, Sweden, and the United States of America.

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