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Global security and ecology

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RESUMEN
Se presentan algunas consideraciones nuevas sobre seguridad global y en particular sobre su componente ecológica. Estas consideraciones se basan en una reciente resolución del Instituto Internacional de Análisis Aplicado de Sistemas.

PALABRAS CLAVE: Ecología, seguridad global, problemas del medio ambiente.

ABSTRACT
Some new considerations on global security, with special reference to environmental problems, are discussed. These considerations are based on a recent position paper by the International Institute for Applied Systems Analysis.

KEY WORDS: Ecology, global security, environmental problems.

To stress universal human values, on the strength of the increasing interdependence of states and the urgent ecological problems; to improve the political situation in the world, and to weaken the nuclear threat: this all requires a deeper insight into the problem of global security. No doubt, this problem focuses now onto global ecology and, in particular, on its socio-economic aspects. Among the important manifestations of this trend is the discussion in the International Institute for Applied Systems Analysis (IIASA), of a 3-year (1989-92) Project on Global Security and Risk Management (GSRM), in which a substantiation of priorities plays the key role.

A major objective of the GSRM is the analysis of the needs and prospects of new approaches to global security and risk management. Such a task involves (Strong, 1989):

1. Examining the principal risks which may affect the survival of the world community, including those of a military, ecological, economic, demographic, political, humanitarian and social nature, by identifying the thresholds or "boundary conditions" in each of these areas, which when exceeded will lead to a global threat to human life and civilization. Of principal importance is an interactive approach to the solution of these problems, identifying priorities on this basis.

2. Developing approaches towards an early identification and evaluation of each of the risk components, as well as of the role of their interaction.

3. Identifying ways in which existing agreements, programmes and institutions can be improved and new measures initiated to strengthen international cooperation in defining and monitoring risks and controlling the human activities which give rise to risk situations.

4. Considering ways in which multilateral institutions and, in particular, the United Nations system can play a more important and efficient role in ensuring global security in accordance with the principles of the Charter of the United Nations.

5. Developing practical proposals to implement actions tending to ensure global security.

6. Making the results and recommendations available to the United Nations, governments and peoples of the world.

7. Serving, in an advisory capacity, the main executive offices of the United Nations, including the Secretariat and the Secretary-General, as required.

One of the priority issues is a preparation of a series of position papers on subjects such as (i) redefining the notion of security; (ii) managing the global environmental quality; (iii) defining the conditions for sustainable socio-economic development; (iv) the Third World: internal and international conflicts. Books and film series designed for presentation on television and video will be of a great educational value. One immediate action will be the preparation of the Second United Nations Conference on Environment and Development, to be held in 1992 in Stockholm.

The Meeting on Global Security and Risk Management held at the IIASA (Luxemburg, 30 November - 2 December 1989) discussed the following issues: (i) global environment, risks and impacts; (ii) political and military security, risks, and impacts; (iii) global demographic change: developed and developing countries; (iv) economic development and technology.

Possible response strategies have been considered, as follows: (i) re-defining the notion of security; (ii) possibilities of managing the global environment; (iii) problems of military/political security; (iv) possible modes of international cooperation/action.

Further to these developments in IIASA, a World Commission on Global Security and Risk Management has been proposed. These suggestions have been initiated by Dr. Maurice Strong, President of the World Federation of U.N. Associations (WFUNA), and may be implemented under the auspices of the WFUNA.

The notions of global or international security and risk have not been defined explicitly so far; rather, they have become umbrella terms for describing multiple threats which are not yet in themselves fully and widely perceived or understood.

The notion of international security was until recently confined to military security; but it is quite clear that such a definition is far from adequate. Security (in a broad sense) should include the ability to face substantial threats to (i) human life, health, well-being, and basic rights; (ii) life-support systems; (iii) the resource base necessary to deal with any challenges to the above; (iv) social order; (v) the capacity of humans to adapt to changing circumstances.

Three major categories of threats have been identified:

Military: global nuclear war; the development and proliferation of weapons of mass destruction and the increased accuracy of delivery systems; international arms traffic; major conventional wars (especially if they occur in areas with nuclear power plants or major chemical plants); local conflicts.

Economic and social: mass poverty leading to starvation; economic collapse; the destabilizing effect of capital flight; excessive population growth and urbanization; international mass migration; gene manipulation; pandemics.

Ecological: changes in atmospheric chemistry and their consequences (changing concentrations of greenhouse gases and global warming, environmental acidification, etc.); pollution of fresh water, oceans and coastal zones; deforestation, desertification, soil erosion, land degradation; risks associated with biotechnologies; hazardous wastes; the production, transport and use of toxic substances; lags in regulations governing health and safety leading to the transfer of high-risk industry to developing countries.

Such threats require preventive actions. The strategy of these actions must foresee: substantiation and priorities of objectives; determination of the scales of risks, monitoring and assessing the role of the respective processes; developing solutions of the problems, bearing in mind scientific and technical facilities, socio-economic aspects and existing international agreements; assessing the efficiency of actions.

Three aspects of the problem of global security can be considered : (i) inputs, which can be regulated, limited and controlled; (ii) their consequences, which require different response strategies to provide a sustainable development; (iii) response to changes taking place, in order to modify the inputs and to provide global security.

One of the most important inputs is population dynamics, manifesting itself through a decrease of the rate of growth (except for the year 1988, when the population growth went up from 1.7% to 1.8%); however, there will be an increase in the absolute size of the population. A maximum of about 8 billion people will probably be reached by the middle of the next century, which is most important. The relative scales of poverty, illiteracy and hunger have decreased worldwide, but the absolute number of people suffering from such living conditions grows. Poverty and illiteracy are the factors that stimulate the birth-rate and, of course, infant mortality. The concentration of the population growth in developing countries and the increasing urban unemployment resulting from urban population growth, intensify the socio-economic stress.

Of key importance are the impacts of developing industry and agriculture on the environment and the biosphere. The related problems of changes in global climate and the ozone layer, deforestation and desertification, acid rains and their effect on the biosphere, soils and oceans, are well known. Very hazardous is the continuing reduction of biodiversity. All these problems have an impact upon biospheric dynamics, which accurately determines the closed nature of the global cycles of substances due to biodiversity (Gorshkov and Kondratyev, 1988).

Limits to biospheric stability

Most important is the fact that natural processes in the biosphere have the highest possible rate of changing the environmental properties. This rate exceeds ten times the present rate of anthropogenic impact on the environment and ten thousand times the average rates of geophysical processes.

The concentrations and rates of variation of chemical substances involved in the biogeochemical cycles can be characterized by the masses and rates of change in organic and inorganic carbon. The mass exchange of other elements can be evaluated from the mass-exchange of carbon, based on similarity relationships typical of biota. The stored amounts of biologically active organic and inorganic carbon in the environment are of the same order of magnitude; they are about 10 times the annual primary production. If the global cycles were open, these reserves would be spent in about ten years. Then, all vital processes would stop. Without anthropogenic disturbances, the fluxes of synthesis and decomposition of organic substances by natural biota balance to an accuracy of four significant figures, thus stabilizing the environment over geological time.

Slow variations of the environment in geological time as a result of geophysical processes will be compensated by biological processes. Thus the flow of inorganic carbon from the ground into the environment is compensated by the flux of organic carbon dropping out of the biotic cycle and accumulating in sediments. The difference between synthesis and decomposition caused by any slight inbalance is compensated by biota in a way to counteract any geophysical change of the environment. The mass of organic carbon in sediments is 3 to 4 orders of magnitude larger than the mass of carbon in the biota and the environment. Therefore the flux of inorganic carbon from the ground to the environment balances the average flux of organic carbon into sediments to an accuracy of 3 to 4 significant figures. On the whole, the biota controls the fluxes of synthesis and decomposition of organic substances to an accuracy of 7 to 8 significant figures.

In order to maintain a given chemical composition of the environment the biota must follow Le Chatelier's principle: any external disturbance of the environment must generate processes in the biota which compensate this disturbance. The compensation of environmental disturbances by the biota can take place at the expense of fluctuations in the rates of synthesis and decomposition of organic substances.

Synthesis and decomposition of organic substances are produced by various kinds of living organisms everywhere in the global biota. The coincidence of four to seven significant figures in the mean seasonal oscillations of the fluxes of synthesis and decomposition of organic substances cannot be accidental. An evolution of millions of years has selected species and communities which can provide it. These communities, together with the environmental components formed by these species, are the Earth's biosphere.

The basic fact is that impacts on the environment and the biosphere can only be compensated by undisturbed or weakly disturbed biota. When the biomass of biota is destroyed, the process of synthesis and decomposition of organic substances stops. When natural biota are supplemented by cultivated species the latter loose the ability not only to compensate for external fluctuations but to close the chemical cycles in the absence of disturbances as well.

The preservation of living species is necessary, not merely because of the unique nature of their genetic contribution, but mainly because of their unique ability, as natural communities, to provide for environmental stability. Global stabilization of the environment and the biosphere cannot be provided if living communities are confined to protected reserves constituting a mere 1-2% of the land surface. Biological diversity is needed over the entire globe.

As for the solution of the problem of global ecological security, two strategies toward an ecologically sustainable long-term development of civilization may be considered.

1. The preservation of the weakly disturbed biota to provide both the closedness of the chemical cycles and the stability of the environmental and biospheric properties at a needed level (not just in genetic banks and biosphere reserves). There are good reasons to believe that the allowable thresholds of disturbances have already been exceeded. Mankind will have to cut down its share in the expenditure of biospheric production, population and industrial production.

2. Developments toward creating the manmade wasteless technologies and artificial (cultured) biotic communities, *i.e.* creating the "noosphere". Apparently, in the noosphere and in the biosphere together more than 90% of the energy and mass exchange must be spent on preserving the closed cycles of substances and the stabilization of the environment. Less than 1% should be spent on socioeconomic development: this is less than humankind has enjoyed in times of an undisturbed biosphere.

These considerations suggest two conclusions: (i) biospheric stability is a necessary condition for global ecological security and, hence, for a sustainable socioeconomic development; (ii) an urgent problem is to develop and implement a global system of ecological observations using conventional and satellite observations, to monitor the processes in the biosphere and in the environment, to protect the biosphere from further destruction and to control its recovery.

At present, several means of ecological observations are available. Plans are being made and implemented for the development of a global observational system, especially of space-based observations. However, the development of expensive observational means without an adequate understanding of their objectives (without problem orientation) may provide information which will be excessive in some respects and deficient in others.

Thus the problem of planning an optimal observational system and its satellite components in particular, must be assigned considerable priority.

Planning an optimal space observational system

The optimal planning of a system of remote sensing from space is plagued by many problems, including the high cost of experiments, limitations to the weight of instruments, power supply and capacity of on-board stored information. A number of scientific aspects of the problem of the satellite data interpretation must also be borne in mind: mathematically incorrect inverse problems using either reflected or absorbed radiation to retrieve the para-

Table 1

The choice of spectral intervals (μm) using the factor analysis technique. From Kondratyev and Pokrovsky (1989)

Group of problems	Factors 1	2	3	4	5	6	7
I. Oceanology	0.45-0.53	0.64-0.69	0.70-0.90	0.57-0.64	0.82-1.30	0.50-0.58	0.42-0.44
	0.45-0.53	0.64-0.69	0.70-0.75	0.62-0.64	0.96-1.10	0.50-0.57	0.42-0.44
II. Hydrology	0.70-1.30	0.51-0.59	0.44-0.52	0.67-0.74	0.57-0.67	0.30-0.40	0.38-0.49
	0.96-1.10	0.51-0.57	0.44-0.52	0.67-0.74	0.62-0.67	0.70-0.75	0.42-0.49
III. Geology	0.51-0.63	0.62-0.70	0.70-0.89	0.40-0.51	0.8-1.30		
	0.51-0.57	0.62-0.70	0.70-0.75	0.42-0.51	0.96-1.10		
IV. Forestry and agriculture	0.51-0.57	0.59-0.70	0.75-0.78	0.70-0.74	0.40-0.51	0.55-0.58	0.88-1.30
	0.51-0.57	0.62-0.70	0.76-0.78	0.70-0.74	0.42-0.51	0.55-0.57	0.96-1.10

meters of the medium and the uncontrolled fluctuations of the atmospheric optical properties.

In planning remote sensing experiments two extreme cases must be excluded: either excessive or insufficient information due to poor choice of observational conditions. In both cases the solution of the inverse problem may be seriously affected.

Two approaches have been developed to planning of multipurpose remote sensing systems: one informative and one economic. In both it is assumed that the information users in various fields of economics can accurately specify the major requirements of information (spectral channels, observation geometry, spatial and temporal resolution, and so on.

The informative approach

The idea of this approach is to select the most important factors and to determine the vectors of the factor loads in a formalized space of requirements. The results of determining the optimal sets of spectral intervals are shown in Table 1 for different groups of problems. Note that the top rows represent the requirements of information users without taking into account atmospheric corrections in various regions of the electromagnetic spectrum, or the economic constraints of space-based experiments. The bottom rows show the ranges of spectral channels of sounding, with the H_2O, O_3 and NO_2 absorption bands excluded in the following intervals: 0.38-0.42, 0.57-0.62, 0.755-0.760, 0.785-0.790, 0.810-0.845, 0.910-0.960, and 1.10-1.16 μm. The contribution of molecular scattering by the atmosphere causes the small information content in the channel of 0.30-0.40 μm. Hence this channel is not used in remote sensing systems.

The table shows, for example, that for "forestry and agriculture", measurements in two narrow channels are desired: 0.55-0.57 and 0.76-0.78 μm. Yet the experts cannot obtain information in these spectral intervals by any available instrument. The narrow channels 0.64-0.69 (or 0.67-0.74 μm) are useful for both "oceanology" and "hydrology". Experts in "geology" and "forestry and agriculture" use information obtained in the broad spectral interval 0.62-0.70 μm, thus combining the channels for groups I and II. This interval is provided by existing instruments as a single spectral interval, meaning that the instruments do not meet the users' requirements in groups I and II, because the relevant intervals are not separated.

Information obtained with the thematic mapper (TM) agrees best with the requirements of "geology" and somewhat less with "hydrology". The multispectral scanner SS meets users' requirements even less. It does not give any information in the channel 0.4-0.6 μm and only provides data in the combined interval 0.62-0.70 μm.

This discussion shows that the available satellite-borne instruments are inadequate for meeting the requirements of users of satellite information in several fields of applications.

There is an urgent need for a more reliable specification of the requirements of various users with respect to the selection of spectral channels. This aim can be achieved by analysis of super-multichannel data of such instruments as the spectrometer "Spectr-256" developed by Bulgaria for the EOS system of the programme "Mission to the Planet Earth".

The economic approach

In the future the development and realization of space-based remote sensing systems will be fully supported by the industries interested in space-derived information. Hence, economic viability of instrumental complexes and their long-term operational survival on board the space platform is essential. The multispectral character of space information and its multi-purpose applications should enable us to analyze the problem of optimal planning of the systems. Maximizing the overall economic efficiency of a multi-purpose observational system V depends on the condition that the efficiencies of individual processes v_i ($i=1,...,N$) are bounded by special unequalities.

For example, in the case of "oceanology" problems, spectral channels 0.53-0.55, 0.66-0.68, 0.53-0.61, 0.61-0.64, and 0.55-0.57 μm are most economical. Other problems may have economically justified spectral regions of their own. Thus, for "forestry and agriculture" it is more useful, from the economical point of view, to obtain information for the spectral channel 1.5-0.8 μm than for channel 9 (0.96-1.10 μm). As for hydrology, no channels have been found at all, in which measurements could be ruled out on economic grounds.

The socioeconomic aspects of a stable development

Now, of particular concern are the global dynamics of population and the present trends of the development of technologies when the level of energy cost does not stimulate energy-saving and resource-saving (low-waste) technologies. Demographic contrasts between developed countries (a decrease of the number of people and an increase of the average age) and developing countries (the growth of population and a decrease of the average age) are on the increase. Industrialization in developing countries considerably increases their share of exploitation of biospheric resources (*e.g.*, deforestation) and the pollution of the environment, especially greenhouse gases in the atmosphere.

Four mechanisms of environmental change pose a threat: (i) direct threats to human beings (starvation, disease, radiation); (ii) threats to the land (desertification, rise of sea level, transboundary pollution, and the denial by upstream nations of the water rights of downstream countries); (iii) threats to life support systems (agriculture, fisheries, water supplies, forests); (iv) threats to the economy (depletion of natural resources and instabilities in financial and commodity markets).

Suppliers of low-cost raw materials are mostly developing countries: this increases their debt and intensifies the global socioeconomic stress. Serious problems of global security are the result, the ecological, socioeconomic, political aspects of which turn out to be closely interconnected. There are numerous examples to illustrate this conclusion: global climate changes and their effect on agriculture, water resources and forestry; acid rain and degradation of forests; depletion of resources and the worsening fresh-water quality; difficult-to-predict consequences of the decrease of biodiversity, and so on. All these processes generate instability on the regional and global scales, leading to a situation where the national problems can be solved only in the context of global security based on effective international cooperation.

The access to nuclear and chemical or biological weapons also requires a better international cooperation to prevent mounting dangers. A solution of the global security problems requires interdisciplinary studies in order to implement recommendations to governments and to the U.N. which will be effective and practical. The experience of IIASA is of great relevance. As an example, the model RAINS provides an interactive simulation of processes such as atmospheric pollution by industrial wastes; their transboundary transport in the atmosphere, soil acidification (respectively, forest degradation and, in many cases, a decrease of soil fertility), pollution of natural waters and the impact of sulphur dioxide on forests. On the basis of such models one can develop expert systems and formulate political action.

At present, the following important recommendations can be stated:

1. Developments are needed, as well as an international agreement at the U. N. General Assembly level, on an optimal global system of ecological monitoring based on conventional and satellite observations. Such observational data should be used as input for numerical simulation models of global ecodynamics (biospheric dynamics, changes in climate and ozone layer, the dynamics of water and forest resources, etc.). Further development of such models will make it possible to implement an early detection (and warning) of harmful trends of the developing ecological situation, and to implement possible scenarios of preven-

tive measures against anthropogenic impacts on the environment and the biosphere.

2. There must be free access to data of global ecological monitoring and assessments of the trends of the development of the ecological situation for all countries. The solution of this problem as well as an agreement on the development of an optimal system of global monitoring can be implemented, only on the basis of an agency within the U. N., able to take responsibility for the problem of global ecological security.

3. Since there are reasons to believe that the Earth is already overpopulated, urgent efforts are needed at the U. N. level to stimulate further studies in the field of ecodemographic problems, in order to ensure a sustainable socioeconomic development all over the world.

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