System Approach – Decision Support in the Management of Environmental Protection

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Abstract

Relationships between society and environment became an important subject for research in all domains of science. The emergency of problem solving and the incomplete knowledge of numerous elements, processes and interactions have created a number of problematic situations in managerial terms. Therefore, in the field of management researches pursued to cherish the accumulated experience and to formulate or reformulate a number of theories according to the requirements of environmental protection. Solving environmental problems at managerial level faced many difficulties due to insufficient information, unclear responsibilities, reduced predictability, large social implications, and increased social and political pressure. The system approach could bring in a useful perspective for decision making by supplying information on the possible evolution and characteristics of the ecosystems and socio-ecological systems that occur under the influence of economic, social and political factors at different spatial and temporal scales.

Keywords: *human-nature relation, system, complexity, decision making, environmental protection*

JEL classification: Q57

The notion of system is part of the current thinking. A system represents a number of elements having a structure that explicitly defines the interactions among elements. Any problem in that the system notion is involved depart from the identified or supposed existence of a system about that there are information regarding its structure and functionality. This information is not complete; knowing the system remain that is based on initial information.

System theory about the living world appeared as an expression of the need to solve certain problems. The development of mathematical techniques and models characteristic to this theory reflects the trend of this theory to have a holistic approach of the living world. Humans need different knowledge about the composition of nature, about the relations among its elements, and about the human-nature interaction (Bran and Ioan, 2004).

Acquiring this knowledge necessitate a cognitive effort that is featured by the system analysis. The system analysis supposes information gathering on inputs and outputs of the system and on the relations between them. An ecological system with more species, the forested area, a lake etc. could be distinguished as an analysis phase and lead to the description of those systems functioning as poli-functional systems.

The Amazon forest is a natural and economic system that needs to be comprehended with knowledge for a rational human intervention. Transposing the concepts of natural sciences or economic sciences, adaptation of analysis methods to the particularities of these systems classes gives to the system analysis a pronounces interdisciplinary character.

From the perspective of system theory the physical nature of dimensions that feature of a system could be supplemented with other dimensions. A system could be characterized through performances – we will understand a certain relation between inputs and outputs.

From the applicative perspective the system theory subordinates both analysis and synthesis. The humans aware action on system defines:

- the purpose of system analysis;
- consist in finding the inputs that produce a certain output that are close as possible with the objectives of system functioning and with the accomplishment of certain performances.

The management of an economic system – an industrial enterprise for instance, aims the accomplishment of system specific performances: maximization of benefits and productivity, minimization of production costs (Bran, 2003).

The problem of system management comes back to the search of inputs (volume and structure of plans, level of technical endowment, labor, raw material needs, production schedule), are able to provide the envisaged performances.

System management could be resolved through a number of concrete ways. The human experience and intuition have an important role in the case of very complex systems (Popa and Rădulescu, 2009). Among these methods there are simulation and optimization.

The population of a certain geographical area with a range of animal and plant species leads to complex interaction among species triggering the extinction of certain species or changes in the equilibrium ratio among species undermining the ecological balance. Actions that have not entirely known consequences risk miss-accomplishment of objectives or “high prices” for accomplishments.

In this respect, many decisions for certain ways of action imply the occurrence of undesired effects. In order to overcome such situations simulation could be used based on system models.

Simulation with models that avoid intervention on real systems meanwhile unfolding the implications of decision (input) that need supplementary information. The decision could be taken in the moment of acknowledging the possible effects that could be produced (Rădulescu et al., 2009). Even in case of decision that does not involve intervention there is needed information about the future behavior of systems.

Simulation that allows the anticipation of a system is called prognosis. A typical example is the weather forecast. The possibilities to interfere with meteorological processes are minimal, but knowledge about their evolution could mean a lot in terms of preparedness and adaptation. Mathematical models that use variables such as size, speed, temperature, pressure, and humidity of certain masses of air allow the anticipation of weather patterns.

Optimization has a central plant among the applications of system theory. The progresses in geo-ecology, biology, and genetics made at the beginning of the XXth century are achieved based greatly on the contributions of system theory. In natural and life sciences, fields where the complexity degree is increased significantly, the current state of applying system theory is characterized by system analysis problems, oriented toward system management.

The most significant intrusion of system theory was made in economic and social sciences. This penetration was many times threatened by the dangers of reductionism, stranger for the materialist-dialectical conception.

The system explanation of certain economic and social mechanisms is a reality that cannot be ignored. The current state of system theory does not allow yet a holistic approach of economic and social systems. The complexity of these systems is not restricted only to this dimension. It also features the relations among elements and subsystems.

Application restrains of system theory in this field suggested new contributions, such as the undetermined fuzzy approach, extension of polyvalent logic or reformulation of some system concepts within the wide frame of economic and social sciences. Norbert Wiener, the father of cybernetics noticed that the methods of technical automatics could be applied also for living organisms. On the other hand, from the perspective of Ludwig von Bertalanffy biology is the root of system theory.

There are many examples that reveal the various intervention possibilities for influencing the structure and the evolution of the environment. These also generate multiple approaches of the ecological problems.

Analysis of system stability has proven its utility for ecological balance within the framework of human-nature impact. System theory finds wide application in economic and social sciences. A system that is so complex as it is the system of national economy has to be modeled using a large number of variables and relation. The feed-back pattern is maintained. Inputs do not depend only on state and outputs, but also on external influences on the system. Expressing occupied population by a single state variable is not possible because in the production of national income only the population working in production process is involved. A model of economic and social development enlightens the role of technical progress as feed-back of material production.

Currently it could be concluded that there are several reasons that support the achievement, perspective, and limits of system theory. The implications for research of complex systems are surprised by Bran (2001), and they fall in two directions to be followed further:

- treating as it is possible both biological and social systems within the current system theory;
- expansion, generalization and even the reformulation of system theory in such a way that it could be applied to real complex systems that belong to biological and social environments.

The second direction is in the conception of many experts the roadmap to further development of system theory. The evolution of system theory is featured by an accelerated evolution, resembling the evolution of Physics from Newton to Einstein. We assist today a speed up of system circuit from theoretical aspects to applicative ones that proves the profound scientific character of the system theory.

One possible application of this theory could be applied for the representation of human-nature relationships.

Human-nature relationship is represented by numerous and diverse conceptual models that express contradictory vision. The human-nature relation is featured by much scientific uncertainty even after several decades of research focus in this direction. Consequently this relation subjected to wide and intense debates that led to the formulation of more conceptual models in the attempt to make a clear representation of key elements and relations occurring among them. Due to the significant subjective contribution these representations are sometimes contradictory.

The theory of socio-ecological systems departs from the premise that accomplishing the objective of sustainability supposes the understanding of integrated socio-ecological systems' functioning. This model represents the human, social and natural dynamic as part of an integrated system in which there are obvious social-ecological interconnections and in which the limit between social and natural systems are artificial and arbitrary.

The model envisages shading light on the sources of changes that have the power to transform adaptive systems. The analysis targets economic, social, and ecological changes that undergo with different paths and at different spatial and temporal scales.

In figure 1 there is a visual representation of the socio-ecological system concept. There could be noticed the focus on the role of social learning. The components of the system's hierarchical structure are connected through the knowledge and understanding of ecological processes that are further translated in managerial practice. Meanwhile, there is not excluded the possibility of other change determinants to come into action.

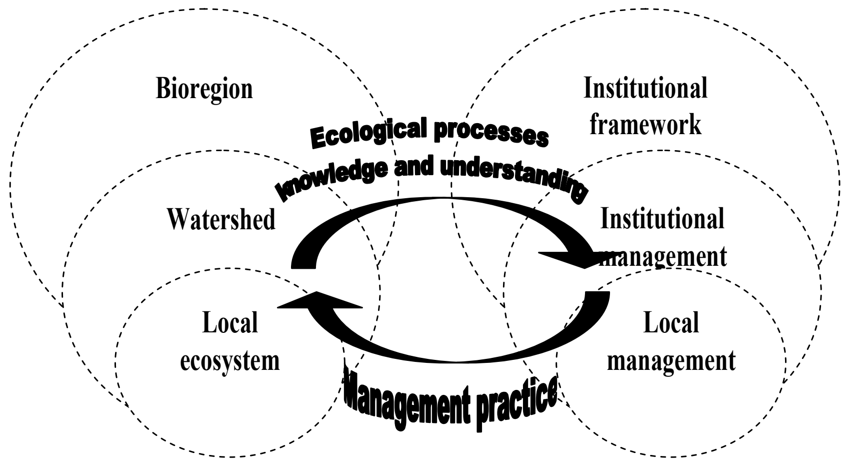

Figure 1. Socio-ecological systems
(by Berkes and Folke, 2002)

The core of this model is resilience management. The resilience of socio-ecological systems is rooted in strengthening mechanisms that prohibit the passage to undesired configurations. Resilience management could be considered the integrated management of socio-ecological systems within uncertainty conditions and it means to learn to leave in terms of the system not to control it.

Resilience management is based on iterative combinations of scientific knowledge and traditional knowledge for the determination system resilience source. This could allow the identification guidelines and of intervention points. The necessity of different types of knowledge is determined by the need to legitimize and by the conditions of public participation. The most frequently used tool for resilience management in scenario design.

The core concept of the socio-ecological systems model is the adaptive cycle of renewal. This was developed in order to explain the biological dynamic in ecosystems, being than uptaken for the explanation of change in socio-ecological systems. According to this concept, ecological, economical, and social changes are produced through four successive phases of cycle, as follows:

- ✓ rapid increase and exploitation (the r phase);
- ✓ accumulation, monopolization and structure preservation (the K phase);
- ✓ rapid decrease or release (omega phase); and
- ✓ renewal and reorganization (alpha phase).

Through the theory of adaptive cycles the socio-ecological systems model proposes a dynamic concept that transcend spatial and temporal scales and allow the explanation of non linear changes. The purpose is to integrate the real ecological dynamic in the human anticipative behavior.

The concept of adaptive cycle of renewal were also used for explaining evolutionary change in ecology, economic change and business cycles in economy and for the cycles of development and fall of civilizations in history. The concept is criticized for its limited capacity to predict abrupt changes. The driving force of adaptive cycle is competition and it stems from the ideas of Charles Darwin, for nature, and of Adam Smith, for economy, and of Herbert Spencer for the evolution of human societies. Focusing on competition could reduce the attention given to other factors and ignores the power of cooperation, self-sacrifice, and reflection on values. Thus, it could be said that the model denies the human option for choosing values and priorities, others than the ones dictated by competition.

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