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# FORECASTING OF ENVIRONMENTAL DAMAGE AS A PART OF THE R AND D FORECASTING SYSTEMS

The system of R+D forecasting based on the needs model is divided into subsystems, viz. needs satisfaction complexes. One of these is the environment protection complex (satisfaction of needs for clean air, water, etc.). The forecasting procedure involves the following: analysis of past and present environmental damage, determination of the interaction with maleficent complexes, determination of threats to environmental equilibrium explorative forecasting (future damage and socio-economical implications), generation and hierarchization of problems to be solved by science and technology in the forecast-horizon in order to prevent or abate environmental damage.

## 1. R+D FORECASTING SYSTEM

R+D forecasting may be carried out in two ways. One of these makes use of the anticipation that the development of science and technology results from the needs of these two spheres of cognizance and activity and is endogenous in nature. While research is stimulated by the science's own cognitive needs, technology either improves what has already been created or introduces innovations. All these may be accomplished as a result of information flow within the two spheres, i.e., either from applied sciences to development, or from one sphere to the other. The results (development of scientific problems, technological innovations or products) are passed to social uses and implementation.

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The other way on which R+D forecasting is performed makes use of the fact that science and technology are domains of social activities directed to, and stimulated by, social needs – both material and non-material. Resolution of scientific and technological problems, as well as innovations, owe their origin to the 'suction' stimulated by social demand, viz. social organizations and individuals bringing pressure on satisfying group and unit need that are believed to be of crucial importance. Prediction of trends in scientific and technological research desirable from the social point of view includes the recognition of extremal, exogeneous 'forces'.

In this report, consideration is given to the method of R+D forecasting which involves social background and implications.

## 2. MODEL OF THE FORECASTING SYSTEM

The process of extensive social reproduction (expenditure production–distribution–consumption) should these days include one more element, i.e. R+D. Research and development have become a starter for most of the investments or implementations – which is in agreement with the concept of the results achieved in science and technology.

The process of reproduction and socio-economical development calls for the solution of a great number of different problems or – to be more exact – for the satisfaction of needs. By virtue of the systems theory of needs, the whole area of socio-economical activity may be divided into needs satisfaction complexes. Hence, each of the elements included in the process of extensive social reproduction are fulfilled in respective complexes. These may be classed in the following three groups:

I. Complexes of direct satisfaction of needs.

II. Instrumental complexes (for direct satisfaction of needs and attendance).

III. Complexes of attendance for a macrosystem (attendance on Complexes I and Complexes II).

The groups of complexes itemized as I subdivides to form two spheres. Either of these aims at satisfying the needs of individuals and groups of population. One of these spheres consists of the following 5 complexes to satisfy material needs: nutrition, protection against life and hazards, environment protection, housing and personal belongings. The other sphere comprises another 5 complexes to satisfy non-material needs: procreation and growth, labour and employment, psycho-social needs, culture and recreation.

The complexes of item II contain 18 groups of tool-making (instruments) for the satisfaction of direct or indirect (e.g. export) needs.

The complexes included in item III aim at satisfaying the following needs: material and resources, energy, transport, communication, informatics, organization and management, national defence, protection of inhabitants, home trade and foreign trade.

## 3. COMPLEXES OF ENVIRONMENTAL NEEDS SATISFACTION

The aim of this future complex is to protect the ecosystem against degradation, to restore and preserve the natural resources of the biosphere over the whole area of the country (soil, water, air, animal life and vegetation), as well as to create such ecological conditions in dwelling and recreational centres that will be favourable to human health and life.

The complex of interest includes: town planning and development (settlements, urbanized areas, industrial and agricultural regions, forests and reservation areas), water management, air pollution control, preservation of such natural components as soil, fauna and flora, landscape protection, conservation of natural ecosystems in urbanized regions (airborne dust, noise radiation), municipal service (water supply, sewerage, sanitary services, verdure, cemeteries), forestry reclamation of industrial land, R+D service, manufacture of environmental equipment and instrumentation.

## 4. DIAGNOSTIC AND FORECASTING RESEARCH

We may assume that the needs incorporated in the environmental complex will occur in a certain hierarchical system such that combines unit needs with everybody's interests. The most probable hierarchization in terms of importance is as follows: 1) maintenance of life, 2) good health condition, 3) full activity (high efficiency, mobilization and simulation of human powers), and 4) full satisfaction of individual beings.

Investigation of needs by analysis, diagnosis and forecast involves objectivization and quantification of respective indices. Investigating environmental needs, it is advisable to point out the shortcomings. In other words, to determine in which of the domains included in the environmental complex and to what extent human needs are not satisfied. Thus, we may analyze shortcomings which account for 1) dissatisfaction, 2) decrease in productivity and working capacity, 3) health risks, and 4) threats to human life.

## 5. INVESTIGATION OF HAZARDS RESULTING FROM THE UNFULFILMENT OF THE ENVIRONMENTAL COMPLEX FUNCTION

Investigating the history of, and putting forward a diagnosis, an actual environmental complex, we may avail ourselves of the findings based on measured shortcomings. From the viewpoint of forecasting (viz. probable variations with time in the range of needs satisfaction), it is of interest to consider all the factors indicating the probability that the goals of the complex

fail to be fulfilled in the future. Information (or, more adequately in the case of the environmental complex, determination of hazards) may be obtained from:

1) diagnostic forecast viz. extrapolation of hazards imminent over the functioning of the complex (this means that the dissatisfaction of needs will increase, and the possibility of determining the 'final' state of the shortcoming in the forecast horizon will lessen),

2) determination of the main contributors to hazards – both inside and outside the complex (complex of services and instrumental complex),

3) definition of the effects resulting from the dissatisfaction of needs,

4) hierarchization of hazards by making use of appropriate criteria.

On investigating the problem in question, it is of importance that the hazards be adequately distinguished from their causes and effects. Thus, increased atmospheric emissions of metal-bearing dust particulates will be identified as hazard; absence (or low efficiency) of scrubbers will be defined as one of the causes (contributing factors), and the contamination of soil, flora and fauna will be considered as one of the effects.

## 6. HIERARCHIZATION OF HAZARDS

The hierarchization of hazards may be performed on the basis of some fundamental criteria as a starting point. The criteria (which will be listed below) may be given weights (e.g. from 1 to 10), assigned by experts to each of the hazards, and then classified, starting from those of the highest significance.

The identification of hazards should involve the following criteria:

Population criterion: according to this criterion, the weight of the given hazard increases with the increasing percentage of the population exposed (shortcoming, damage, disease).

Noxiousness criterion: acccording to this criterion, the weight of the given hazard increases with the increasing destructive influence on the fundamental goals of the complex (e.g., diseases creating risk of life have a more significant weight than those contributing to a temporary absence from work; deficit of raw material which accout for the discontinuation of an important production is of a greater significance than that accounting for a decreased output or a change in the production profile).

Dynamism criterion: hazards found to have exhibited a tendency to rapid increase in the past few years are characterized by a higher dynamism, which enables prediction of a further increase of the given hazard.

Removability criterion: according to this criterion, the highest weights are assigned to those hazards (deficits, damages) that are irreversible or difficult to remove (e.g., insufficiency or deficit accounting for irreversible effects, delay difficult to make up, lack of raw material with no substitutes, damage which can be made up with high expenditure, durable genetic changes).

Interactivity criterion: according to this criterion, the weight of the hazard increases with the increasing number of complexes which interact with the investigated complex and are subject to the unfavourable influence of the given hazard.

## 7. SATISFACTION OF ENVIRONMENTAL NEEDS AND MENTAL DISPOSITION

Degradation of environmental values is perceived as a nuisance, particularly when experienced in the form of polluted air and/or water. 'Average' air and water pollution which exceeds the admissible levels involves indirect measures of estimation. These measures take the form of destructive effects experienced by inanimate and animate nature, man and his health being particularly exposed to this influence.

In terms of perception categories, excess pollution levels in air and water perceived by the sensory system of man are thought of as creating special hazards. They make people feel that a direct threat is imminent over them. This feeling has an undesirable influence on the mental disposition (both of individuals and groups of population), irrespective of the toxic effects experienced by other organs.

Drastic conflicts may arise in the case of continuous exposure to polluted air, or when the available water is unfit for household and sanitary purposes (or agricultural production). Those events, however, have become increasingly frequent and have been influencing an increasing number of population in the past few years. The result is as follows – people experience mental stresses are subject to permanent tensions and pressures, or suffer from serious neuroses (which have become known here and there as an 'ecological unit disease' of psychiatrical type). The new unit disease has joined the group of a number of other unit diseases which have already made an ill name for themselves – such as radiotexemia (resulting not so much from labour exposure as from natural environmental radiation), blood diseases associated with exposure to fluorine, lead, copper and cadmium, to say nothing of minemata (blood-poisoning from mercury exposure) or itai-itai which have affected large population groups in Japan.

The problem of threats to ecological needs may be considered by macro or micro approach. Macro approach involves large-scale environmental hazards from air and water pollution associated with the principal trends in economy and policy-making. Micro approach is practical to analyze local hazards in affected regions (emissions or discharges from a single source or a group of sources, e.g. synthetic fibre manufacture, power generation, smelters, etc.). The result is that heavy metals enter the atmospheric air or water courses, and airborne carbon bisulphide becomes a serious nuisance to the adjacent area.

## 8. FORECASTING APPROACH

Poland is afflicted by a number of local hazards, but the main source of large-scale ecological conflicts includes the raw material and energy complex.

As far as air pollution is concerned, the contribution (both in particulate and gaseous forms) of power plants accounts for about 50°/o of total emission and for over 70°/o of total fly ash or sulphur dioxide release.

Of the various problems dealt with in water management, the ever increasing mineralization has recently come to the forefront. Mineralization of water streams and reservoirs owes its origin to mining processes executed under unfavourable geological conditions which make almost all of the mineral resources link with brackish or drainage waters discharged onto the ground surface. Local salinity measured in some of the near-by 'rivers' often approach levels as high as those of the Baltic Sea (up to 7g/dm$^3$). Waters carried by the two principal rivers of Poland, the Odra and the Vistula, are in their upper stretches beyond any class of purity.

In forecasting research, the environmental problems in question may be considered either by a joint or a 'dismembered' approach. In the joint approach they are integrated into the contributing complex (in our case, this is the fuel and energy complex). In the dismembered approach, the object of main interest comprises every change observed in the given environmental medium (air, water) and the resulting environmental impact on the elements of the ecosystem. In everyday practice both approaches are recommended.

The joint approach should provided data required for strategic decision-making in the sphere of economy. It should make use of a full-scale macro-economical calculus incorporating all levels of measurable and not measurable losses in several horizontal systems which are possible to predict and calculate.

The dismembered approach should enable determination of many-variant scenarios for eco-technical (soso-technical) activities with the aim to minimize the effects of ecological hazards by joint technological and natural undertakings.

One of the goals of an environmental forecast is to combine the two approaches in order to establish the scenarios of events that might result from the many variants of strategic decision-making in the sphere of economy, as well as from the variants involved in soso-technical activities concerned with individual components of the ecosystem.

The considerations included in this paper show without any doubt that environment damage forecasts should constitute an essential part of the R and D forecasting process. The interdisciplinary nature of generating an environmental forecast (which makes use of natural, technical, economical and social sciences, i.e. of the entire science complex) creates certain problems and difficulties. These being so, it is necessary that further investigations focus primarily on the methods of forecasting in the field of the complex of environmental needs which is an important element involved in the complex of needs satisfaction comprising both individuals and groups of population.

## PROGNOZOWANIE DEGRADACJI ŚRODOWISKA JAKO CZĘŚĆ SYSTEMÓW PROGNOZOWANIA B+R

System prognozowania B+R, oparty na modelu potrzeb, jest podzielony na podsystemy, mianowicie na kompleksy zaspokajania potrzeb. Jednym z nich jest kompleks ochrony środowiska (zaspokajanie potrzeby czystego powietrza, wody etc.). Procedura prognozowania opiera się na analizowaniu dawnych i obecnych uszkodzeń środowiska, określeniu interakcji między środowiskiem a kompleksami powodującymi jego degradację, określeniu zagrożenia równowagi środowiskowej, orientacyjnym przewidywaniu (przyszłe uszkodzenia i implikacje socjoekonomiczne), formułowaniu i hierarchizacji problemów, które będą rozwiązane przez naukę i technologię w horyzoncie prognostycznym, aby zapobiec uszkodzeniom środowiska lub osłabić je.

## DAS PROGNOSTIZIEREN VON UMWELTDEGRADATION ALS BESTANDTEIL DER F+E SYSTEME

Das System des F+E Prognostizierens stützt sich auf dem Modell der Bedürfnisse und wird in Untersysteme eingeteilt. Ein Untersystem der Bedürfnisse bezieht sich auf die Befriedigung der Umweltbedürfnisse (reine Luft, reines Wasser, usw.). Das Prognostizieren ist nicht nur auf der Analyse der vergangenen und gegenwärtigen Degradation gestützt, sondern auch auf die Bestimmung des gegenseitigen Einflusses der Umwelt und der für Degradation verantwortlichen Komplexe gezielt.

## ПРОГНОЗИРОВАНИЕ ДЕГРАДАЦИИ СРЕДЫ КАК ЧАСТЬ СИСТЕМ ПРОГНОЗИРОВАНИЯ НИОКР

Система прогнозирования НИОКР, основанная на модели потребностей, разделена на подсистемы, то есть на комплексы удовлетворения потребностей. Одним из них является комплекс охраны среды (удовлетворение потребности в чистом воздухе, в воде и т.д.). Процедура прогнозирования основывается на:

- анализировании прежних и нынешних повреждений среды,
- определении взаимодействия между средой и комплексами, вызывающими её деградацию,
- определении степени опасности для равновесия в среде,
- ориентировочном предвидении (будущие повреждения и социо-экономические импликации),
- формулировании и установлении иерархии проблем, которые будут решены наукой и технологией в прогностическом горизонте, чтобы предотвратить повреждения среды или уменьшить их.