Geo-Cybernetics – a 21st Century Cybernetic Approach to Sustainable Development and Environmental Protection

Ioan STANGU, Romania

Key words: geo-cybernetics, matter, substance, energy, transformation, information, entropy, geospatial measurements, cadastre, GIS.

SUMMARY

At the beginning of the 21st century, mankind seems to be confronted with special natural phenomena which are determined, on the one hand, by the natural development of the Earth and by the uncontrollable and sometimes irresponsible activities of humanity, on the other. Therefore it is absolutely necessary to ensure the equilibrium of Man-Nature relationship by means of a decisive intervention of decision-making factors and of science, too, on a planetary scale has become compulsory these days.

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1. INTRODUCTION

The activity unfolded by Man in the middle of his environment, which is determined by the multitude of life-preservation elements, which ensure nourishment and dwelling conditions in parallel with all the other artificial elements created and achieved to further develop human society, may produce multiple "transformations"to our natural habitat.

Unfortunately, these transformations which are being produced by Man in his environment overcome the limits imposed by Nature, a fact that leads to disturbances with serious effects called "pollution", which is in fact more than that, it represents irreversible natural destruction phenomena.

All climatic changes, determined by complex natural phenomena produce, in their turn, "specific changes"which manifest themselves nowadays through global warming, storms, hurricanes and heavy rains in some areas of the Earth having as immediate effects catastrophic floods, landslides, droughts, etc, accompanied by important human and material losses.

The natural evolution of the Earth, as a live organism, in its multiple manifestations, produces a "certain type of change", independent from man's will, such as the earthquakes and the volcanic eruptions with their disastrous effects.

The multitude of these "pieces of information"characteristic to these "changes", necessary in the process of control, analysis and decision-making in management activities asks for the use of some scientific domains that could "measure"and "keep the evidence"of these changes in time and space, as well as of geo-spatial measurements, of cadastre and GIS and other land sciences together with a new way of cybernetic thinking and action.

2. FROM CYBERNETYCS TO GEO-CYBERNETYCS.

Cybernetics, as a science, is defined by its creator, the American scientist Norbert Wiener, in his work, **Cybernetics**, as a "domain of control theory and communication in machines and in live organisms, as well".

This definition, which today is surpassed by the very development of cybernetics, was extended by Wiener himself particularly over the field of social and economic sciences.

The further development of this new science offers us some definitions which are not unitary, being more or less complete, which shows the position of the authors in relation to cybernetics, as well as to their own field of activity.

Therefore, some emphasize the control (Wiener, Conffignal, Berg), others – regulation and self-regulation (Klaus, Lange, Gremiewski) or the reverse connection (Apostol), or communication and information (Ruyer, Gluskov), while others stress up the completeness, the final action (Moles) or others who think of this science in terms of automatic machines or life-imitating robots (Boulanger).

Closer to the complex domain we have tackled so far, the environmental transformations operated by humanity and the analysis of these changes cybernetically, which we call "**geo-cybernetics"**, seem to be the definition given to cybernetics by other authors who define it as :"the theory of self-regulating dynamic systems"or " the general science of management and regulation of interconnected action systems that deal with all the general principles and law research that govern all these systems, irrespective of their concrete character, or " the general theory of complex dynamic system management"or even, that cybernetics studies the general laws of the processes that occur within some complex dynamic systems when these change from a state to another, irrespective of their physical or social nature", or " the science of the general laws of information change within complex control systems".

From the definitions above we may select the quasi-unanimous opinion that cybernetics is the "science of system management".

All the scientists that study such problems admit that the subject of cybernetics deals with the control of complex dynamic systems, which may include the animals (and the man) as well as the machines (electronic devices as complex dynamic systems) and the social systems (society, industrial units, production, etc.)

The study of cybernetics is characterized by the fact that management processes are being studied without taking into account the system substrate, i.e., its substantial and energetic characteristics. It deals with informational processes as they are the ones that determine the system behavior, no matter if it is of a substantial, energetic or social nature. By analyzing the analogies existing between the functional principles that belong to various systems (biological, technical, economical, social, etc), cybernetics preserves from the components of these systems only those elements that are characteristic to them all. So, as we see, cybernetics doesn't study "the content"of the systems, but only their "structure".

Cybernetics doesn't analyze objects, but behavioral ways. It doesn't ask a question like that:"what is this object ?", but " what does this object do?".

Scientifically, the behavior of some complex dynamic systems cannot be foreseen if we do not know the informational processes of reception, processing and transmitting that lie behind. And similarly, we can't analyze the information we get if we don't possess a precise scientific characterization of that system behavior. All the social, economic, technical, etc. phenomena may evolve differently in accordance with the information we get, process and transmit.

The behavior of the complex dynamic systems is connected directly with the processes of reception, processing and transmitting of information. As a result, the control is an informational process.

The informational processes that determine the behavior of these complex dynamic systems evolve according to their own laws, totally different from the laws of mechanics, physics and chemistry. So, if the physical and chemical processes occur according to their specific laws, whose behavior is given by modifications in substance and energy, the behavior of the phenomena in the social, economic and biological domains is determined by the laws according to which they receive, process and transmit the information.

There are two categories of phenomena if we take the behavioral characteristics into account: the substantial and the energetic phenomena, on the one hand, and informational and organizational processes, on the other. The informational and organizational processes and phenomena are those whose behavior depends upon the signal received and by the action of processing and transmitting, the informational and organizational actions rather than by the quantity and quality of the substantial and energetic action.

As an informational process, the command occurs in a certain general order, therefore in a certain organization for all the complex dynamic systems.

Cybernetics is also characterized by the fact that it doesn't explain the complex systems through others, less complex in structure. On the contrary, it looks at the complex systems the way they are, as complex systems, emphasizing their essential characteristics by means of specific laws and categories.

The cybernetic way of thinking, as opposed to the classic way of thinking which considers the organism and the society as being mere mechanisms, conceives the machines as artificial organisms with a certain finality and behavior.

If, traditionally, we had to pass from well-known, simpler elements to others, more complex, to systems composed of these known elements, the cybernetic thinking goes in reverse: from complex totalities with their functioning to the gradual discovery of their constituents and of the connections between them which ultimately ensure their functioning.

Only gradually do we reach the part starting from the whole, and from the system to the element.

If the classical systems present a “development”in time, cybernetic systems have a “behavior”in time. For the cybernetic systems, the concept of behavior implies the concept of milieu (environment), too, where the system makes use of its particular type of behavior.

With the help of cybernetic abstracting, which allows the comparison between the scientific results that come from completely different domains of reality, we may speak about systems that may preserve a certain “state”or follow a certain development, irrespective of the changing influences of the environment. The concept of behavior is isomorphic with the concept of “operation”as any system behavior means the performance of a set of operations. If such a set of operations, i.e., a certain behavior, turns into a theoretical norm, then it becomes an integral part of the methodology and changes itself into an algorithm

2.1 The Cybernetic Components of Matter: Substance, Energy, Information

Anyway, cybernetics opens up ways of getting new viewpoints about the essential aspects of matter. The present level of human knowledge, the cyberneticist’s already expressed opinions allow the highlighting of the three essential aspects of matter: the”substance”, the “energy”and the “information”. (apud Wiener)

The evolution of society first emphasized the “substance”which deals with the substantial side of matter. This aspect is emphasized on the production plan as substance, material transformation and processing represents the main problem of all the material goods.

But soon, the evolution of modern sciences as well as the development of production throw a different light upon the energetic aspect of matter. This aspect, very actual nowadays, determined by the first aspect for the production, transformation and transmitting of energy required by substance transformation and processing appears as the second important aspect of matter.

As long as the processes of transformation of substance, of its processing, but also the production, transformation and transmission of energy were relatively simple, the problems connected with the information, always interwoven with the other two aspects, could have been solved almost simultaneously, in a spontaneous and tacit way. But once with the diversification of all the goods, this activity was no longer possible.

Cybernetics is responsible for having emphasized the third aspect of matter, which had been previously foreseen by anticipations: the “information”and “organization”aspects of matter. Without getting into details about the concept of information, we may introduce the definition given by Wiener to information which is unanimously accepted nowadays: “information is merely information, it is neither matter (substance) nor energy”.

It is therefore important to point out that information is vital and so often all-present that we may say that man's existence relies on the permanent presence of both information and its connections as well.

2.2 Management = an informational process

Cybernetics introduces for the first time, consciously and systematically, the structural aspect of matter. Each "substantial"system has a given structure, i.e., a given "order", hence, a given "organization".

In its turn, any process of management based on the selection, processing and transmitting of information is possible only on a structure, on a certain organization which serves in the maintenance or the improvement of the structure. In the process of goods creation, this new aspect presents itself as a command and regulation technique, on one hand, and as an informational technique, on the other, which, together make up the basis of automated modern production.

We may say that, the automated, modern production represents the unity between the substantial, energetic and structural-informational aspect which became possible only when this new aspect has been noticed systematically, scientifically, taking on the appearance of a new theory.

As a result, information is not an exterior aspect, a phenomenon, an object, but it is an objective property of things, processes and phenomena. It is actually one of the general properties of matter.

The informational aspect, and the organizational aspect as well, as compared to the substantial aspect occupies the first position in modern production. In this context, we must admit that there is no information that should not be connected to substantial structures or need the energy necessary for its further maintenance, formation and development. The three components may be presented as logical implications: the substantial aspect, the energetic aspect and the informational aspect.

The information appears as an arrangement in its development from inferior to superior and we must therefore admit that information arranges and organizes the substantial and energetic processes. By extending it to the human activity in the territory, we may appreciate that information appears as an ordering of various forms of manifestation of human activity in the territory.

If the sciences, in general, look at information through the processes they analyze, cybernetics generates a characteristic treatment and explaining of the information. It studies information only from its management functional role point of view. In its essence, management is an informational process. As a result, all the processes and actions are meant to ensure the

preservation of system equilibrium (homeostasis), so their rational behavior represent an information.

At the same time, the three aspects of matter are to be found in a close cybernetic interdependence due to the fact that the energetic-substantial aspect of matter presents a certain ordering(organization) within a given space and developing within a certain time as an event, phenomenon or process, object or state.

The establishment of information relationships within the system makes up a logical chain, similar to a closed circuit logical chain is represented by a series of events which move in a given order, the so-called normal order of the information unfolding. The normal order of the information unfolding within the system closes up the informational circuit.

2.3 Information = Energetic Transformation of the Substance

As seen above, I consider that information is not simply information, as Wiener pointed out when defining matter and information, but it is actually the component of a logical chain of actions from inside the matter - substance, energy, information- that all these are in a close interdependence and as a consequence, the information is the result of actions that take place between the substantial and the energetic aspects of matter.

So**, information** is, in my opinion**, the result of energetic transformation of substance known by the man**.

We may motivate this point of view by the fact that information is an exterior process, a phenomenon, a thing, doesn't exist outside matter under a different shape, but it is a result determined by conscious human activity, of substance controlled energetic transformation with a purpose and secondly, that information doesn't exist outside substance energetic transformations.

Any other energetic transformation of the substance leads to **entropy** and as a result to disorganization, or rather, to natural hazards.

If we resort to a simplifying hypothesis, the definition we found for information, as a component of matter, can be graphically represented in Figure 1.

The significance and matter components, according to Figure 1, are the following:

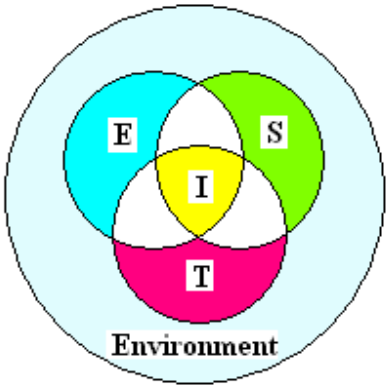

Fig.1*: Matter Components*

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E - represents the energy, matter essential component which serves to the controlled transformation of substance by the man;
S - represents the substance, the concrete, natural component of matter which the man transforms with the help of energy
T - constitutes the controlled energetic transformation of substance by the man;
I - represents "information", i.e. the result of substance energetic transformation, or mathematically:

$$I = f(T:E,S)$$

2.4 The Concept of Geo-Cybernetics

Geo-cybernetics, in the light of the ideas above, may be defined as the **science of the management of man-created artificial transformations and modifications in his environment as well as of the risk reduction to natural hazards, and of entropy reduction by means of the informational system of geospatial measurements, the cadastre, of GIS and other sciences connected with the territory, in concept and cybernetic thinking.**

This concept is, in my opinion, a requirement of today's human activity and particularly of the future, which needs the action of several sciences in **the process of human activity management** due to the problems created by both man and nature, and having as major aim the process **of sustainable development of human society and the actual protection of the environment.**

My personal interest concerning the use of cybernetics in human activities management in the territory dates back to the time when I was working on my doctoral paper when I had the opportunity to study Wiener's theory about cybernetics as well as other studies that framed up my "cybernetic thinking". It also left me thinking about Wiener's definition of information: " information is simply information, it is neither substance nor energy".

All the studies I dedicated to this dilemma combined with the research activities meant to modify and transform the environment led me to the logical conclusion as to how to define "information"as being: the result of man's conscious activities to "energetically transform the substance".

On this basis, determined by the support of"the environmental informational system"(s/chapt.3.1) which can be achieved by the complex system of geospatial measurements, by the complex system of cadastre records, for all real estate (land or/and buildings), GIS and by other sciences related to the natural and artificial resources of the environment, we therefore reached the concept of geo-cybernetics.

This name, very useful in the future, comes from geo = geoid = earth, meaning environment, to which we add the name Wiener gave to cybernetics, for which we preserved the letter Y.

In this way I also bring my contribution to the general effort for protecting nature and to actively participate in the environmental protection of the world I live in.

3. THE ENVIRONMENT – A COMPLEX CYBERNETIC SYSTEM

Man - humanity at large – lives and earns his living by using our planet's natural resources, by using the environment conveniently within the society that it has created in time.

The evolution of human society on the Earth, very different in space and time, the requirements forced upon us by the need to ensure our everyday nourishment and lodgings, etc. have determined the appearance of a complex land planning and buildings of all types which make up together the so-called artificial resources.

We may represent graphically, through a simplifying hypothesis, the environment we live in which includes three factors, Figure 2, whose significance and characteristics are the following:

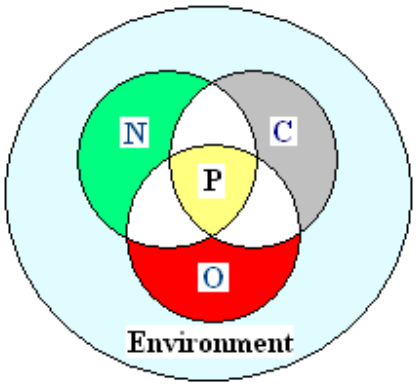


Fig.2*: **Environmental factors***.

O - the man (the population) is the dynamic factor, ever-growing, with an essential role in changing the environment.
N - the natural habitat (the territory) that includes the sum of all the natural resources, it is a factor limited in time and space.
C - the changed framework that includes the sum of all artificial resources, i.e. the elements of the natural framework modified by the man together with the totality of buildings, a dynamic factor dependent on the natural background and therefore limited in time and space.
P - the products achieved by man, under various forms through: industry, agriculture, buildings, etc.

The three factors together (O, N, C) that constitute the humanity's milieu are in a mutual interdependence within the space determined by their "intersection". At the same time, these factors are in mutual relations, two by two, in spaces determined by such intersections.

By means of this scheme we may emphasize the cybernetically-based circuit determined by the human action upon the land which ultimately leads to the process of a controlled and directed "transformation"made by the man and completed by means of "information", as a result of substance energetic transformation (see s/chapt. 2.3)

This information can be obtained only through a complex, multi-discipline system of sciences specific to all the human activities of changing, modeling, planning and endowment in time and space of the environment based on technical and scientific facilities and on specialists in this field.

So, a harmonious economical and social development in the territory depends on the best ways, means and methods the society finds appropriate, for an efficient combination of the three factors in order to make human activity more concrete in all its forms.

As an objective necessity of the society, this activity implies the coordination of the multiple interests that interfere on the same territory within an organized frame in order to make a rational use of the resources.

The society exerts this function by the concrete way of using the environment which at the country, county and city levels is shown by the way in which all the artificial resources are being placed, created and used properly and also how the whole territory is organized and coordinated.

Contemporary civilization, under conditions of population increase, makes possible and necessary an intense territorial mobility, creates new models and media of social life, develops great urban agglomerations within relatively small areas. The need to ensure the daily population supply in these areas has deep effects upon the position, the profile and the specialization of agro-food production in the area and it influences the optimum way of using and planning the territory.

Of course, the implications are much more numerous. I have emphasized only a few in order to demonstrate the role human society may play in the regulatory function it has over the whole territorial system in order to preserve the equilibrium of the whole environment.

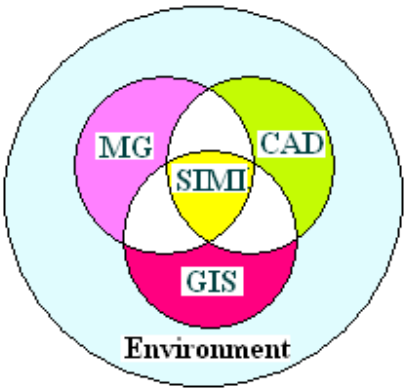
The regulatory function is achieved through the continuous modification of the territorial structures by means of “models”and by ensuring the system functioning without “disturbances”.

To know the various types of connections between the phenomena and the processes that happen in the territory, the direction and their action tendencies, the complexity and interdependence of various sectors of economic-social life, the dynamics of the mutations that happen in the territory - all these require the presence of “information”in the management process.

3.1 The Informational System of the Environment

The “information”, as a result of the human activity of transformation and modeling the environment, required by the management activities, determines the introduction of a complex system of gathering, stocking and processing of all the information characteristic to the process of transformation of the natural resources and of the creation of artificial resources necessary to human life and well-being.

This complex system, Figure 3, that measures up, emphasizes and processes all the information about the environment may be made up of the following:



MG - the system of geospatial measurements.
CAD - the system of cadastre recording.
GIS - the geospatial informational system.
SIMI - the environmental informational system

Fig.3: ***The Informational System of the Environmental***

The informational flux among the three systems suggests bi-univocal relations and they also show that the intersection of the three components represents the environmental informational system.

The use of cybernetics as a modern method of research and management is more visible these days in all the fields of human activity where there are analogies with this science.

So, geo-cybernetics, as a science and as a part of the technical, economic, social, etc, activities presents, as we have shown before, the main cybernetic categories : the system, the model, the information, the command, the regulation, the self-regulation, etc.

4. "GEO – CYBERNETICS"– AN ENVIRONMENTAL REGULATING AND SELF – REGULATING SYSTEM

The concepts of regulation and self-regulation are fundamental issues of cybernetics. From Wiener's own definition, we conclude that cybernetics was born from an analogy between the human beings and the technical devices created by the man. Any analogy support itself on at least one common trace.

The main common characteristic used by Wiener was self-regulation. He pointed out that both humans and the machines are capable to preserve for some periods of time a certain equilibrium in their relations with the environment. So, in humans, the temperature, the pressure, the chemical composition of the cell etc are preserved in a state of equilibrium. There is a regulation mechanism that keeps up the temperature of the human body at 37 ° Celsius independent from the environmental temperature and this phenomenon is called homeostasis.

The same happens with some machinery, in the technical field.

This phenomenon resides in the capacity of both beings and artificialstructures created by the man to answer in a way or another to the interaction between them and the environment – the self-regulation principle. As Wiener pointed out, the major way to achieve self-regulation is "command"which implies the presence of "communication".

As a result, as Wiener used to say, all the economic and social phenomena regulation is similar to the live and artificial organisms self-regulation principle.

In the society the regulation is not done automatically, but by means of functional relations on which the function of coordination and organization is based. The point of contact between the system and the environment is the "program".

Conventionally we may consider that the system is regulated when the program and the resources for its achievement are established by a higher hierarchy, being self-regulated when the program is established by the territorial cybernetic system itself, taking into account the conditions of the resource self-regeneration. So, the self-regulation of the organizational and controlling systems is analogous to the process of adaptation and selection of the biological systems.

Once the program is adopted through regulation by a superior territorial factor or through self-regulation there appears the second analogy with the beings, namely the internal self-regulation.

This category – the regulation- may be defined in general terms as a process where a regulated value or an output value of a system is maintained in a dependence by the input value.

The regulation is achieved by means of measurements of the output values, by comparing it with the input value and by acting upon the system processes so that the difference between the two values should be as small as possible and preserve within optimum limits imposed by the necessity of conservation and the normal functioning of the system under analysis.

Self-regulation is produced when not only the output value is kept dependent to the input value, but also in reverse, in order to eliminate the "disturbances"that appear along the way as well as of the preservation of the system under its optimum functional parameters, the input being controlled by the output.

The aim of regulation in a cybernetic system is to keep up all its functional parameters within some constant limits, i.e., to have a "stabilizing " function for the command. This happens because both inside the system and outside it a series of disturbances may occur which may divert the result of the action of processes or phenomena that take place in the system from the command value.

Regulation and self-regulation can be performed, in cybernetic systems, either by “correcting”the deviations of the real values from the norm(or command value), or by a compensation or removal of the disturbances that made them, by comparing the command value –the input- with the result value – the output.

This operation presupposes “an inverted”action, the so-called reverse connection or feed-back or retroaction which closes up the chain of connections between all the elements of the system..

The reverse connection represents the fundamental notion of regulation and self-regulation, being the elements that coordinate cybernetic system functioning.

The reverse connection represents the fundamental notion of regulation and self-regulation, being the elements that coordinate cybernetic system functioning.

The system components linked by means of direct and reverse connections, the regulated system and the regulating one which, together, make up the geo-cybernetic system of management and organization in the territory.

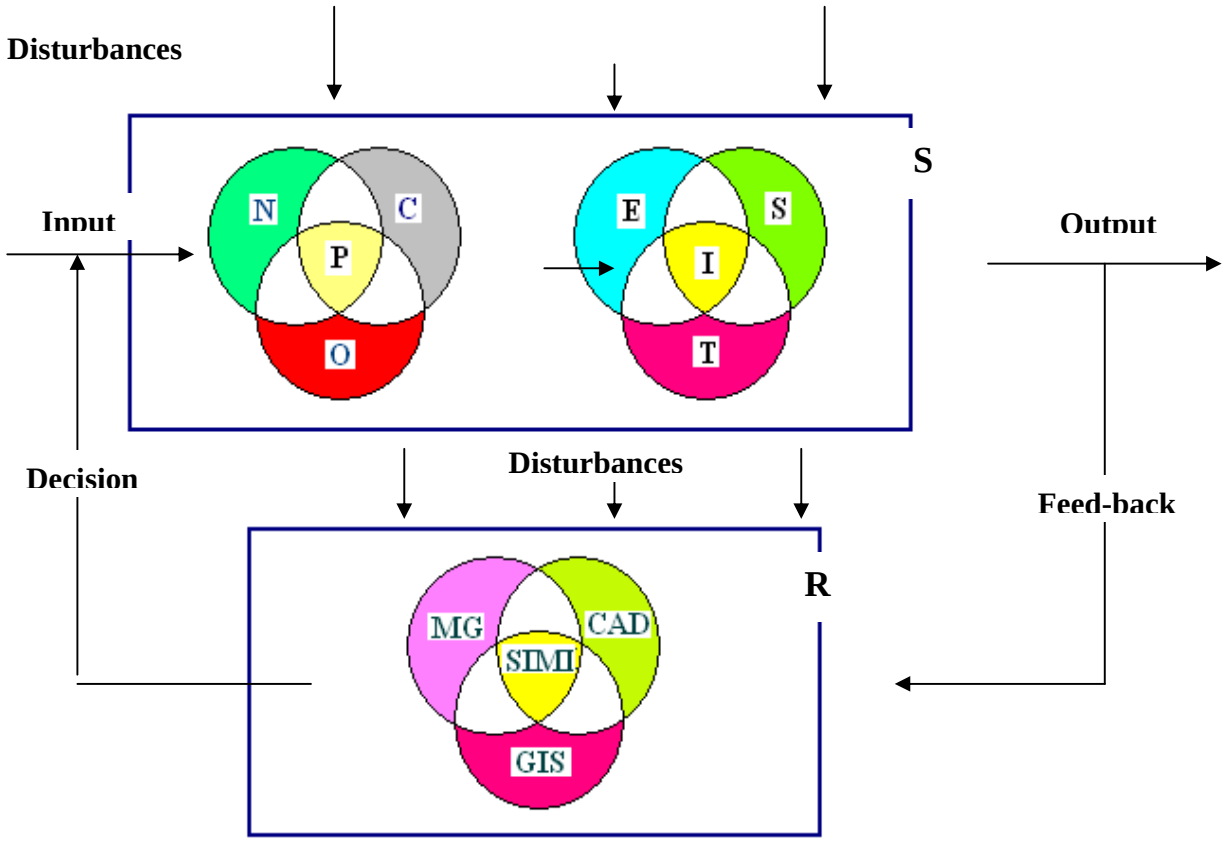


Fig.4: ***The Geo-Cybernetic Block Scheme of Environmental Management***

Corresponding to the cybernetic concepts, the specific notions of organization and control as well as of the personal points of view shown in the previous chapters, the geo-cybernetic block scheme of Figure 4 represents ***the synthesis*** of all the ideas that make up the **concept of "geo-cybernetics"**.

5. CONCLUSIONS

The whole problem presented in this paper needs some extra information to be better understood:

- Our life on the Earth requires a different way of approach in as far as Man- Nature relationship is concerned.
- Science, in general, that is present in almost all the activities of transformation characteristic to human activity in relation to Nature must adapt itself and work out according to the new requirements of a sustainable development as well as to the environmental protection as such.
- The definition we gave to "information"different from the one given by Wiener may contribute to a more consistent approach to the concept of management and to the act of decision- making as well.

- On this basis, **geo-cybernetics** may become a discipline or a study program, a specialization, perhaps, with a curriculum adapted to the new requirements.
- The ideas presented here contain, cybernetically speaking, two categories of information: the knowledge I gathered in time from all types of sources I have studied and whose essence has been used here in this paper as well as **the personal contribution underlined and written in blue**.
- For the sake of simplifying the text from a graphical point of view I gave up giving numbers with extra signs.
- For the sake of simplification, I also made a selection of the bibliographical titles.

REFERENCES

[1] Wiener, N, *Cybernetics,* Scientific Publishing House, Bucharest, 1966.
[2] Klaus, G., *Cybernetics and Society,* Political Publishing House, Bucharest, 1966.
[3] Lange, O., *Introduction to Economical Cybernetics*, Scientific Publishing House, Bucharest 1967
[4] Ross Ashby, W., *Introduction to Cybernetics,* Technical Publishing House, Bucharest, 1972.
[5] Stangu, I., *Doctoral Thesis,* The University of Agricultural Sciences, Bucharest, 1978.
[6] Stangu, I., *The Cadastre – The Interface between Human Society and the Environment,* FIG, XXII International Congress, Washington, DC, 2002

BIOGRAPHICAL NOTES

Eng. Ioan STANGU, Phd., Associate Professor in Topography and Land Management, "Lower Danube"University. Cadastre, Management and Protection of Environment Department, Galatz, ROMANIA**. FIG Academic Member.**

CONTACTS

„Lower Danube"University of Galatz
47, Domneasca Street, 800008 Galatz, ROMANIA
Fax: (+40) 236 461353

Private Adress: Melodiei Street, nr.16, Bloc C12, ap. 6,
Code 800062
Galatz, ROMANIA

E-mail: istangu@ugal.ro
Phone: +40336435779
Fax: +40336435778

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