Information support for strategic management processes’ in geoecology and agriculture

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Abstract. The report discusses the current situation in the field of information support in solving the problems of sustainable development of regions in their application to the field of knowledge in geoecology and agriculture. The basis for such a combination of these areas of practical activity is their structural unity in the original object of study. The purpose of the research is to develop “human-machine” systems for making optimal management decisions in the field of strategic management of sustainable development processes of territories at the global, regional and local levels of the organization. Object of research: active, including “dissipative”, complex organized systems of the class “nature” – “society”. The starting points of the methodology and management theory are the following concepts: unified Field Theory (late XX century), new “Scientific revolutions” and “Sustainable development of regions”; the leading scientific methods are “noospheric” and “geosystem” approaches. The research results and their practical significance lead to the conclusion that it is necessary to move from differentiation of all available knowledge about Nature and Society to their full integration.

1. Introduction

From the Concept of “Scientific revolutions” (Kuhn T, 1962) it is known that modern science cannot develop successfully without regular methodological rethinking of its fundamental foundations. Today, in the Earth and Society Sciences, this is the process that we observe, since the beginning of the new century, there is a fundamental rethinking of the old (or “mechanistic”; Newton I, 1687) paradigm and the transition to a new natural science knowledge and paradigm: “noospheric” thinking. Vernadsky V I this theory characterized by an indissoluble “connection of the laws of nature, thinking and socio-economic laws of the development of society”. Today the main task for our civilization is to solve the problem of sustainable economic and social development. For the first time this problem recognized since the work of the Commission of Brundtland G H (1967); later it accepted by the world community as the “Concept of sustainable development” (CSD in the abbreviation of the UN, 1993; in Russia – three years later).

Unfortunately, still this Concept not perceived by fundamental science as a new scientific Paradigm of the XXI century. So, despite the considerable efforts of science, today it is not clear how to implement it in the current practice of managing the development of territories at different levels of the organization of the planet, how to achieve the goal formulated in it, or at least objectively assess the degree of approximation to it?

Thus, regardless of the achieved level of natural science knowledge about Nature and Society, the correct and effective solution to this problem mainly reduced to the function of strategic
“management” of the processes of sustainable development of the planet in space and time. At the same time a special role is assigned to the study of the function of their full information support, and, as part of their adequacy to the Concept of “Pure reason” Kant I and widely known philosophical laws of dialectics. This requires special development of technologies, methods and models for making optimal strategic decisions (artificial intelligence systems, data banks and knowledge, neural structures and networks, methods and models of decision-making, etc.). Therefore, to put it briefly, the subject of this report is to answer the question: what exactly, from the side of fundamental science and computer science, can we offer today for the practical solution of the entire complex of problems of CSD?

2. Materials and methods
All the initial materials research methodically divided into two consecutive parts: methodology, theory, conceptual apparatus and technologies, methods and models of strategic management of territories at the global, regional and local levels of the organization of the planet. Thus, these subsections reflect the essence of the report.

The first part of them include. The Concept of “Pure reason” (Kant I, 1781-1790) and the General laws of dialectics (Hegel G, 1817). A New paradigm of the system representation of the world (“Unified field theory”, etc.; the end of the XX century, UFT [1-3]). The system and normative approaches (in terms of the study of “ratio”, or a preliminary adequate study of “the reasonable beginning, principle, meaning” of any phenomenon; Huizinga J, 1938 [4]). The initial theories in the study presented as follows. The theory of the “noosphere” (Le Roy E and Chardin P, 1927; Vernadsky V I, 1933 [5]). Fractal geometry of nature (Mandelbrot B, 2002 [6]). “Geosystem” approach (“basic principles and criteria of system thinking”; Capra F, 1991 [7] and as well as the theory of unity of “micro-“ and “macro-”organizations of the world around us [8]) and “A new theory of entropy” (Panchenkov A N, 1999 [9]) and other works. The conceptual apparatus and practical aspects of its use determine the work. The basics of “Theory of Morality-as-Cooperation” [10], concept of “noocracy” (it is considered as “a new global society based on science and knowledge”), concept of “Knowledge Industry” and methods of technology of “Reengineering” (Stonier T, 1987; “information as the most important input resource of modern production” [11]), synergetic and dynamic information theory [12], “noospheric” thinking and environmental consciousness [13-14]. All the items in this section methodically represent the “metaknowledge” for geocology (2017).

The main methods of research. Game theory (Neumann J and Morgenstern O), NBICS (nano-, bio-, info-, convergent and socio-humanitarian technologies), GIS, GRID, “Blockchain” systems and technologies, BIGdata, neural networks, artificial intelligence systems (AI), self-learning systems (SOMS), virtual models (VIM), games with Nature (“Game against Nature”) and games with “non-zero-sum”. All of them must be supplement by other previously known laws and rules. For example, they include, in particular. “The mathematical theory of the struggle for existence” (Volterra V, 1906), “plate of tectonics” (Wegener A, 1912), “the principle of minimum entropy growth” (Onzagher L, 30s of the XX century), the economic theory of “equilibrium” (Nash D, 1950), “Exergy” (Rant Z, 1956), laws and rules of “environmental axiomatic” (Reimers N F, 1994). In general, there are more than 150 of them.

3. The results of the study and their discussion
According to the generally accepted practice in academic science, the solution of all the declared scientific, technical and technological problems carried out according to the following scheme: “object” => “subject” => “methods” of research. At the same time, the methods and technologies of “Knowledge Industry” and “Reengineering” actively used, that is, operations previously performed to rethink and re-evaluate all known scientific achievements and modern approaches to the use of information technologies, which are necessary for making optimal decisions at the strategic level of management. As a result, the following directions and separate aspects of all stages of studying the problem.
First of all the definition of the term “management” clarified from these positions. We know that in modern philosophy under this term understood certain mathematically and logically generalized “function” of any (inert and living, “conservative” and “dissipative”, biological, technical, social) complex organized “systems”. It provides practical implementation of the following aspects of their appearance, existence, functioning and development: a) “preservation of the structure – maintenance of the mode of activity; b) implementation of its program and goal of development”. Here it also emphasized that this term is fully adequate to the theory of the “noosphere”, the conceptual apparatus of strategic management and all other provisions of Section 2.

From the standpoint of the General theory of control of complex systems (Wiener N, 1968; Bertalanffy L, 1969; Haken G, 1980; Prigogine I, 1990 and others), the first-initial and fundamental problem is the conscious choice of a modern scientific paradigm, within which is assumed to study and solve all questions of future optimal management of them. Today we know two scientific paradigms: “mechanistic” and “noospheric” thinking. If we follow from synergetics and dynamic information theory that the latter always “is a remembered choice of one option from several possible and equal” [12]. Thus, the choice of one of the two paradigms is inevitable. Hence, if we follow epistemology when studying the fundamental foundations of the courses, it is clear that when the initial paradigm changes, our thinking about the phenomenon under study must also change a priori.

To explain the possible solution of this important question for the theory of CSD, we can use the principle of “correspondence” by Bohr N, 2013. It state: “the change of one natural science theory to another reveals not only a difference, but also a connection, a continuity between them that can be expressed with mathematical precision”. Graphically, the general informational meaning of this principle shown in figure 1, where the old and new paradigms are conventionally designed as two circles of different dimensions (they are designated as I, II).

![Stages and directions of solution search](image)

**Figure 1.** Variants of three possible information States two scientific paradigms or scientific theories.

From figure 1, it follows that full compliance with this principle achieved only in the third option of their information states (“c”), when the main condition mathematically provided and implemented. It follows that the “particulars” of the old paradigm or theory in relation to any “hypothetically” advanced and newly proposed form of scientific knowledge about Nature and Society in principle should not contradict each other.

The concept base of modern “noospheric” thinking is determine by both the newest paradigm and the one that follows from it and all other natural science knowledge, such as [13-14]. The main physical and informational characteristics of these two (“thermodynamic” and “noospheric”) modern
paradigms of system representation of the world were published earlier in one of our works ("Metaknowledge" for geocology: methodology, theory and conceptual apparatus. Preprint No 225. Khabarovsk: CC FEB RAS, 2017 pp 45). Based on the system analysis and synthesis of its comparative characteristics, the following constructive conclusion was made: the physical and experimental proof of UFT and the “New entropy theory” [9] in their unity completely “close” all the must be specially marked main (according to “ratio” – the initial) methodological and theoretical problems of CSD. Moreover, theoretically, the measure of expanding our knowledge in such a transition to a new paradigm should grow by at least 6.8 times! (according to Wheeler’s J calculations of “The Planck energy density of physical vacuum and nuclear matter” [3]).

Hence, as the initial object in the study, the Active Complex organized Systems (ACS) of the class “nature <= society” are accepted. The subject of research are the concepts of “balance” and “Sustainable Development”, CSD. Thus, physically ACS are mutually integrated integrity of systems and objects, the properties of which cannot be reduced to the properties of their constituent subsystems and are considered as living systems, where the main driving mechanism of functioning and development is conflict (under conditions of uncertainty). Hence, the practical implementation of CSD considered methodically and technologically as a sequential transition of the research logic from descriptive to constructive and, further, to normative aspects of interaction between Nature and Society at all required levels of management of global, regional and local nature management, but with their specifications. Also, on the basis the principle of “complementarity” by Bohr N, 1913 [14], the following concepts were defined. For the ACS as the initial “object” of management a system definition given and underlined the next circumstance. Conflict under uncertainty, as well as a general area of knowledge (specialty 25.00.36 “Geocology”). While “ecology” was defined as the area of knowledge about the forms of existence and the limits of interaction between geospheric shells (or, by Armand A D, 1968, of geosystems of a higher level of organization of the planet: cosmo- (or so-called to “the first” Lagrange’s point space), litho-, pedo-, hydro-, atmo-, bio-, anthropo- spheres).

We note that this representation of the original object of research (ACSC) was the basis for combining similar fields of knowledge (or “ratio”), such as geocology and agriculture. This is explained and proved by the fact that in practice they are fully adequate to the above seven main elements of their “participation” in any material (or production) cycles of functioning and development of regional territories. However, they differ in mass and time of their implementation: for the first – it usually expressed in thousands and millions of years and, as a rule, the planetary scale of material and physical changes (“plate tectonics”); for the second – it is usually “annual” cycles of development.

Hence, for geocology (and therefore for agriculture) in general, the following formula can be proposed. GP, LR (object – are the planet's geospheres, subject – are life-supporting resources); = > BS, NS (initial theories – are biosphere and “noosphere”); → CE, SD (goal – the conditions of “Equilibrium” and “Sustainable Development”); GL, RL, LL (management levels – global, regional, local); CU (the main property of their functioning and development – conflict under uncertainty). According to our estimates, in order to make effective management decisions at any global, regional, or local level, at least 24 separate theories, terms, and new concepts (according to the principle of “complementarity” by Bohr N, 1913) are necessary, outside of which the implementation of CSD is in principle impossible. For the “subject” of the study – (the concepts of “Equilibrium” and “Sustainable Development” of the ACS, technically and technologically they require the development of future automated systems for making management decisions, ASMD) – we have introduced a block of “meta-knowledge” of all natural Sciences about the Earth and Society. They are logically (theoretically, methodically and technologically) related knowledge of the highest level about the object, subject, problem (task) subdomains and methods of research of each of the complex of Earth Sciences, Society and Natural science the general objective function of which is aimed at making effective management decisions in the process of their mutual “co-evolution” (Timofeev-Resovsky N V, 1968).
As a complete result of the research, the following target function was proposed for all levels and functional directions of management decision–making: “min” of losses of initial natural matter with “max” of material and social benefits received. At the same time, the General material basis, including the entity will be study, is the concept of “entropy”. Here, as an explanatory example, we can give the following well-known physical example. So, according to Hawking S, all reasonable scientific and practical activities of people at all times, by and large, can be reduced to a single scheme: this is a consistent “binding” of the free entropy of the Universe into its newly organized and necessary forms for man today and in the future [1].

According to experts of the United Nations (1985; Environmental aspects of the activities of transnational corporations: A survey. N.Y.: United Nations, pp 144), the CSD should include three main groups (or spheres of life and activity of the society): current and future production, consumption, and state (human and environmental). In a broader context, it requires that the following five components of sustainable regional development mutually linked: “production activities, consumption of natural resources, the state of ecological systems, environmental quality and human well-being”.

In 2017 at the Computing Center of the FEB RAS (Khabarovsky) the project “national concept of sustainable development (NCSD) Russia” was completed [13]. At the same time, (in 2009), two new (informational) properties were developed (in addition to the previously known 14 [7]): “Information complexity”; “time factor” (table 1). They are essential for information support of CSD and ACS at all, including strategic, levels of management of processes of sustainable development of regions. As the highest measure of moral evaluation of “noospheric” thinking and all the results of calculating possible options for strategic management, seven basic rules of confessional and cooperative behavior should serve [10]. The main methods for solving such problems are “Game against Nature” and games without zero sum (“non-zero-sum”).

| Table 1. Principles and criteria of system thinking, the most important information properties of complex systems. |
|---------------------------------------------------------------|
| **The “thermodynamic” paradigm** (“object-oriented” approach) | **The “noospheric” paradigm** (“normative” approach) |
| **Information complexity** | **Time factor** |
| Research and analysis of the information state of active systems based on the study of the information characteristics of its individual parts. (The information complexity of system regulated by the information flows in its subsystems). | The study of active systems based on the generality of its information state, determined by the unity of its structure and the dynamics of processes occurring in it. (In the active systems each of the new structure characterize by new processes and information flow, which is not reduce to a simple change due to newly acquired or lost functions of the system). |
| **Time factor** | System management provides for the achievement of “attractor-structures”. In this case, time is not the initial input parameter, but it is determined in the process of optimizing the structure of the transition of the active system from one state of the system to another. (Time is “secondly” in relation to the structure of the transition). |
| (Time is the initial parameter for system object management). | |

Under “attractor-structures” in synergetics are understood the “such real structures in open nonlinear media that are affected by the processes of evolution in these media as a result of the attenuation of transient processes in them (Knyazeva E N and Kurdyumov S P, 1992).

In the information field of “management” of the ACS class “nature ↔ society”, logically, methodically and technologically, two organizational levels should be distinguished (or information “subdomains”): “internal” and “external”. The first directly related to the natural (physical) laws of the
development of Nature (including and a man, as the highest biological and social being, who is simultaneously both the “object” and the “subject” of management). The second determined by the current level of our thinking, as well as the material and technical capabilities of Society as a whole.

Further, in the task sub-district of management, seven classes (three groups) were allocate for future solution of specific practical tasks: interpretation, diagnostics and monitoring, planning and reconstruction, forecasting, management (their grouping is associated with the possibility of using direct and reverse logical output in the ASMD). Thus in the all management processes in general, one should distinguish between two different informational areas of research. First, the “strategic” management (in addition to baseline data, in the process carried out optimization calculations should use known mathematical “scale relations”). Second, “tactical” management (at the time of planning, it is only short or a medium-term); here it must be limited to only raw data. It should also be note that the tasks of interpretation are among the most difficult for practical implementation, since they directly depend on the level of knowledge we have achieved of the surrounding world at whole. The next two classes by definition do not require the use of any methods for optimizing decision-making; in them, it is enough simply to switch to the “scale of order” known from mathematics. Other classes of problems cannot solved directly without using a common objective function and a class of optimal control methods and models.

Let us briefly consider the last statement on a conditional example of the structure of the main elements of sustainable development of regions, which presented in figure 2. Here in the quality of first materials were use: Virtual Laboratory Wiki. Electronic resource. URL: http://www.wikia.om/finam.fm/archive-view/3026/ (accessed 12.05.2014).

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**Figure 2.** Example of a general information structure of regional sustainable development schemes.
In this scheme first three initial blocks that determine the theoretical basis of the object of research: a complex organized system (ACS; in this concrete case, its object restriction introduced in the form of a complex "economy – population – nature"; EPN (Keshienko S K, Polumienko S K and others, 2008). At second, if graphically, to highlight the centers of these blocks (relatively, it dots 2-3-4 points), then in general the sustainable development can be reduce to a procedure of their movement in the direction of the possible bias to the center of the figure, or its unshaded region. In figure 2 marked by arrows pointing from positions of decision makers (DM), the dynamics of the “desired movement” of his theoretical thought. Either as defined in the formulas (1), (2) [13]; figure 1 “Structure “metaknowledge” algorithms of the geocology – a technology and methods for searching for a complex optimum. At third, if the DM in this scheme is designated as point 1, and points 2-3 and the arc located between them, as well as the entire dark area of one of the directions of the sustainable development (“habitable world”) are taken as a phase (information) space of all theoretically possible (under uncertainty) actions of DM (1). Then they all can be consider as complex probabilistic events. This explains the “duality” of the positions of points 2-3. Then the entire process of optimal management of such a system and its results should theoretically be located inside a “closed region” bounded by three arcs and points 2-3-4.

For this level, the proposed control scheme provides for the process of forming a new “structure-attractor” on any territory (in principle, this is a physical analogue of the well-known term from geography and ecology and the concept of “Ecological framework of the territory”, EFT; Vladimirov V V, 1982). Today, under this term, we understand “a stable set of elements directly related to the ecological state of the territory of the “core” (or so-called “sustainable modes”) “attractor structures” of the ACS, which physically and informatively ensure its stability, balance and sustainable development in “space – time”; (for more information, see: other works of the author). In this case, by analogy with the known DNA and RNA, “system” as a special material structure, “secondary”, and “frame”- “primary”.

Therefore, all of the environmental policy in the strategic management of regions propose could be considered as follows. First, all expenditures on “people” (Society) and environmental measures are “investments in the future and a means of achieving competitive advantage” [7]. Secondly, in the strategic management of such resources the main attention should be on maintaining the structure and stable functional state of the “core” of the studied ACS. Technically and technologically, this is a way to implement the well-known principle of “equifinality” by Bertalanffy L, 1950: “a system can reach the same final state under different initial conditions”. We consider this provision as the main methodological way to achieve optimal functioning and development of the system. An example of calculating the optimal solution – in the form of a “saddle” point – presented in [13].

4. Conclusion
The solution to the problem of information support for the processes of sustainable development of regions is essentially the result of a correct understanding, interpretation and calculation by each researcher of the initial beginning, essence, principle, meaning and purpose of CSD as a dynamic process of ACS. For it should be based the transition to a new Concept of system representation of the world. In the future, this will significantly increase our fundamental knowledge of Nature and Society, as well as the environment of our planet as a whole.

However, new scientific approaches, methods and technologies needed to ensure the optimality and effectiveness of such solutions for the practical implementation of strategic management courses. Currently, they are not already fully defined and developed. Today, fundamental science and computer science can offer the following promising areas of research: Game Theory, including "Game against Nature" and games with “non-zero sum”; NBICS (nano-, bio-, info-, convergent and socio-humanitarian technologies), GIS, GRID, “blockchain” systems and technologies, BIGdata, neural networks, artificial intelligence systems, self-learning systems, virtual models (VIM). According to our estimates, the development of VIM models and methods for solving games with “non-zero sum” is the most important for us now. The first allow you to move from 3-dimensional to multi-dimensional,
including graphical representation of data and knowledge of sustainable development processes in “space – time”; this is the Concept of “Neogeography” (“mixed” GIS-technologies, “vector” + “raster” representation of ACS; Turner E, 2006). Second, it makes it possible to repeatedly reduce the time for solving large-scale (or BIGdata) and logically complex strategic management tasks, including significantly increasing the variability and optimality of their solutions. The combination of all of the proposed effort will allow us practically to come to grips with the theory of “noosphere” and the Concept of “noocracy”.

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