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STRATEGIC REGIONAL POLICY

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EDITORS

PART II

WARSAW 1985

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STRATEGIC REGIONAL POLICY

Paradigms, Methods, Issues and Case Studies

A. Straszak and J.W. Owsiński
editors

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PART II

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V. ENVIRONMENT

AN APPROACH TO ENVIRONMENTALLY BALANCED REGIONAL DEVELOPMENT POLICY AND THE SUSTAINABILITY OF THE BIOSPHERE *

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INTRODUCTION

Acceleration of scientific and technological progress and of industrial, metropolitan and agricultural development leads to man's confrontation with nature. The influence of man on nature changes the equilibrium of its laws and established processes which leads to unpredictable consequences. Generally, these are negative, such as desertification, water and atmospheric pollution, increase in soil acidity or salinity, destruction of forests and severe exhaustion of natural resources, impacts on human health and genetic mutations in plants and animals. This primarily occurs at the local and regional levels, leads to unpredictable negative consequences for the separate regions, and gradually also leads to negative consequences for the entire biosphere.

The increasing scale and significance of man's role as an agent of global change was forcefully articulated between the two World Wars by a remarkable group of scholars. These included the French theologian and paleontologist, Pierre Teilhard de Chardin, the Austrian-born American biophysicist, Alfred J. Lotka, and above all, the Russian mineralogist, Vladimir Ivanovich Vernadsky. Vernadsky (1926) first formulated the concept of the biosphere as the only terrestrial envelope in which life can exist. In Vernadsky's opinion the most significant aspect of man's development was not his technology per se but rather the sense of global knowledge and communication engendered by that technology. He portrayed this "noosphere" or realm of thought as a new geological phenomenon on our planet. Vernadsky's main concept was strongly developed by Soviet Academician Vladimir Nikolajevich Suckachev (1964) as a complete science of biogeocenology or the science of ecosystems.

Man's role as an agent of global change is associated with the emergence of an increasingly interdependent world economic system (Richards, 1985). Following the second World War, expanding industrial and agricultural development

* revised version of the paper, as of June 1985 (eds.).

increasingly intensified the global economic interdependence among nations. It also began to introduce issues of ecological and geophysical interdependence between countries. This has led to some significant achievements in monitoring, in defining the issues in scientific and technical terms, in raising public awareness, and in institutional and policy action, on the national and international level. At the same time, research on the biosphere is characterized by an increasing scale and complexity of problems. Examples are the SCOPE program on the major physical cycles, the ICSU exploration of an international geosphere-biosphere program, NASA's work on global habitability, the WMO's World Climate Programme, UNESCO's Man and the Biosphere Programme, and UNEP's report on the World Environment 1972-82. Furthermore, there is the work of high-level commissions on prospects up to the year 2000, IUCN's World Conservation Strategy, the OECD's work on economic and ecological interdependence, and the WRI's new program on The Global Possible.

At the International Institute for Applied Systems Analysis (IIASA) there are many subjects under investigation, such as Acid Rain, Climate Impacts, Design of Resource and Environmental Policies, Population Aging and Changing Lifestyles which are deeply concerned with the sustainability of regional development and development of the biosphere as a whole*. Most of this investigation is characterized by a considerable uncertainty in initial empirical information, a large number of input variables which are collected in different ways (official statistics, experts' estimates, indirect observation, etc.) and have different structures (qualitative, quantitative) and most of which can hardly be forecast. Nevertheless, the preliminary analysis of the investigations on the biosphere shows that:

- the cumulative impact of industrial, agricultural, and social development on the environment has approached a level where it is dangerous for particular regions and can be dangerous for the biosphere as a whole;
- better integrative understanding by international organizations, governments, and the scientific community is now urgently required to plan effective interventions that will bring the above situation under control;
- the demand for help in creating such integrative understanding is high but it is not being met by present isolated research activities around the world;

It is therefore very important in the biosphere studies at IIASA to integrate subjects already being investigated and to focus new investigation on an interconnected, manageable number of key issues which cover the processes that affect life on our planet and the role of life itself in the evolution of our present environment.

The standard agenda of investigations, as it concerns the sustainability of development, includes at least three interrelated groups of issues: natural resources, environmental pollution and human settlement issues.

Key natural resources issues include:

1. Depletion of forests, particularly tropical forests;
2. Loss of genetic resources;
3. Loss of cropland, soil erosion, and desertification;
4. Depletion and degradation of groundwater resources;

*In early 1985 within the Environmental Policies Program at IIASA a special "Ecologically Sustainable Development of the Biosphere" project was created.

5. Energy, including fuelwood.

Key environmental pollution issues include:

1. CO_2, O_3, trace gases, etc. and climatic change;
2. Air pollution, including acid rain;
3. Water pollution, including coastal and marine waters;
4. Soil pollution;
5. Hazardous wastes.

Key human settlements issues include:

1. Land use and tenure;
2. Shelter;
3. Water supply, sanitation, and recreation;
4. Social, education, and other services;
5. Management of very rapid urban growth.

THE HIERARCHY OF PROBLEMS TO BE SOLVED AND THE SCALE OF SYSTEMS IN WHICH THEY INTERACT

The problems to be solved can be divided into groups of environmental development concerns, as suggested by Clark and Holling (1985). Nevertheless, each group of problems interacts on a different space and time scale, and is involved in different systems. Therefore, I suggest that the problems that concern each generation should be analyzed within the systems in which they interact, as follows:

- The first group comprises small-scale problems concerning *local environmental systems on the landscape level.* Such problems are: local air or water pollution, soil erosion by water or wind, sustainability of agricultural crops, forest or fish die-off due to pollution, etc. These problems mostly affect the social well being of people and involve only certain branches of the economy and some management bodies. They have proved to be largely controllable. Moreover, they can be analyzed easily with the use of quantitative models.
- The second group includes the larger-scale problems of *economic-environmental systems on the regional or national level.* The problems are: regional resources utilization, industrial and agricultural development, assessment of the impact of human activities on the environment, environmentally balanced sustainable regional development strategies. These deeply concern the socio-economic development and living conditions of human populations— ethnic groups in certain regions or nations. Despite the complexity, these problems can be solved on the basis of systems analysis by using complete and incomplete models and choosing appropriate regional development strategies.
- The third group includes large-scale problems of *macro-systems on the transregional, zonal or continental level.* The problems are: long-distance transportation of air pollutants, acid rain, long-distance water transfer (between basins), large international rivers, depletion of tropical forests, loss of genetic resources, desertification, shifts of agricultural and forest productivity onto marginal areas due to climatic changes, depletion of living marine resources, etc. These problems have shown themselves to be more

- The fourth group consists of even larger-scale problems directly concerned with the *development of the biosphere on a global scale*. Such problems are: climatic background fluctuations due to sun-earth relations, biogeochemical cycles and evolution leading to a dynamic exchange of chemical constituents among the oceans, the atmosphere and terrestrial biosphere, biogeochemical cycles of soils, global economic-industrial growth, energy consumption and emissions into the atmosphere of significant amounts of active constituents, CO_2, O_3, trace gases, etc., anthropogenic changes in the atmosphere, their climatic and economic consequences, pollution levels in the oceans and their ecological consequences, anthropogenically induced global biospheric change and transition to the noosphere. If these extremely complex problems can be managed at all, it is only with a commitment of resources, and a consistency of purpose that transcends normal cycles and boundaries of scientific research and political action. Nevertheless, there is no other alternative but to try to formulate the approach and find tools (a system of models) with which it would be possible to describe the basic properties of the dynamics of the biosphere which could serve as a point of departure in the efforts made to understand evolutionary trends and biogeocenotic processes in the world and to react to them either by adaptation or confrontation.

APPROACH TO THE SUSTAINABILITY OF THE BIOSPHERE

When seeking the sustainability of the biosphere, the problems discussed above, from our point of view and in terms of the current possibilities for IIASA, can be solved on four levels – global, zonal (continental), regional and local (Figure 1).

An Analysis of Issues on a Global Level

An analysis of the problems that arise and change course on the global scale can be made outside IIASA in highly specialized institutions in both Eastern and Western countries. The characteristics of the issues of global change can include:

- climatic background fluctuations due to sun-earth relations;
- analysis of changes occurring in different geophysical media and their impact on biosphere sustainability;
- analysis of anthropogenic changes in the atmosphere and their ecological consequences;
- analysis of pollution levels in the oceans and their ecological consequences;
- analysis of possible anthropogenic changes in climate and their impacts on the sustainable development of the biosphere; and
- modeling the naturally and anthropogenically induced changes in the biosphere and possible transitions to the noosphere.

Our understanding of global changes can be integrated on the basis of the above-mentioned analysis and simulation of general laws governing the biosphere (Moiseev et al, 1984). The revealed aggregate impact of global changes will be taken as an input for proposals of regional and local action to redevelop the biosphere.

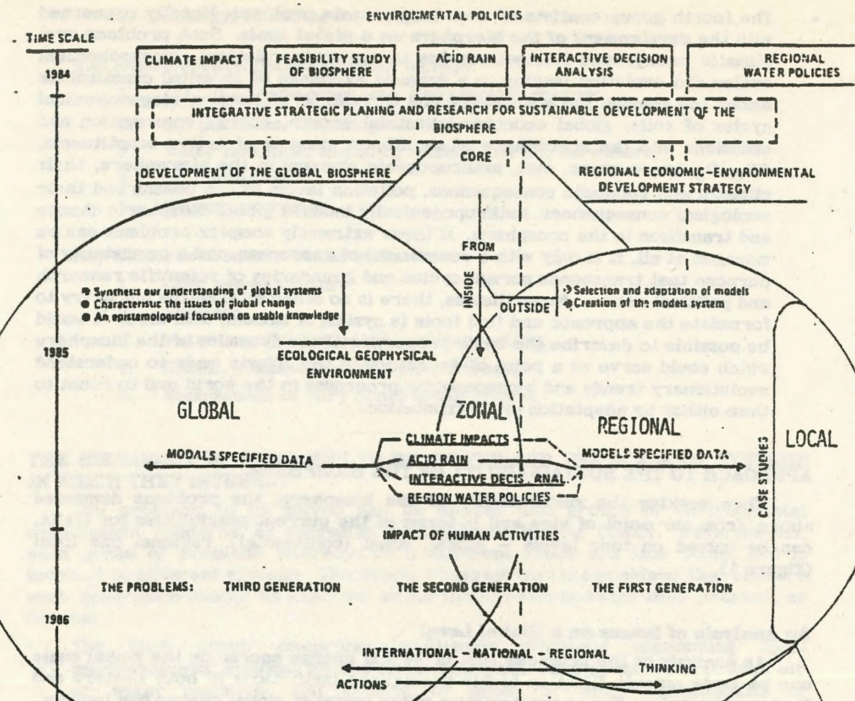

Figure 1: **Main scheme of an approach to sustainability of the biosphere.**

Analysis of Issues on the Zonal or Continental Level

Some issues which characterize environmental changes on the zonal or continental level are already being studied at IIASA (e.g., Acid Rain, Climate Impacts) and appropriate models and software are being prepared (Alcamo et al, 1984) (Parry, Carter, 1984). Other problems must be solved using a collaborative network of organizations. The environmental changes on the zonal and continental level which have an impact on the biosphere as well as on regional and local systems, can be characterized as follows:

- analysis of long-distance transportation of air pollutants and acid rain;
- analysis of water transfers from one basin to another; international rivers;
- analysis of depletion of tropical forests and desertification with attendant climatic changes;
- analysis of depletion of living marine resources.

The revealed negative impact of the factors mentioned above must be transformed to systems of a lower level in order that counteractive policies may be worked out to deal with them.

Analysis of Issues on the Regional Level

The research on Sustainable Regional Environmental Balanced Development Strategies (SREBDS) concentrates on the alternatives of regional resource utilization, industrial and agricultural development, as well as the development of other economic branches, and the assessment of the impact of human activities on the environment. The main goals of the research are the development of concepts, tools, methods, and software for regional economic and environmental development analysis and selection of better management strategies while taking into consideration the sustainability of the regional system in long-range dynamics. Such a strategy has to be worked out on a multidisciplinary basis and must involve the experience and joint efforts of economists, biologists, ecologists, mathematicians, statisticians, hydrologists, and specialists in agriculture, forestry, demography, and health. In other words, the problems to be solved belong to the sphere of applied systems analysis.

To achieve the goals mentioned above, the activities should include the preparation of strategic concepts and the core of the model system, including supporting models to describe the links between industrial and agricultural development, utilization of natural resources, changes in the environment, the influence of these changes on recipients, including man, and the adverse influences on the socioeconomic development of society. There are some integrated regional models which have already been developed (Brouwer, Hettling, Hordijk, 1983). The cycle is modeled as follows: economy changes the environment (air and water pollution, soil erosion, destruction of forest ecosystems, etc.), the changed environment influences natural resources, production means and people, and through this by the reversible link it influences the economy. The model system (Figure 2) consists of the following blocks: information data bank, economy, categorization of territories into influenced zones, ecological evaluation models, determination of changes in recipients' state, economic evaluation of damage, and environmental quality regulation.

The information is stored in a data bank from whence the primary information for modelling is drawn. The territory of the region chosen is divided into squares of 10 x 10 kms. For every square, the data regarding its geographic position, structure of the farm lands, environment and economic activity are determined.

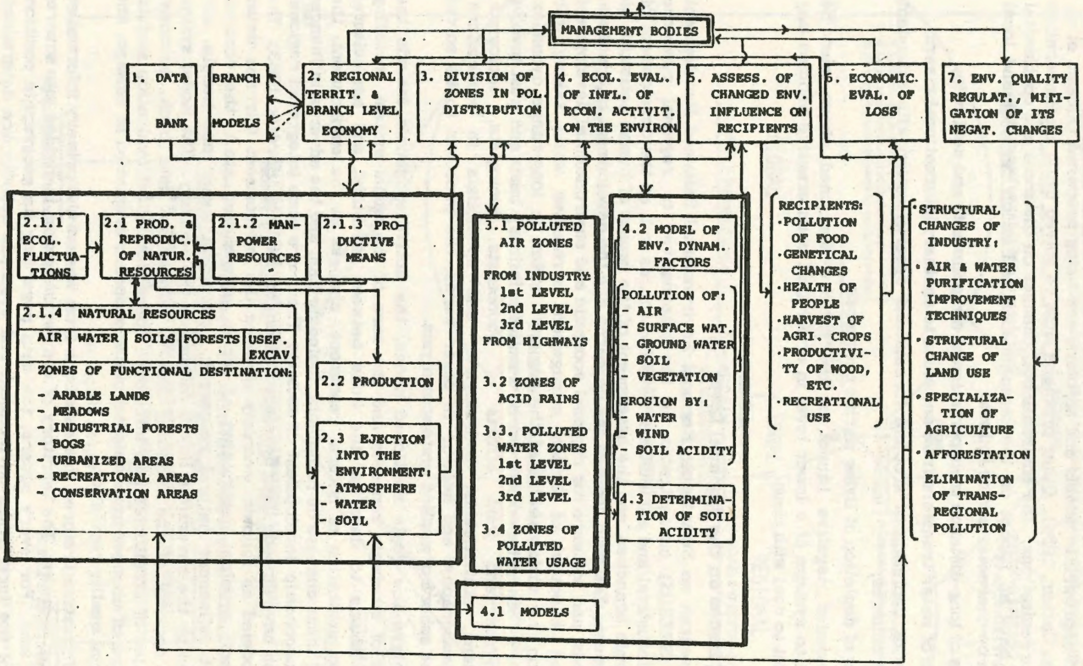

Figure 2: The scheme of a system models for the analysis of regional-economic-environmental systems.

The main items of the economic block are:

- to balance the production and utilization between branches;
- to determine the indices of economic activity for the region as a whole and separately for the main land users;
- to characterize the activity of natural resources reproduction;
- to determine the influence of economic activity on the environment; and,
- to balance the utilization of natural resources.

The following kinds of influence on the environment are included in the economic block:

- emissions of toxic substances into the atmosphere including those from industrial activities and motorized vehicles;
- water pollution; and
- soil pollution.

In the block of categorization of territories into influenced districts, the following zones are distinguished:

- air pollution by industrial emissions and motorized vehicles;
- water pollution; and
- utilization of polluted water.

The block of ecological evaluation of the influence of economic activity on the environment is determined to characterize the level of air, water, soil and vegetation pollution and the level of soil erosion. It is worked out on the basis of the following models: model for evaluation of chemical runoff and soil erosion in agricultural farmland (Knisel et al, 1980) which is affected by various management systems (CREAMS); model of environmental factor dynamics (Krutko et al, 1982); model of acid rain (Alcamo et al, 1984) and soil acidity (AR).

In the block of recipients their state is determined under the influence of environmental char._cs. The main kinds of recipients are as follows: quality of food stuffs, genetic changes in animals, state of health for humans, crop capacity, productivity of natural resources (forests, water basins), condition of recreational resources, and main productivity funds.

On the basis of the changes of recipients, the economic evaluation of damage is made, which is caused by environmental pollution and which in turn affects the national economy. By the reversible link this damage influences the economy and negatively affects its future development.

The block of environmental quality regulation deals with the simulation of means to improve environmental quality. The main means are as follows: changes in the structure of the industry; changes in the structure of land utilization, air and water purification; and introduction of technologies with less waste materials. Besides, the negative influence on some recipients can be decreased by means of physical planning and functional redistribution of the regional territory, for example, by relocating food crops, recreational areas, settlements, etc., away from strongly polluted zones (Kairiukstis, 1982).

The model system provides the management bodies (planning) of the zone or the region with the optimal scenario of natural resources utilization and environment formation of a region, and also with various alternatives. This scenario forwards the decisions taken to the management bodies (ministries, departments or complexes). By means of their economic systems the latter influence the natural resources and environment on the specific territory. The annual or five-year results of such activity together with the volume of industrial production are received through information channels and comprised in the models system. This makes it possible to correct the annual and five-year scenarios of natural resources utilization and environment formation.

Analysis of Issues on the Local Level

The activities on SREBDS are supported by detailed local studies on the landscape level. As mentioned above, regional economic-environmental models evaluate the ecological consequences of economic development and facilitate a determination of landscape redistribution according to function; (e.g., exploitable forests, agricultural, recreational, water-soil protected zones, urbanized territories, etc.). For the main branches experiencing the most dangerous environmental impacts from the other economic branches of the region, the following tasks are to be solved:

- agricultural problems regarding sustainability, pollution impact, and agricultural practices that threaten other objectives in land use: What are their causes, which counteractive policies are possible, how can their effectiveness be continuously monitored?
- forest die-off due to pollutants: What are its causes, which counteractive policies are available, how can their effectiveness be continuously monitored?
- water management problems regarding sustainability of use, and pollution impacts that threaten other objectives in land use: What are their causes, which counteractive policies are possible, how can their effectiveness be continuously monitored?
- recreational areas and genetic resources, in terms of sustainability of use, pollution impacts: Which counteractive policies are possible, how can their effectiveness be continuously monitored?
- urbanized territories, in terms of pollution impacts that threaten human health and other objectives in land use: What are their causes, which counteractive policies are possible, how can their effectiveness be continuously monitored?

For the analysis of the above-mentioned separate branches of the regional economy adequate models should be used. They should include a simplified regional interbranch economic development model and a more detailed territorial model. For example, in the detailed model of the forest sector, as a branch of the economy the forest resources are analyzed with demand; when there is a shortage of forests to cover demand measures must be taken to meet this demand. When there is no opportunity to satisfy the requirements, the structure of production in the interbranch model is altered. The following submodels are used in the forest sector model:

1. the submodel of forest biocenose (for the analysis of the sustainability of the forest system and the forest front of influence upon the environment);
2. the submodel for analyzing the specialized sectors of forest growth: industrial, agroprotective, recreational etc. (Kairiukstis, 1981).
3. the submodel for analyzing the renewal of forest resources;
4. the submodel for analyzing forest utilization (Deltuvas, 1982);
5. the submodel for the analysis of demand for forest products; and,
6. the wood processing submodel.

In addition, forest die-off is currently being analyzed at IIASA with the help of a model (POLLAPSE) on pollution and forest collapse (Grossmann, 1984).

For the above-mentioned specific branches of the regional economy, the anticipated results (when these problems are solved) will be as follows:

- an indication as to which counteractive policies for agricultural crops, forest die-off, water quality, recreational areas, and urbanized territories are best in a specific area, as far as concerns sustainability of the separate branches and sustainability of regional development;
- information on which counteractive policies are effective and which will lead to financial loss;
- a new tool for much better management of agricultural and forest land use, water basins, recreational areas, urbanized territories, other resources, etc.
- help to direct and synthesize research on the above-mentioned problems concerning the sustainability of local and regional systems development;
- assistance in establishing a data bank and an environmental monitoring system on the regional level.

GENERAL APPROACH TO THE METHODOLOGY

The complexity of the above-mentioned problems and systems in which they commonly interact constitutes the subject of investigation on sustainable regional development as well as sustainable development of the biosphere as a whole.

The systems comprising the global biosphere differ greatly in space, time and complexity. They are open, and essentially interact with the ecological and socioeconomic environment. The hierarchical nature of systems is very complicated, with cooperation and conflicts between different subsystems. Possibilities to control the subjects under investigation, on large-scale systems in particular, are very limited. The higher the level of the hierarchy, the fewer the possibilities to experiment with the subsystem. Therefore, it is necessary to use an integrative approach to elaborate a strategy of systems management (control) in a united, hierarchical structure during the process of receiving and collecting data.

The systems under consideration have many facets, each of which can most adequately be addressed with a different set of tools. That is the reason why a "multifaceted" hierarchical approach can be used. At IIASA this approach has been suggested and widely used by W.D. Grossmann (1984) for small-scale local systems analysis, in contrast to large-scale models which were strongly criticized previously (Lee, 1973). We developed the former approach for the analysis of problems and systems related to the sustainability of the biosphere. Complementarily, the main scheme was extended to four levels of problems and factors to be analyzed, methods to be adopted, as well as systems to be covered. Using this approach, we intend to investigate interrelated local, regional, zonal and global systems, according to the strength of the impact felt on each other. The zonal system among them is the turning point. It is expressed in a maximum of outside environmental cross-action and a minimum of management cross-action (Figure 3). For most of the problems discussed above this approach permitted the use of dynamic models in combination with a geographical information system and the generation of a time series of highly precise geographic maps.

Nevertheless, in many cases (particularly in analyzing complex regional socio-economic and environmental systems) it is not realistic to use formal methods and mathematical models. Such models are usually based on the assumption that the models describe these systems exactly and sufficiently. However, it is not

THE HIERARCHY OF BIOSPHERE SYSTEMS: PROBLEMS TO BE SOLVED AND METHODS TO BE USED

PROBLEMS	THE HIERARCHY OF SYSTEMS	CHARACTERISTICS AND DOMINANT FACTORS	METHODS
Understand geosphere–biosphere interactions, environmental fluctuations and biogeochemical cycles. Reveal the factors that seriously constrain sustainability and habitability of all lower systems.	GLOBAL	Absence of permanent structure. Lack of data. Fluctuations of the universe.	Theoretical hypotheses importance of empirical data.
Preserve sustainability. Decide structure of all lower systems. Decrease risks. Explore, recognize and exploit opportunities. Prepare system so that it can cope better with "whatever may happen".	ZONAL	Uncertainties in structure and data. High influence of the outside environment. Climatic. No decision systems.	R&D. Evolution, succession. Biocybernetic approach. Principle of viability and resilience. Importance of subjectivity. Scenarios.
Within the defined structure: Preserve the structure, keep the system going. Problem solving such that interdependencies and feedback reactions are taken into account.	REGIONAL (National)	Uncertainty in data and to a lesser degree in structure. Considerable influence of the outside environment. Sustainability of human population. Few decision systems. Many interdependencies.	Strategic management. Holistic approaches. Importance of experience. Considerations must include reactions. Aggregated dynamic models. Preserving of balance.
Prepare counter policies which are best in a specific area. Solve the many routine jobs quickly and precisely. Help sustainability of all higher systems.	LOCAL	Preciseness in data and structure. Low influence of the outside environment. Social well being. Many not interacting decision systems.	Optimization both heuristic and exact. Adaptive control. Real time process control.

INCREASE OF OUTSIDE ENVIRONMENTAL CROSSACTION

INCREASE OF MANAGEMENT CROSSACTION

Figure 3: The hierarchy of biosphere systems: problems to be solved and methods to be used.

always possible to build mathematical models with the required properties and the user must spend a lot of effort in verifying the practical applicability of the solutions obtained in husbandry schemes. For these cases more practical environmental impact assessments and socio-economic methods, developed by R.E. Munn (1979) as well as incomplete models, can be used.

Using both approaches, an analysis of the main constituents of the global biosphere and verification of the theoretical hypothesis about possible changes will illustrate what the most serious constraints are for the future sustainable development of lower scale, i.e., zonal, regional and local systems. On the other hand, analysis of local and highly aggregated regional systems will reveal the factors which have negative or positive impacts on the sustainability of the systems of a higher level.

Let us consider an approach to environmentally balanced regional development using the example of the Lithuanian SSR.

THE APPROACH TO SUSTAINABLE REGIONAL DEVELOPMENT IN THE LITHUANIAN SSR

The Lithuanian SSR is one of 15 republics of the Soviet Union with 3.5 million inhabitants living in an area of 6.5 million hectares, i.e., the average population density is 53 km^2. In the last few decades industry as well as agriculture has been highly developed. The average yearly crop production of cereals for the last five years was between 2.5 - 3.0 tons/ha., for meat 0.13 tons/ha., and dairy products 3.6 tons/animal.

The Lithuanian Republic is a highly cultivated part of the USSR. Land reclamation by closed drainage was carried out on 60% of the area of collective farms. Extensive road networks (0.5 km per km^2) were established. Two large (approx. 400-500,000 inhabitants) and 12 small towns (about 100,000 inhabitants) were developed.

In Lithuania, traditionally developed complex silviculture is practiced (the average area of forest preserve is 3,000 ha., forest husbandry - 30,000 ha., with one highly educated specialist each per 1,000 ha.). The forests constitute 1.8 million ha. (27.6%) of the total land surface. This means that approximately 75% of the demand for wood is met. There is a well organized nature conservation service in Lithuania. In addition, Lithuania is well-known for sport hunting and tourism.

Despite great efforts by the State for nature conservation, natural resource utilization and technogenic use of the land have a negative impact on the environment.

Negative Consequences of Human Activities During Technogenic Reconstruction of the Landscape.

Industrial growth, increased motorization, land reclamation, and intense agricultural activities have destroyed the natural landscape. Extensive land use has caused deterioration of the soil and water. Investigations show that land reclamation and cultivation, as well as the intensive use of pesticides sharply diminish the variety of soil fauna (Atlavinyte, 1978 and Eitmanaviciute, 1982). Hydrophilic species of worms disappear, and other species have diminished fivefold. The variety of ornithofauna also suffers greatly. Insectivorous birds (e.g, thrushes and finches) have been greatly decimated because they use small field bushes for reproduction rather than forests. The disappearance of forests and bushes inside arable lands reveals the negative consequence of surface water runoff. The arable lands in the Aukstaiciu and Zemaiciu uplands especially suffer from erosion. Using the CREAMS model (which was adapted at IIASA), model calculations of runoff, amount of water evaporation and deep percolation were carried out for the hilly Utena region with regard to soil types, variety of forms of landscape. Model calculations show that in 1972-1980 runoff and deep percolation correspond to about one-third or 204 mm precipitation per annum. This determines soil erosion processes which in conformity with the degree of steepness, mechanical particles specification and crops grown there can form 100 tons/ha. of drifts in the nine-year period (Kairiukstis and Golubev, 1982). The aforementioned erosion processes do not happen on slopes with belts of forest cover.

The increase of the plain field area causes wind erosion and depletion of soil fertility. It is a special characteristic of the light soils. For example, in Lithuania, such areas cover about 190,000 ha. The investigations carried out (Pauliukevicius, 1982) show that the annual runoff washes away from every ha. of arable land 50-250 kg of chemicals dissolved in the water. Every year the Nemunas river carries away about 0.5 million tons of drifts into the Kursiu Marios Lagoon. It is partially for this reason, as well as due to a scarcity of sewage treatment plants in large towns and industrial centres, that water pollution has not been sufficiently reduced.

The west point winds being predominant, the industrial pollutants from Western Europe, England and Scandinavia are transported to Lithuania. Acid rain, oxidized deposits, harmful gases, and carcinogenic substances reach the Lithuanian territory in 1-2 days. They cause acidification of soils, water pollution and deterioration of the forest ecosystems. Against the background of the whole atmospheric pollution, the zones of high local pollution around industrial centres like Jonava, Mazeikiai and Keadainiai prove to be dangerous to the forest vegetation, which in its turn is the index of the conditions for human existence. Under the impact of emission processes, litter, soil and water reservoirs accumulate large quantities of dust, fluorine, nitrates, ammonia, chlorite sulphates, phosphates, potassium and other harmful compounds (Vaicys, 1982). Within a radius of 3-5 km from the source of pollution, as shown in the data of the Lithuanian Institute of Forestry, coniferous forests wither. In the places more remote from the pollution sources under the influence of emissions, changes of morphological, physiological, chemical and species composition of vegetation take place. In these areas, the increment of coniferous forests is 30-50% and deciduousness 20-30% less in comparison with non- affected areas. The white fungus disease which affects needles, leaves, branches and trunks is widely prevalent. Cancer of larch and pine-tree sprouts is especially dangerous.

Increased environmental pollution increases mutagenesis. It has become a characteristic of modern civilization. Among some four million pollutants circulating in the biosphere, in the Baltic region alone we found about 300 pollutants bearing mutagenic effects. They expose the genetic stability of species to great danger. Geneticians of the Vilnius State University (Lekevicius, 1980) determined that in the 3-8 km radius of the Mazeikiai oil-refining plant the frequency of point mutations in field vole (Microtus arvalis) increases 10 times. The same phenomena are observed on non-irrigated meadows with a high usage of mineral fertilizers. It is notable that the field vole is an example of chemical pollutants on animal species and possible impacts on man. In many countries there is now sufficient data to prove that human beings who come in close contact with chemicals such as mercury, and with plastics such as polyvinylchloride and who live in a polluted environment, suffer from chromosomal aberrations causing retarded or handicapped offspring.

At the same time, the environment transformation process was and still is an inevitable precondition and consequence of the further development of society. It gives an opportunity to create productive agriculture, to develop industry and transportation networks, to create a good economic basis for higher material, cultural and social population welfare.

The problem faced is how to deal with these conflicts, and in particular:

- How to avoid situations in which certain economic branches and planning organizations disregard local environmental conditions and only solve problems of their own interest?
- How to avoid the creation of bordering territories with contradictory functional purposes, which increase the self-decay of economical branches, prevents the stable economic development of the whole region and has an adverse affect on the environment?
- How to coordinate the interests of the separate economic branches and concerted development of the whole region?

The traditional environment protection agencies are unable to deal with these shortcomings. It is necessary to rationalize natural resources utilization of the region, taking into account redeveloping measures for the sustainability of regional development and the creation of better environmental conditions. While undertaking regional physical planning of the territory, one must not only consider the needs of each branch of the economy, but also the long-term perspectives of socio-economic and environmental development of regional human populations. In other words, sound environmental principles, maintaining the balance between ecological systems and the socioeconomic development in a chain of natural resources utilization and reproduction to ensure long-term economic development.

In order to realize the above, we urgently need a reliable set of tools for economic-environmental situation analysis and scientific experts system for top-level decisionmakers. Only in this case do possibilities really appear to select and implement Sustainable Regional Environmentally Balanced Development Strategies (SREBDS) for each region.

Environment Formation as a Part of Natural Resources Utilization and Socio-Economic Development of the Region.

In the last few years, the universal process of man's intrusion into nature and the spontaneous destruction of ecological systems in Lithuania was met by the rational use and reproduction of natural resources, in combination with the purposeful formation of an optimal environment. To support such an alternative, better interaction between scientific experts and decisionmakers was achieved (Kairiukstis, 1985). The efforts of scientists at the Academy of Sciences, branch institutes and higher schools were united under the program, "Man and the Biosphere". The General Model System (GMS) was created, which made it possible to optimize the development and specialization of the main resource utilizing branches of the national economy on a territorial basis (Kairiukstis, 1982).

Keeping to the tasks of sustainable development of the national economy, efforts have been already made for natural medium optimization (quantity of main landscapes determining its state), to determine the functional destination of the landscapes. An evaluation of separate territories was carried out. For example, the Department of Geography of the Academy of Sciences revealed the anthropoclimatic resources of Lithuania (Figure 4). It appeared that regions favorable from the point of view of the anthropoclimate such as the continental

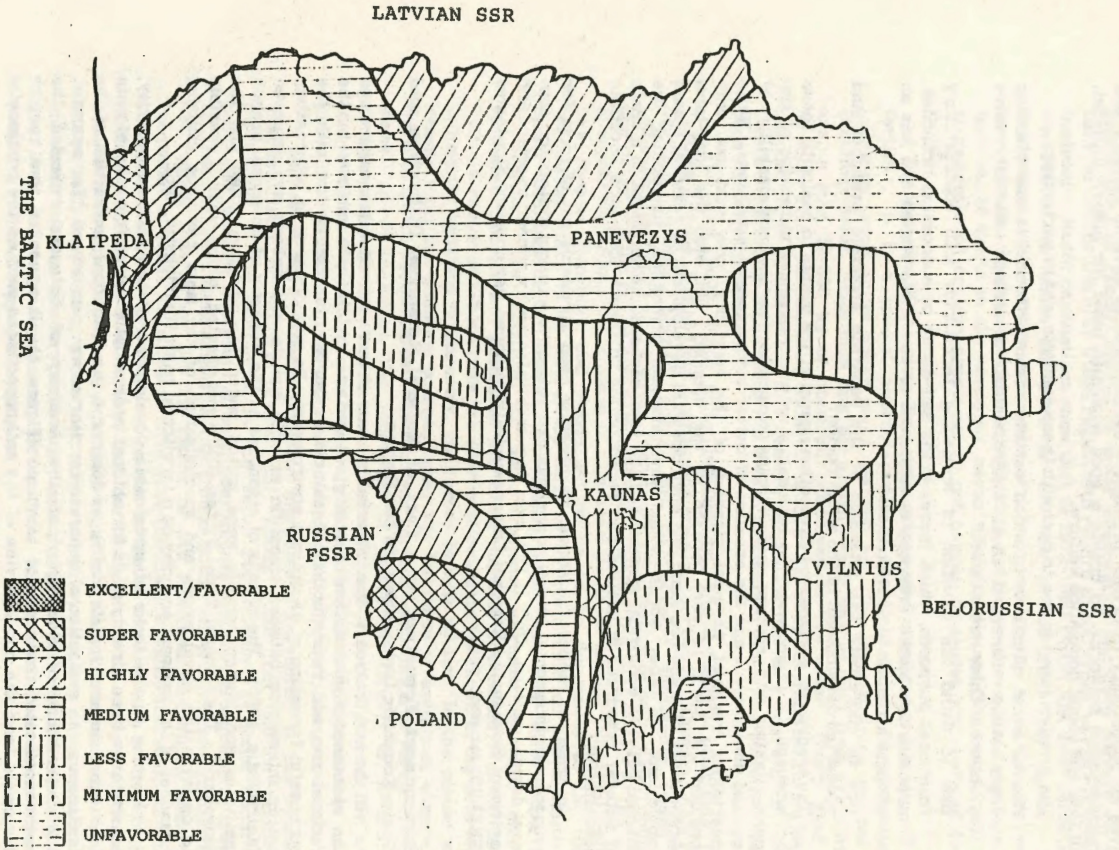

Figure 4: Anthropoclimatic territories of the Lithuanian SSR.

Source: Department of Geography of the Academy of Sciences of the Lithuanian SSR.

sea-shore of the Kursiu Marios lagoon, west and middle Suvalkija, the central part of North Lithuania havė hardly been used for the development of recreation and health resorts. The Institutes of Construction and Architecture of the Lithuanian SSR together with the Vilnius State University prepared a distribution scheme of recreational regions (Figure 5). While undertaking such an optimization one has to take into account the local anthropoclimatic peculiarities, air and water pollution, so that the objects destined for recreation are notable for the healthy climate.

The joint efforts of scientific research institutes and scientists of higher schools distinguished those zones being protected for special purposes. They concentrate the natural fund of flora and fauna, landscape variety as well as historical and ethnographical objects. These zones include reservations of grassy and forest vegetation genofund and of separate animal species. Only the concentration of these territories and the legalization of their status can protect them from ever growing industrial penetration and from negative consequences of agriculture and industry. Moreover, part of the protected territories should at least satisfy the utilitary needs of recreation (berry plantations, fields of intensive recreational sport hunting, etc.).

The Department of Geography of the Academy of Sciences of the Lithuanian SSR evaluated the degree of erosion and denudation in Lithuania (Figure 6). Together with the Lithuanian Research Institute of Forestry and the Institute of Botany, those regions were determined which are lacking in forests (Figure 7). Means for afforestation were prepared to protect arable lands and waters (Kairiukstis et al., 1980). The investigations of the Institute of Physics of the Academy of Sciences of the Lithuanian SSR have made it possible to discuss in broad terms the background atmospheric pollution, fall-out of sulphur, fluorine, nitrogen and other compounds, to make model calculations and to reveal the influence of large industrial objects and towns on the neighboring regions. Data are stored on the intensive use of fertilizers and pesticides and their influence on ecosystems links in separate regions. All this is the basis for the monitoring and also the prognosis of inevitable change of forests and arable lands. This also serves as a basis to obtain a sustainable environmentally balanced regional development.

The state of the natural ecosystems depends on climatic background situations which have an impact on all ecosystems. Dendrochronological investigations carried out in the Lithuanian Research Institute of Forestry and in the Institute of Botany reveal the long-term rhythm of the forests' growth. Approximately every 11 and 22 years the maximum and minimum in the growth of trees repeats itself. The long-term (about 50 years) fluctuations of favorable and unfavorable ecological conditions are determined (Figure 8). For example, favourable conditions in 1904, 1915, 1925, 1945, 1957 and 1968, in areas with high humidity the growth of trees was 20-30% above average. Vice versa, in 1908, 1930, 1952, 1963 and 1978 the growth of trees was 20-30% below average. The fluctuations mentioned are in good correlation with crop capacity of agricultural lands. For example, the yield of cereals in that year is higher in which the marsh vegetation increment increases. It is thus possible to forecast forest growth and the growth of other vegetation for at least the next decade. Fluctuations of climatic conditions also bear an influence on the general economic situation in the region. This phenomena can perhaps be explained through the "fluctuation factor of entrepreneurship" developed by W. Krelle (1983). It must be taken into account while modelling the ecological situation and socio-economic development.

The successful use of the ecological situation, forecast for the coming decade, and its adjustment to man's economic activity, make it possible to enlarge the ecosystems suitability and to grow more stable yields. For example, in Lithuania,

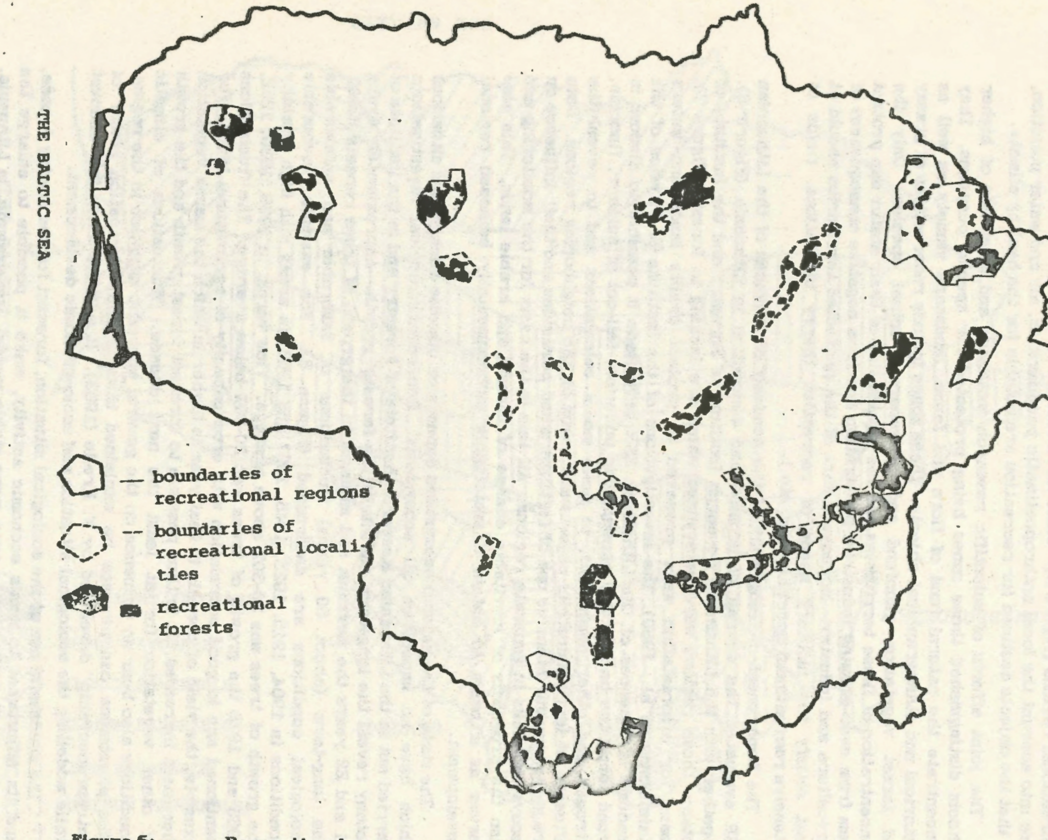

Figure 5: **Recreational resources of the Lithuanian SSR.**

Source **Scientific Research Institute of Building and Agriculture and the Vilnius State University, Lithuanian SSR.**

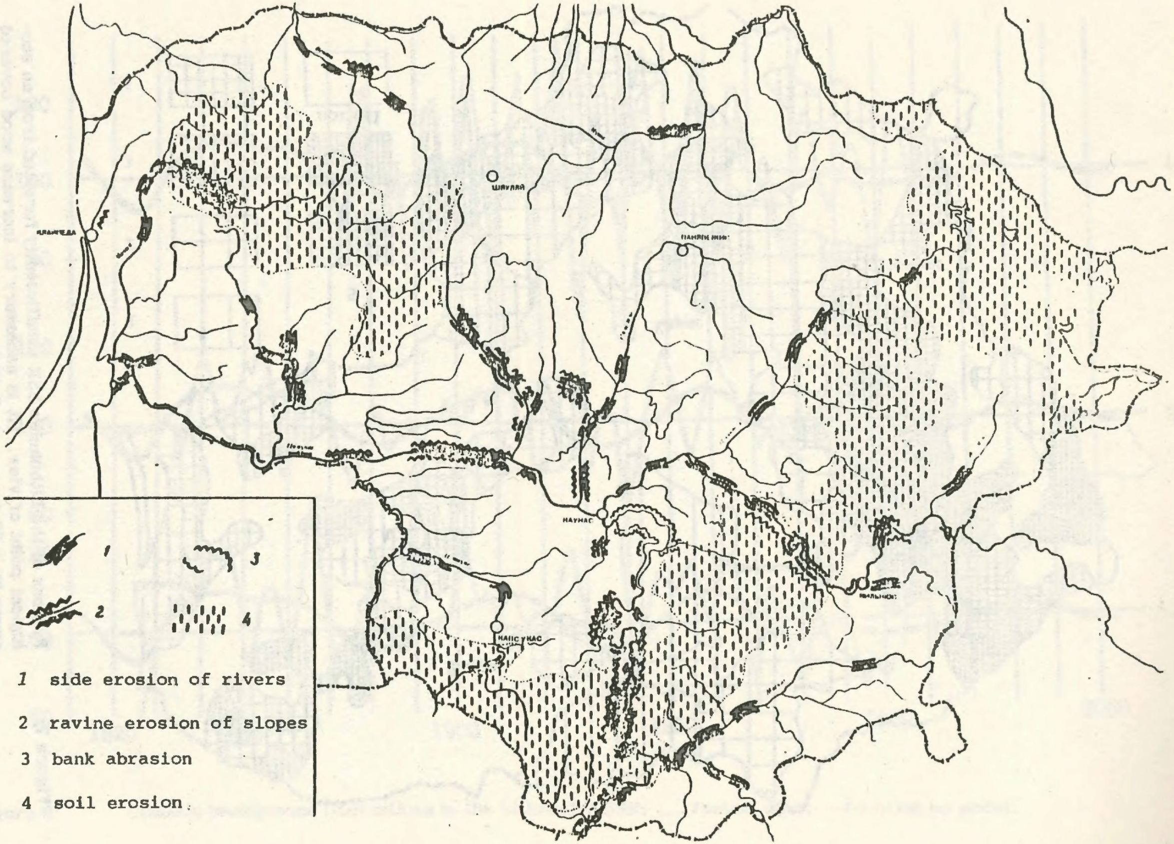

Figure 6: **Cartosheme of the distribution of erosion and denudation processes on the territory of the Lithuanian SSR.**

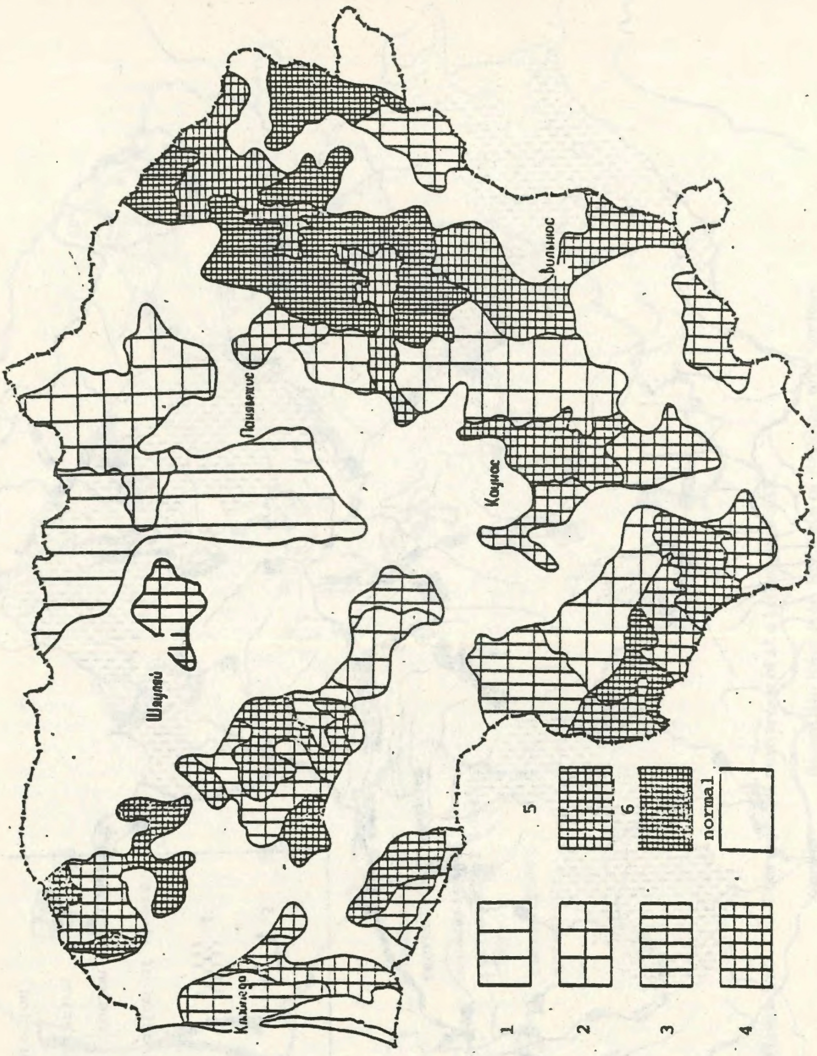

Figure 7: Regions of the Lithuanian SSR insufficiently forested from an ecological point of view. (It is necessary to increase wood covered areas by 1-3% in area 1, 3-5% in area 2, 5-8% in area 3, 8-10% in area 4, 10-15% in area 5 and over 15% in area 6.)

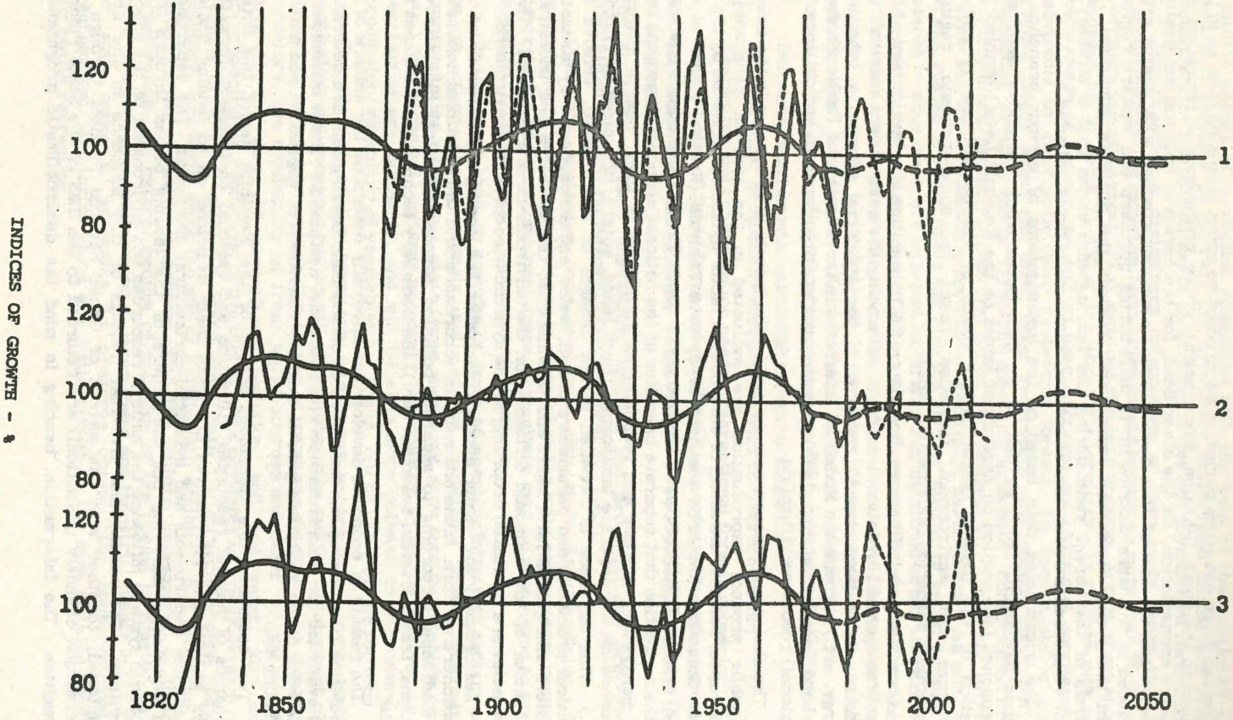

Figure 8: **Climatic background fluctuations in the Lithuanian SSR; —— factual data; -- forecast by model.**

during the drier and warm period, more productive crops should be sown as in the regions to the south (Ukraine, Byelorussia), giving preference to irrigation and moisture accumulation. On the other hand, for the period of cold and wet weather forecast for the end of this decade, one should be provided with sowing grain produced in the same district or in neighboring northern and western regions, widen the grassy fields and repair and maintain the drainage equipment. An analysis of the cereal yield during the last decades shows that a strategy of adaptive agriculture such as that outlined above might prove valuable.

The accumulated data based on the investigations of various branches of science (Gvishiani, 1977) as well as on data banks using the above mentioned approaches (see section on Analysis of Issues on the Regional Level) enabled the creation of the General Model System (GMS) of the optimal use of natural resources and environment formation based on socio-economic regional development scenarios (Kairiukstis, 1982).

Economic models (Buracas, Rajackas, 1982) simulating the development of the main branches of the national economy influencing the environment (agriculture, forestry, water management) and also of the industrial complexes (chemical, energy, etc.) through the Models of Interbranch Reproduction of Public Products and Land Use (Rutkauskas, 1978) give an opportunity to forecast and optimize the (regional) resources utilization.

The ecological consequences caused by the industrial processes in the course of public product reproduction are evaluated in the typified geographical landscapes. Besides, the model of environment factor dynamics suggested by the All Union Scientific Research Institute of Systems Analysis (Krutko, Pegov et al., 1982) and the CREAMS (Knisel, 1980) are also used. The adapted models are based on the suggestion that separate branches of the national economy, depending upon the management systems and technologies dominating in them, bear a different influence on the separate landscapes (farm lands, waters, urbanized territories, etc.). This influence is revealed in the changes of hydrological, erosive and chemical processes and parameters in soil, water and atmosphere. By simulating possible changes of farm lands and technologies, the desirable and undesirable tendencies of the economic influence on the environment are revealed. Those tendencies are evaluated according to the dynamic concept of the environment.

Analogously, the model adopted evaluates the ecological influence of the atmosphere on flora, fauna and man. In accordance with the functional destination of landscapes according to separate pollution sources (chemical plants, power stations, transportation networks, etc.), the necessary technological changes are made.

The results of economic development integrally determine the welfare of the population. The ecological consequences of economic development are determined and evaluated for each landscape with functional destination. These consequences determine productivity and genetic stability conditions of vegetation and animals, including man.

The decisionmaking (planning) bodies of the Republic select the optimal scenarios of natural resources utilization and regional environment formation. They analyze the alternatives and pass their decisions on to leading bodies—ministries, departments and industrial-agricultural complexes. The departments and complexes, carrying out the orders of the leading bodies through their economic systems influence the natural resources and environment on the specific territory. The annual and five-year results of this influence in the areas monitored, together with the amount of Gross National Product through the information channels (statistical) are returned to the GMS of the State Planning Committee. The information, bearing in mind the dendroclimatic prognoses of natural change of ecological conditions with the help of the mentioned models, makes it possible to correct the previously established annual and five-year scenarios for the optimal use of natural resources and environment formation.

For example, a preliminary optimization of farm lands shows that in the Lithuanian SSR the agrarian territories should occupy no more than 55-57% of the territory including about 17% of meadows stable to erosion. Forest areas should be widened up to about 31-33% of the country's territory. In regions with a small percentage of forests, as well as near highways and industrial complexes, it is advisable to grow antierosion protective forests. To keep a stable moisture regime, boggy areas and inner water reservoirs must occupy about 5-6%. The remaining territory (about 7%) will be inevitably urbanized. Conservation areas of various kinds, national and natural parks, recreational territories and territories under sanitary protection according to specificity, should occupy the most wooded areas, places of sandy dunes and with the greater number of lakes. Because these places in some cases are adjacent to farming and industrial-urban territories, the necessity for interstitial or buffer territories are needed. A special management of these territories is then determined. Therefore, the farming or forestry activity on specific territories are determined not only by the soil and climatic peculiarities, but also by the functional landscape destination. For example, forestry, in accordance with the dominating landscape destination specializes in:

1. Industrial wood growth - exploitable forests subsector;
2. Soil and water protection - agroprotectional forests subsector;
3. Recreation and rehabilitation needs - recreational forests subsector;
4. Conservation of flora, fauna and genofund - conservation forests subsector;
5. For scientific and hunting fauna needs - recreational hunting forests subsector.

For all these forestry subsectors, modules and programs are prepared for specialized economy management (Kairiukstis et al., 1983).

Optimizing landscape farm land will also show its specificity. Highly specialized industrial agriculture is retained in the main agricultural regions. In recreational and conservational areas, agriculture must be specialized to grow the so-called "bioproduction", unpolluted by chemicals.

On the other hand, in suburbs or lands adjacent to industrial centers as well as in other areas strongly polluted by industrial waste materials and transportation networking, state farms should not grow food (vegetables, cereals, etc.) but "technical" cultures necessary for industry, as well as flowers. As these territories are presently, and will be even more polluted in the future, their production, especially of vegetables and fruits, will be less suitable for food.

The division of the territory into zones according to their functional destination and economic regime will affect industries and the development of some towns. As we know, previously the growth of towns was determined by demographic structure, the availability of fresh water sources and other natural resources. Data on the state of atmospheric pollution, soil and water, also on the anthropoclimatic resources, prove that it is not advisable to evenly develop all the regions or a small state. It would complicate the struggle against industrial pollution, and would make the use of purification equipment and industrial waste materials more costly. In general, with the uniform development of industrial urbanization, the natural medium of pollution of the region is greater. All the more so as the even distribution of large towns and industrial plants in the region or state make it impossible to preserve non-polluted conservational and recreational territories which are distinguished by the most suitable conditions for health recreation.

In conclusion, it should be stressed that in the future, when the nature protection scheme of the Republic has been completed, the territory distribution has been carried out according to its functional destination, the economic activity in nature has been specified, a reasonable combination of branch and territory management fulfilled, only then will it be possible to escape the detrimental consequences in nature caused by branch management. It will promote a more rational use of natural resources, a stable development of agriculture, specialized water and forest husbandry with less expense in funds and labour force, to achieve a higher production; it will also help to lessen food cultivation pollution by industrial waste materials, to widen the urbanized areas and at the same time to retain clean recreational zones to ensure genofund and conservation zones for many years. Mitigation of the negative impact of human activities on the environment at a regional level will help to achieve a more sustainable development of systems of a higher level, including the biosphere as a whole.

CONCLUSIONS

The cumulative impact of industrial, agricultural and social development on the environment has approached a level where it is dangerous for particular regions and can be dangerous to the biosphere as a whole. At the same time, the environmental transformation process is still an inevitable precondition and consequence of the development of the material, cultural and social welfare of mankind.

In the process of general penetration of man into nature and the spontaneous destruction of ecological systems an alternative is made—the rational use of natural resources and reproduction united with an optimal and purposeful environmental formation. To realize this task, system approaches to large-scale global, zonal, regional and local problems to be solved were developed. Using the multi-faceted approach to resources and environment management, the situation in Lithuania was analyzed (regional level). Enlisting the rich heritage of scientific research and in collaboration with IIASA, the General Models System (GMS) was prepared on an interbranch basis. GMS should be of great use for the management and regional development planning agencies of the Republic. It consists of three blocks of models: economic models, models for the ecological evaluation of a medium, and models for the evaluation of social consequences of economic development and ecological changes. The cycle is modeled as follows: economy changes the environment (air and water pollution, destruction of natural ecosystems, etc.); the altered environment influences the biota including man, and through this by inverse link it influences the economic and social development of society (micropopulation).

According to the GMS, the territory distribution optimization of the Republic conforming with the main landscapes was carried out beforehand, the specificity of the main landscapes' functional destination was revealed, the buffer zones between the landscapes of contradictory destination was pointed out, and tasks for the specificity of economical management (agricultural, forestry, etc.) were defined.

The use of the above-mentioned systems approach and the multi-faceted analysis of the rational use of natural resources and environment formation, when completed, will help to avoid detrimental actions in nature, to achieve the sustainability of regional systems and mitigate biospheric collisions.

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DISCUSSIONS

Paper by L. Kairiukštis

Discussion participants: A. Straszak, J. Owsiński, K. Polenske, R. Espejo, L. Kairiukštis.

Most of the questions were asked in order to obtain extra explanation as to the notions and structures used throughout the paper. These questions, related e.g. to the place of regions in the systemic structure outlined or to implementation and application of the comprehensive view presented, are satisfactorily answered in the text at hand.

Apart from that a question was asked in what way it is intended to influence policy makers - i.e. national and local governments - in order to increase the understanding of problems at hand. The answer pointed out that the only practicable means was to provide information to these who are resposible for activities influencing the biosphere, to make them aware of reasonable constraints connected with such activities.

Paper by S. Ikeda

Discussion participants: A. Kochetkov, K. Polenske, L. Kairiukstis, S. Ikeda.

Several explanations were asked for. First: the empirical basis for the input/output model - at the national level according to the international standard breakdown, i.e. approx. 200 categories, and at the regional level more aggregate tables synthesized from otherwise available information. Some activities, like fish processing industry, were left out because of lock of adequate data. Some other ones, like private sector investments, are treated through aggregates.

As to the formal side of the model development, it is provided by the three-year contract from the Ministry of Science and Education, and the model developers hope for an extension of another three year period in order to complete the work.

Paper by P. Holnicki and A. Żochowski

Discussion participants: T. Vasko, K.P. Moeller, D. Boekemenn, A. Straszak, R. Bolton, P. Holnicki.

In response to questions one of the co-authors explained that: the control variable of the model was production level of a given factory, the sources located outside of the area considered had not been accounted for because of lack of appropriate data, and: location and time variables had not been used as control ones in the model, although this could be done within the same model structure. Many of the model features resulted directly from specifications made when accepting the contract.

On the policy side, in view of the preliminary nature of the model no experience could as of then be gained on the enterprises' reactions. In fact, the model builders were responsible solely for model development.

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