Ministry of education and science of Ukraine
V.N. Karazin Kharkiv National University

INFORMATION GEOGRAPHY & GIS

Textbook

Kharkiv – 2023

UDC 911: 004] (075,8)
I-60

Reviewers:

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Recommended by the decision of the Scientific and Methodological Council of V.N. Karazin Kharkiv National University (Protocol № 4 of January 25, 2023)

I-60 **Information** geography & gis : textbook / K. Niemets, K. Kravchenko, P. Kobylin, I. Telebienieva. – Kharkiv : V. N. Karazin Kharkiv National University, 2023. – 92 p.

The textbook is a theoretical and methodological basis for studying the selective course "Information Geography and GIS" for students of educational qualification level "Bachelor" in the specialty 106 "Geography", Educational Program "Economic, Social Geography and Regional Development". It can be useful when studying pecial courses such as: "System and Spatial Analysis in Human Geography", "Scientific Workshop", "Information Technologies in Areal Management", "Human-Geographical Forecasting", "Methodology and Contemporary Technologies of Human-geographical Research".

The textbook is designed for full-time and part-time students of geographical specialties of universities of I-IV accreditation levels, as well as university lecturers, geography teachers and all those interested in information theory, evolution of systems, general theory of systems development, synergetic, study the basics of the information concept of interaction between society and nature.

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CONTENTS

GENERAL PROVISIONS

The course "Information Geography & GIS" is a selective one in the bachelor's training in the specialty 106 Geography, educational programs “Economic, Social Geography and Regional Development”, “Geography of Recreation and Tourism”, and it is based on the knowledge gained by students in the study of such disciplines as higher mathematics, probability theory and mathematical statistics, physics, computer science with geoinformatics, geoinformation technologies, philosophy, history, and methodology of geographical science, human geography, physical geography, modeling of human-geographical processes, etc.

Students gain basic knowledge of information theory, information theory of systems evolution, general theory of systems development, and synergetics, learn the basics of the information concept of interaction between society and nature during this course.

It combines general scientific approaches (mathematical-statistical, mathematical) with the methodological foundations of human geography, which allows students to create competence relating to the processing of statistical data, construction of statistical models, and correct processing of geoinformation data.

This course is taught after the course "Theory and Methodology of Human Geography", which allows students to understand the role and place of information and statistical methods in the geographical methodology. On the other hand, it precedes many other special courses for the educational programs “Economic, Social Geography and Regional Development”, “Geography of Recreation and Tourism”, creating favorable opportunities for the application of information theory and statistical methods in performing independent tasks from these courses.

The purpose of the course is to form students' competencies regarding the essence and mechanisms of information processes in social and geographical systems, as well as the approaches and methods of their research.

The subject of the course is the study of the theoretical foundations of information theory and synergetics as a science about the self-development of social and geographical systems, their interaction, and specific methods of information analysis of the socio-geographical process.

Course objectives:

- to form students' modern knowledge about the types of information exchange and kinds of information in social and geographical systems;
- to form students' knowledge about the mechanisms and essence of information processes in social and geographical systems;
- to form students' ability to use research and analysis methods of information processes in social and geographical systems;
- to form students' competence in using information indicators in socio-geographical research.

Course content: information as a measure of uncertainty and heterogeneity of socio-geographical objects; information models of social systems and environmental management.

Educational and methodical support:

1. Niemets K. Kravchenko K., Kobylin P. Telebienieva I. Information geography & GIS: textbook. – Kharkiv, 2022. – 107 p.
2. Niemets K.A. Training program ***SYSMODALL*** for the analysis of information indicators of system evolution depending on the principle of formation of hierarchical levels. 2008. (archive of the department);
3. Niemets K.A. Training program ***INFENTROP*** to determine the development trajectory of a given system (development direction). 2009. (archive of the department).

As a result of studying this course:

Formation of general and professional competences:

– ability to use information technologies, skills in using software tools;
– ability to system geographic thinking;
– understanding the cause-and-effect relationships of development and interaction between nature and society and the ability to use them in professional, social, and pedagogical activities;
– capability to apply basic knowledge of fundamental sciences when studying natural and anthropogenic geographical systems of different hierarchical levels;
– ability to use theoretical knowledge and practical skills to model various aspects of the territorial organization of society's vital activities;
– ability to apply the skills of working with statistical data, collecting, summarizing and processing statistical information reflecting the state of public territorial systems;
– cartographic competence: the ability to provide a comprehensive geographic assessment of the territory based on the results of map analysis, the capability to display geographic objects and processes using cartographic works;
– ability to use geographical information technologies to solve experimental and practical tasks in the field of geography.

Ensuring the achievement of the following program learning outcomes:

– basic knowledge of social and geographical sciences: object-subject area, conceptual and terminological apparatus, theories and concepts, laws and regularities, research methods, etc.;
– basic ideas about the territorial organization of society, concepts of territorial structures;
– theoretical foundations and applied aspects of the application of geoinformation systems and technologies in geographical research;
– to collect, process, analyze and systematize scientific and technical information to solve geographical problems;
– to build cartographic models, design cartographic works using contemporary methods and technologies;
– using methods of remote sensing of the Earth, to be able to recognize geographical objects and processes and apply them for the analysis of environmental parameters;

- using digital data, algorithms, maps, to be able to use computer and geographical information systems;
- to use special software to process statistical data and obtain new information about natural and social objects and processes;

students must learn the concepts: information geography, socio-geographical process, information component of socio-geographical process, information as a set of data, information as a measure of organization (heterogeneity, diversity), information as a reflection of the trajectory of the system, geographical space, socio-geographical space, information-socio-geographical space, synergetic paradigm, information-synergetic paradigm of human geography, attributive (aspect) and functional (typing) concepts of information, chaos, dynamic chaos, structure, system organization, information entropy, heterogeneity, actogenesis, purpose, means, methods, actogenesis conditions, executive system, direct, reverse links in the management system, systems controllability and observation, thesaurus, types of information exchange: managerial, adaptive, cognitive (active and passive), types of information: managerial, adaptive, monitoring, operative, structural, valuable information, social information and its functions, information resource, mechanisms of information exchange in biological systems, mechanisms and means of information exchange in social systems, perturbation criterion, systems evolution, multisystem of environmental management, evolution multitrajectory, information criteria of evolution, management systems of society: anarchy, democracy, authoritarianism, information thresholds, phase transitions of the global social and geographical systems, lithogenesis, biogenesis, sociogenesis, noogenesis.

Students must be able to: analyze philosophical approaches to knowledge of information processes, use the concept of "information" to describe the state of systems, analyze the system of goals, tools, methods and conditions of actogenesis, build input and output vectors of controlled system, distinguish types of information exchange and types of information in specific situations, to quantify information in simple processes and phenomena, mechanisms of information exchange in natural and social structures, to analyze social and geographical systems in terms of information criteria of evolution, to apply information criteria to optimize the environmental management.

THEMATIC CURRICULUM OF THE COURSE

Chapter 1. Information as a measure of uncertainty and heterogeneity of socio-geographical objects

Topic 1. Information as a scientific concept and as a characteristic of social and geographical systems

Lecture 1. Basic concepts and definitions of information geography

1. Definition of information geography. Object and subject of information geography.
2. The concept of "information", its interpretation and evolution.
3. The concept of the information component of the social and geographical process.
4. The place of information geography in the system of natural and human-geographical sciences.
5. History of information research in natural and social sciences.

Lecture 2. The concept of space in information geography

1. Definition and role of fundamental concepts of human geography:
"Geographical space", (coordinates of the geographical space), "human-geographical space", (coordinates of the human-geographical space), "information-human-geographical space", (coordinates of the information-human-geographical space).
2. Multidimensional sign (phase) space of the human-geographical process.
3. Coordinates of the phase space, their significance in information analysis.

Lecture 3. Role of information in the development of social and geographical systems

1. Functioning of information-human-geographical space.
2. Conditions and criteria for the development of social and geographical systems in the information-human-geographical space.
3. Role of information and information exchange in the Universe self-development.
4. Synergetics as a science of self-development of systems.
5. Philosophical approaches to determining the role of information and knowledge of the world.

Lecture 4. Information resource of society

1. The concept of socio-actogenesis as an active way of society interaction with other systems, the role of information in it. Determination of compromises in actogenesis. The concept of the executive system. Information flow in actogenesis process.
2. Epistemological criterion of environmental management.
3. Information exchange and types of information in the environmental management.
4. Information resource, its role in society.

Lecture 5. Social information

1. Quantitative and semantic evaluation of information.
2. K. Shannon's formula and its use in the applied information analysis.
3. Types of social information and its functions.
4. The role of social information in development of society and social management.

Chapter 2. Information models of social systems and environmental management

Topic 1. The role of information in the interaction of systems of different nature
Lecture 7. Information exchange in natural and social systems

1. Information exchange in natural mineral and biological systems: levels, mechanisms, consequences.
2. Information exchange in social systems: individual, social levels.
3. Basic principles of information interaction of social and natural systems.
4. Information concept of interaction between society and nature

Topic 2. Information models of social systems and environmental management
Lecture 8. Information contradictions of environmental management

1. Environmental perturbation and information. Perturbation criterion.
2. Linear and nonlinear information models of environmental management.
3. Optimal, risky and inefficient trajectories of environmental management.
4. Information contradictions of the environmental management
5. Ways to resolve dialectical contradictions in the multisystem of environmental management.

Lecture 9. Strategy and tactics of environmental management. The role of deterministic and random processes in the evolution of social and geographical systems. Applied information analysis of social and geographical systems

1. Strategy and tactics of environmental management in terms of information exchange.
2. Information resource of society and the choice of the environmental management strategy.
3. Tactical features of environmental management.
4. Transformations of the executive system as a necessary element of environmental management.
5. Scientific and technical "breakthroughs" and changing the strategy of environmental management.
6. Stages of formation of information exchange in the multisystem of environmental management.
7. The role of information in evolution of social and geographical systems. Evolution information criteria.
8. Deterministic processes and their role in systems development.
9. Totalitarianism and autocracy as a result of deterministic processes predominance in society.
10. Ratio of deterministic and random processes in the social systems evolution.
11. Use of applied information analysis in social management.

Lecture 10. Geoinformation systems and technologies. Information concept of interaction between society and nature

1. Fundamentals of geoinformation technologies (GIS).
2. Method of presenting discrete geographical objects in geoinformation systems.

3. Basic functions of spatial analysis in GIS technologies.
4. Methods of sampling and construction of GIS field influence surfaces.
5. Integrated information model of environmental management.
6. Conceptual information models of society development and cognitive processes.
7. Information concept of interaction of society and nature: stages of lithogenesis, biogenesis, sociogenesis, noogenesis and the role of information resource in the development of social and geographical systems.

Topics of practical classes

Practical class No.1. Basic concepts and definitions of information geography

Practical class No.2. The concept of space in information geography

Practical class No.3. The role of information in developing social and geographical systems

Practical class No.4. The value of information resources for society development.

Practical class No.5. Approaches to determining the amount of information. Hartley’s and shannon's formulas

Practical class No.6. Social information. Information exchange in natural and social systems

Practical class No.7. Modeling the evolution of the hypothetical system, and determination of its development dynamics by the information criteria of complexity.

Practical class No.8. Strategy and tactics of environmental management. Estimation of the amount of information. Probability

Practical class No.9. Evolution of social and geographical systems. Information analysis of the evolution of social and geographical systems of the district or regional level on a set of statistical indicators

Practical class No.10. Geoinformation technologies. Spatial analysis in the GIS environment map info. Summing up

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2. **Нємець К.А.** Інформаційний ресурс суспільства як чинник соціального розвитку. / /Регіональні географічні дослідження України та суміжних територій. Міжнародна науково – практична конференція, присвячена 70 – річчю утворення кафедри географії Луганського національного педагогічного університету імені Тараса Шевченка, 27 – 29 листопада 2006 року, Луганськ, 2006, с. 157–159.
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ABSTRACTS OF LECTURES
CHAPTER 1. INFORMATION AS A MEASURE OF UNCERTAINTY AND HETEROGENEITY OF SOCIO-GEOGRAPHICAL OBJECTS

Concepts studied: *information geography, human-geographical process, information component of the human-geographical process, information as a set of data, information as a measure of the organization (heterogeneity, diversity), information as a reflection of the system trajectory, geographical space, human-geographical space, information-socio-geographical space, synergetic paradigm, information-synergetic paradigm of human geography, attributive (aspect) and functional (species) concepts of information, chaos, dynamic chaos, structure, system organization, information, heterogeneity of the system.*

Developing skills: *the ability to analyze philosophical approaches to the knowledge of information processes, to use the concept of "information" to describe the state of systems, ability to analyze the system of goals.*

TOPIC 1. INFORMATION AS A SCIENTIFIC CONCEPT AND AS A CHARACTERISTIC OF SOCIAL AND GEOGRAPHICAL SYSTEMS

LECTURE NO. 1.
BASIC CONCEPTS AND DEFINITIONS OF INFORMATION GEOGRAPHY

Plan:

1. Definition of information geography. Object and subject of information geography.
2. The concept of "information", its interpretation and evolution.
3. The concept of the information component of the social and geographical process.
4. Place of information geography in the system of natural and human-geographical sciences.
5. History of information research in natural and social sciences.

The presence of the spatial aspect in information transmission raises questions about the effectiveness of spatial communication channels, their optimization depending on the properties and characteristics of spatial organization, the availability of information in space, and the optimization of space itself.

All these issues are reduced to the territorial-functional analysis of the space, which is an integral feature of the traditional geographical approach. It combines complexity and territoriality in the object study. This proves legitimacy and expediency of including the problems of information exchange in the subject of geography, which has been happening in recent decades. Thus, there is the geography of communication systems studying spatial development of means and networks of communication that serve as channels for transmitting the information. A new direction of *information* *geography is developing nowadays,* which is aimed at directly studying the information component of the socio-geographical process and should conduct the direct link of geography with the sciences of the cyber cycle.

Information geography is defined as the science of generating, storing, and processing information in natural and social systems. *The object of* its research is an information component of the human-geographical process.

The subject of the study of information geography is human-geographical conditions of information generation in social and geographical systems, its transformation and use in environmental management, and the harmonization of relations between society and the environment.

In addition, there are *information and cyber geography*. The object of its study is an information component of the human-geographical space, and the subject is management of the environmental management multisystem for harmonization of relationship between society and nature.

One of the ways of information communication is the storage of social information in a preserved form on various media, which allows to use it at the right time. According to this idea, for example, a traditional textbook contains scientific information in the form of a logically related text; this is a statement of fundamental laws, patterns, and theories of a particular field of knowledge.

The textbook becomes the scientific information when the information receiver is present, i.e., the subject. It arbitrarily uses the textbook in time as a source of preserved information, namely knowledge. We note that the textbook's author and a textbook serve as channels for transmitting information; its transmitter is society. Extending and projecting this idea on the information interaction of society and nature, extraction and mastering of structural information of natural systems by society in a more general form is the same way of transmitting information in another dimension of time.

Different types of messages are used to transmit scientific information in space and time: literary, audiovisual, verbal, graphic, electronic, and other ones. The value of scientific information may be different for each individual, depending on his thesaurus. Scientific information must be easily reproduced and disseminated relatively quickly in society.

At the same time, labor costs for its mastering are incomparably less than the costs for its generation. Formation of messages following specific standards and using effective methods and means of transmitting information enhance its physical and epistemological accessibility. Therefore, new scientific ideas and concepts are increasingly spreading through numerous social channels and becoming generators of active actions. It is necessary to dwell on this aspect of information in more detail (Niemets K.A., 2005).

Human-geographical process is a consistent natural change of situations in the development of societies in the historical and geographical continuum, changes in the social components of social and geographical systems in the space-time continuum. The components of the socio-geographical process are presented in Figure 1.1.

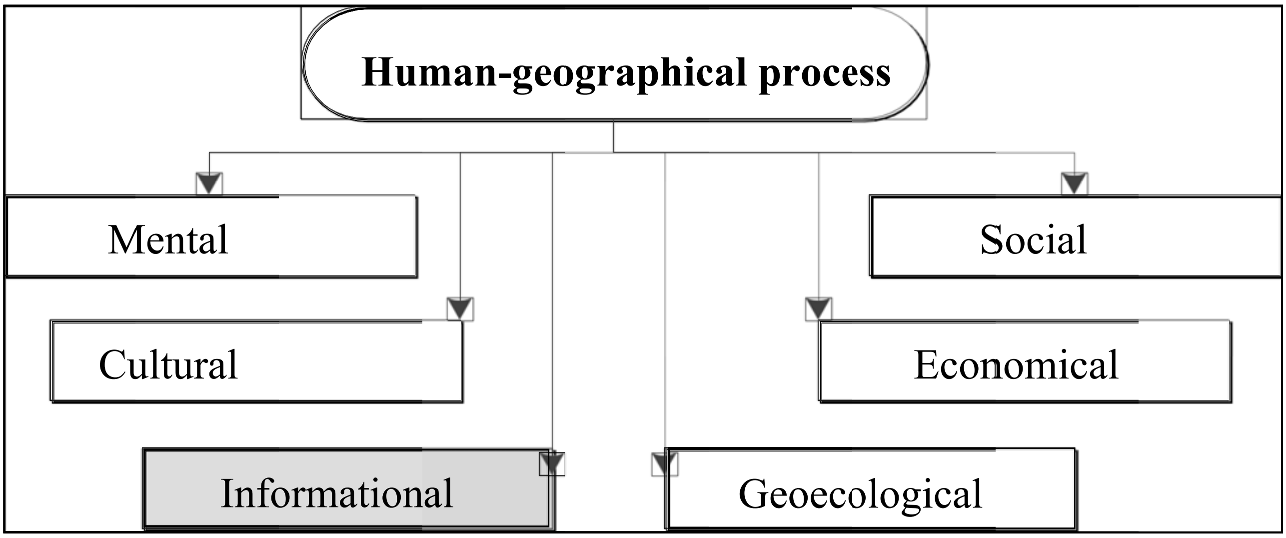

Fig. 1.1. Components of the socio-geographical process

The mental component includes processes forming the individual's mentality at the level of the small society.

The cultural component includes education, art, cultural process, and the formation of moral and spiritual values. It is necessary to create favorable conditions for the socialization of future generations.

The social component includes everything related to society's social development to ensure human social security.

The economic component represents the economic basis of existence and vital activity of society; it includes economic policy, economic thinking, priorities, etc.

The geoecological component shapes society's attitude to the environment.

The information component is the main object of the study of information geography; information processes are the most common processes combining all other components.

Nowadays, *information* has a very wide range of definitions and interpretations. It became a fundamental concept of contemporary science, having passed a complex and long path of discovery and understanding. In ancient times, information was understood as an explanation, an interpretation. Information remained out of the philosophers' and naturalists' attention, and they didn't consider as an object of study for a long time.

Now the *"information"* concept is so common in various spheres of human activity (science, media, politics, economics) that it seems well-studied and quite clear. In everyday life, information is often understood as any statements or data which are output and transmitted through various channels. In this most general sense, information, to a greater extent, reflects the ability and possibility of the subject to receive or transmit it. Therefore, it partially loses its value as a motive and a result of purposeful activity.

In the aspect of human activity, the "information" concept should have a pragmatic meaning. Information should expand the subject's knowledge about that environment segment, which is relevant for it and expects successful action at the moment.

The scientists were interested in the information, it became the subject of scientific analysis and acquired a variety of interpretations only in the second half of the twentieth century. Of course, this interest in information was not accidental. Formally, the reason for its research was the rapid communication lines development. It raised the issue of the reliability of messages' transmission, encoding, and decryption. However, as is often the case, it turned out later that the purely pragmatic meaning of information does not exhaust its importance in developing scientific and technical thought.

Scientists have found that information is essential to natural and social processes and systems. Therefore, along with the fundamental laws of the matter cycle and energy conversion, contemporary science had to find a way to reflect processes and phenomena in the information dimension. Probably, this is a manifestation of the objective regularity of scientific knowledge development, which has already become "tightly" in the usual material and energy representation of the world.

Studies of information, its essence, formation, cognition, transformation, storage, and transmission have become especially numerous since the mid-60s of the last century. At first, the scientists studied mainly the quantitative aspect of information. From the last decades of the twentieth century they focused on the value-semantic aspect, which essentially became the birth of the new scientific direction *of computer science***.** Therefore, the information has acquired the status of one of the fundamental concepts of contemporary science relatively recently. It reflects the most general patterns of the material world development.

Considering the information essence, it is necessary to consider that there are two opposite concepts of this term at the most general (philosophical) generalization level. The first of them, called *attributive* or *aspect* information, defines information as an objective attribute of the matter, regardless of its motion forms. This is a property of objects, which consists of their ordering. It follows from this concept that information reflects the heterogeneity of the matter and energy distribution in the space-time continuum. Object structure reflects space heterogeneity, and their evolution reflects the heterogeneity in time, i.e., the consistent change of parameters and structure. All definitions of the *"information"* concept, arising from the attributive concept, are related to information with the heterogeneity, diversity or order of phenomena and objects, etc.

It is important for geography that the *attributive* interpretation of this concept substantiates the idea of information exchange in inorganic natural systems. In particular, it follows that geographical and geological systems, which are sources of social needs, can generate, perceive, store and transmit information.

The second information concept, *functional* or *species one*, presents information as a functional phenomenon related only to the processes of self-organization and management. It follows that information is a property of only managed systems; the goal-setting is presented in their activity. Most scholars who support this concept refer to such systems as living and social systems and human-controlled systems. The analysis of geographical systems in terms of self-organization proves that the processes of optimization, self-organization and self-regulation can conduct in natural inorganic systems. It is due to the manifestation of the general laws of energy and matter conservation with the participation of positive and negative reverse links. It gives grounds to extend the functional concept of information to the class of inorganic systems.

Nowadays, most scientists who study information exchange problems in natural systems consider the attributive concept of information more authoritative. It is methodologically important to understand information as a reflected diversity, which means that various systems more adequately demonstrate the outside world. In other words, if the system evolves with a constant increase in variety (complexity), it can adapt more effectively to the environment, i.e., extract from it and process more information.

In the choice situation, the information reflects a certain degree of a particular option. When the system receives information from the external environment, it leads to its ordering, i.e., information becomes a measure of order. The concept of information is also associated with entropy denial, novelty or originality, complexity degree of the system, choice possibility, etc. Therefore, the specific meaning of this concept depends on the aspect of system interaction which is relevant in this case.

The vast majority of authors propose to call information as statements or data which not only removes some uncertainty about the world around, but is also used in practice. This turns the information and its analysis into a mandatory element of the chain of purposeful actions, i.e., determining the purpose of the planned actions and the means, methods, and conditions for achieving it.

From this point of view, the most characteristic is the definition of information proposed by G. Kastler (1967) and considered in detail by D.S. Chernavsky (2004), namely, ***information is a saved ("remembered") choice of one development option from several possible and equal***. In this definition, the keyword "saved choice" determines the information fixation occurring differently in systems of different natures.

Therefore, the natural inorganic systems fix the information obtained from the environment through the material exchange in the system's structure in the form of "preserved" structural information. The biological systems memorize the structural information at different levels, namely from phylogeny in the form of consolidation of some properties of organisms and the loss of others in the process of species evolution to ontogenesis in the form of the conditioned reflexes formation. The social systems remember the information through social experience and knowledge. Regarding the option choice, it should be noted that the choice can be random in the process of the system's natural evolution (then competing options can be considered equal) or forced by external influences, such as the management of this system.

The greater the amount of source information and the more accurately it is "deciphered" in explaining and describing the patterns of processes in natural systems, the greater the objective probability of reasonable and safe human actions in environmental management. The information is of the particular importance in the study and forecasting of social systems in the deepening of the socio-ecological crisis, the globalization expansion, and the transition to the information society.

The evolution of the concept of "information" can be defined in three aspects:

- a set of data about a certain segment of reality, reducing the uncertainty of the subject in this situation;
- degree of the heterogeneity, organization, diversity, and structure of systems;
- reflection of the systems evolution reflected in the structure of the system.

Considering society as a complex social system interacting with the natural environment, we inevitably understand that society's needs are not a random product of its development. Their formation is closely connected with the satisfaction possibility through the use of resources of natural systems. In this case, they are involved in the economic activity of society and, together with it, form a multisystem of environmental management with a certain energy reserve to meet any social need. One part of this energy is spent on meeting current social needs; the other one remains in the potential form. New knowledge (scientific information) through changing environmental management goals and developing more advanced technologies and means of environmental management releases the potential energy of the multisystem and directs it into active channel. As V.I. Kusherets notes (2003), scientific information is not a material engine of the multisystem. Still, it releases material forces (energy, material), translates them from the latent state to the active one, and activates environmental management.

This feature of scientific information and knowledge in general, namely the ability to initiate material actions in the multisystem of environmental management, gradually turns it into an essential strategic resource. In the future information society, the principal capital will not be land, production means, money and technology but information. It determines the emergence of property relations to scientific information. It becomes the most expensive product and can be accumulated, sold, and bought. The object of computer science is the scientific information turnover in communication channels, its processing, transformation, coding and decoding, and separation of obstacles.

The importance of semantic analysis and computer science in the transition to the information society will continue to grow. It allows considering scientific information and knowledge as a special kind of societal resource, namely information resource. This is a spiritual working factor of a new type that interacts with material factors and ensures the dynamics of social systems, causes an increase in free energy in the multisystem of environmental management at the expense of its entropy reduction.

Features of the information resource (V.I. Kusherets, 2003):

1. In contrast to material resources, the information resourse increases, not decrease during the society's development and knowledge consumption growth.
2. It has potential significance but manifests as a driving force when interacting with other resources (technical means, technologies, energy, matter, etc.).
3. The secondary knowledge production determines the usage effectiveness of the information resource. It means that new knowledge is acquired by less expensive information interaction, rather than their direct generation.
4. It becomes a direct productive force in the information society, which is associated with increased social labor productivity several times.

The information resource generation, its transmission speed, and the usage efficiency is determined by the power and level of the social communication system development and other factors of the information space functioning (K.A. Niemets, 2005).

Questions for self-control:

1. To justify the definition of the term "information geography".
2. Connection of information geography with other sciences.
3. Definition of the object of information geography.
4. Definition of the subject of information geography.
5. The main differences between information geography, computer science, and GIS technologies.
6. Definition of the concept of "information" as a set of data about a particular reality segment.
7. Information as a measure of the system's heterogeneity, diversity, organization, and structure.
8. Information as a reflection of the evolution of the system.
9. Attributive concept of information, its main provisions.
10. The functional concept of information, and its main provisions.
11. Information as a fundamental basis of the Geoversum existence.
12. The information component of the socio-geographical process.
13. The place of information geography in the system of natural sciences.
14. History of the research of information processes in nature and society.

LECTURE NO. 2.
THE CONCEPT OF SPACE IN INFORMATION GEOGRAPHY

Plan:

1. Definition and role of the fundamental concepts of human geography: "geographical space", (coordinates of the geographical space), "socio-geographical space", (coordinates of the socio-geographical space), "information-socio-geographical space" (coordinates of the information-social-geographical space).
2. Multidimensional featured (phase) space of the socio-geographical process.
3. Coordinates of the phase space, their significance in information analysis.

One of the important concepts of geographical methodology is geographical space. This is a set of places of geographical objects, relationships, and interactions between them (unlike physical space - the relationship and connections of objects differ the geographical space from physical one). The object of analysis in the geographical space is the object's location and its topological and positional (distance, neighborhood) properties. The distance can be considered as a metric characteristic of the geographical space (for example, Euclidean distance) or topological - as a neighborhood of different order (in particular, a neighborhood of the first order (adjacency). Multidimensional metrics are used in the multidimensional space. In addition, non-metric distance (Hamming's measure) is used in the multidimensional space (according to the number of matching features).

Continuity of the geographical space is inextricably linked with the concept of the field of the geographical parameters of objects. A field is a set of points within a field, their coordinates correspond to certain values of the geographical objects parameter. In a broader sense, the geographical field reflects the influence of one object, the interaction of different objects, the spatial distribution of a particular geographical parameter or a component of characteristic features, etc. The opposite concept is the discreteness of the geographical space. It is associated with the spatial representation of a set of individual geographical objects (taxa).

The dimensionality of geographical space is significant in spatial analysis. There are:

- zero-dimensional space (point one), geographical objects are points;
- one-dimensional space (linear one). It is related to distances, displacements, connections;
- two-dimensional space (planar one). It is related to the territorial distribution of geographical phenomena;
- three-dimensional space (volumetric one). This is an analog of physical space;
- multidimensional space (virtual, conditional). It is used for multidimensional classifications, formalizations, systematizations, and analysis.

An important element of spatial analysis is to clarify the territorial organization of social, economic and natural systems, which means:

1. Mutual location (mutual placement) of objects in the space of the earth's surface.
2. Presence of spatial connections between located objects on the earth's surface.
3. Existence of territorial social formations (combinations, systems, structures).
4. Functioning of territorial social formations in time.

The study of these features of the territorial organization of systems in human geography uses a wide range of methods (from general to special ones), discussed in the following sections.

Let's finish by considering the contemporary chorological paradigm of geography with another important aspect. We are talking about the connection "space-time".

As noted above, finally, the concept of the four-dimensional continuous space-time was formed in the twentieth century. This space-time complements time coordinates to three homogeneous spatial coordinates; therefore, all phenomena are considered in dynamics (as processes). The general scientific picture of the world considers space-time (synchronicity) as a relative phenomenon depending on the choice of the coordinate system and relative velocity. These concepts are "grounded" in geography because geography does not yet explore material objects with relative speeds close to the speed of light.

The concept of geographical space in contemporary geography is methodologically inextricably linked with the concept of time. Therefore, the historical approach (method) has become a mandatory element of the methodology of recent human-geographical research. It emphasizes the thesis that the object of the study of contemporary geography is *a geographical process in the geographical space*. Projecting this into the subject-object area of human geography, it is possible to define its object as *a socio-geographical process in the information-socio-*

geographical space. The rationale for this statement is given below, and here we consider the features of the temporal dimension of socio-geographical processes.

The concept of "social" space is important for social geography. This is a space for the development of social systems and their components. This space is nonlinear and multidimensional. Its formalization and analysis require using complex mathematical apparatus. There are many examples from different human and social activity spheres, namely science, art, literature, production, etc. It should be emphasized that using the concept of space in this aspect is not strict at all and is based on its intuitive unifying ability.

The highest level of abstraction of the concept of space is multidimensional phase space, which is used in science and technology to describe complex systems and processes through formal logic and mathematics. Its application makes it possible to investigate the deep mechanisms and interaction patterns of various objects in more detail. This is unattainable when operating in ordinary three-dimensional physical space.

Multidimensional feature space has been increasingly used in geography in recent decades. Human geography, which studies mainly multidimensional phenomena and processes, has advanced especially far in this direction. But geography applies its concept of geographical space, which many generations of geographers developed and improved. Today this concept is the complete reflection of the chorological paradigm. The transition to a multidimensional version of the representation of the idea of the geographical space means that a set of parameters of the geographical objects features studied forms its basis (coordinates). The following sections describe more full features of the multidimensional (analytical) space application. Here we will dwell in detail on its semantic identification.

1. It is clear that the optimal design of the analytical space is possible, considering the coordinate blocks' content. Then, depending on the study purpose and available initial data, the geographical space is decomposed into several components, as shown in Fig. 1.2.

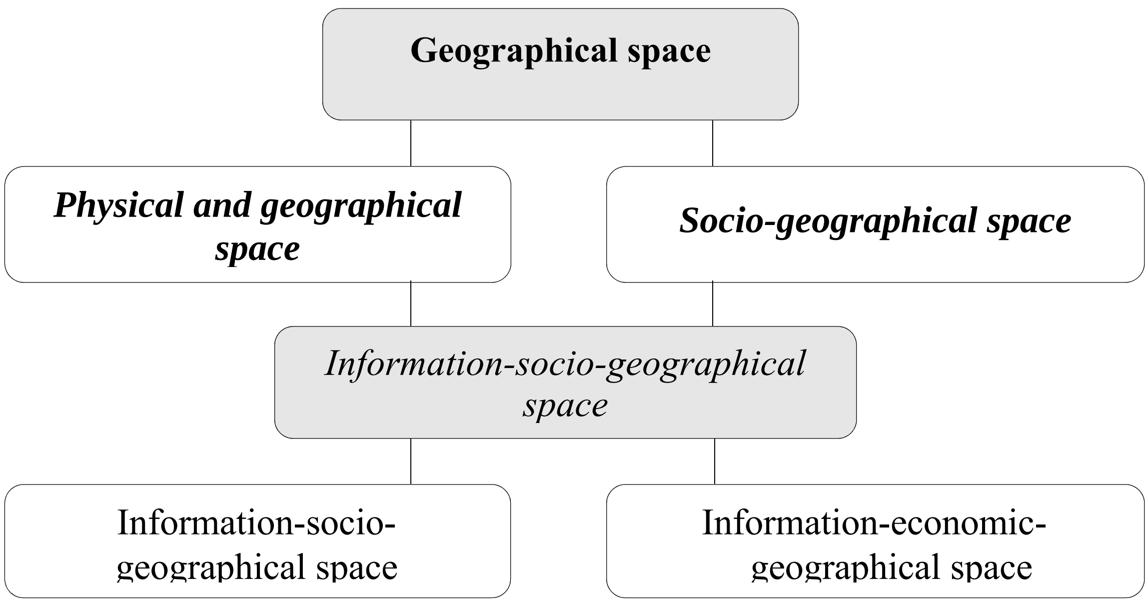

Fig. 1.2. Scheme of the semantic identification of the geographical space

According to Fig. 1.2, the scheme of the semantic identification of the geographical space allocates the physical-*geographical space* at the first level if the coordinates characterize only natural systems or *socio-geographical one*, when there are coordinates blocks of natural and social systems. It is clear that the first case characterizes physical and geographical research, and the second one describes socio-geographical research. Next, consider the division of the socio-geographical space in more detail.

Since human-geographical research increasingly uses information theory measures and methods (due to the need to manage the socio-geographical process), the block of information coordinates becomes mandatory. Therefore, we obtain *information-socio-geographical space*. Within its limits, *information-socio-geographical* or *information-economic-geographical* space can be distinguished depending on the specifics of the socio-geographical research (the purpose and set of source data). If necessary, it is possible to use even narrower coordinate blocks, for example, demographic, education, health, social security ones, etc., for the socio-geographical research. Therefore, changing the volume and content of coordinate blocks enables to achieve certain methodological flexibility and detail of the study. It makes it possible to analyze various subject "slices" of the socio-geographical process.

At first glance, such a semantic identification of the socio-geographical space seems artificial. But in fact, it is justified because each type of the socio-geographical space can substantiate a unified methodology and research technique and develop a standard research algorithm. It can be implemented as a computer program with certain variable branches. In any case, the methodological differentiation of the study of the socio-geographical space should not be a dogma but provides a flexible analysis strategy with the possibility of creative search and foundation of new research methods.

Therefore, we clarified the essence of the environment in which the objects of socio-geographical research function as an information-socio-geographical space.

Questions for self-control:

1. Definition and role of fundamental concepts of human geography.
2. The dimensionality of geographical space in spatial analysis.
3. Features of territorial organization of social, economic, and natural systems.
4. Multidimensional featured (phase) space of the socio-geographical process.
5. To substantiate relationships in the scheme of the semantic identification of the geographical space.
6. Coordinates of the phase space, and their value in the information analysis.

LECTURE NO. 3. THE ROLE OF INFORMATION IN DEVELOPMENT OF SOCIAL AND GEOGRAPHICAL SYSTEMS

Plan:

1. Functioning of the information-socio-geographical space.
2. Conditions and criteria for the development of social and geographical systems in the information-socio-geographical space.

3. Role of information and information exchange in the Universe self-development.
4. Synergetics as a science of the systems self-development.
5. Philosophical approaches to determining the role of information and knowledge of the world.

Serious changes in the global social and geographical system require rethinking the role of the "human factor" in further biosphere evolution. Humanity's technical and technological capabilities have long crossed the threshold of "significance" in the development of natural systems. Many of the latter are already in a state of active or passive society management. So the trajectory of their movement is increasingly moving away from the natural optimal biosphere in terms of the evolution. This threatens to intensify the global socio-environmental crisis.

Many scientists who study this phenomenon concluded about the impact of the stereotype of the "conqueror of nature" formed over many millennia in the human's and society's minds, which is otherwise called *the anthropocentric approach* in environmental management. It should be noted that there are quite contradictory judgments concerning the term *"Anthropocentrism"* in the scientific literature. This concept is used in several research areas, giving it a different meaning. The philosophical encyclopedic dictionary edited by E.F. Gubsky, G.I. Korablyov and V.A. Lutchenko (2001) provides the following definition of anthropocentrism. This is "... a view in which human is the center of the universe and the goal of all events, occured in the world ... ». It follows that everything in nature and society must happen in human's interests. This is the initial meaning of the concept of *"anthropocentrism,"* and most researchers understand it in such a way. The application of the anthropocentrism principle in social issues and problems of social development is quite acceptable, because anthropocentrism desires to act for meeting the people's needs, respecting human rights, social justice and equality, without harming anyone. The social policy of any society must be built on this principle.

However, there are a lot of contradictions when this principle begins to be applied in environmental management, ie in the relationship between society and nature. Firstly, it becomes difficult to understand that such an action in nature is in human's interests. Meeting any social need occurs in the natural environment - humanity is doomed to environmental management. The question is how this need meets. Guided by the principle of anthropocentrism, it is possible to extract the necessary natural resources without thinking about the future, as it was until the middle of the twentieth century. However, by disturbing the natural balance in natural systems, society removes them from the state of homeostasis. Therefore, it signs a death sentence because human, like other species, cannot live outside of nature, and environmental changes will affect her sooner or later. Human occupies his own ecological niche and objectively has no advantages over other species in the biosphere.

As A.D. Ursul noted, a human allows conscious and unconscious actions in interacting with natural objects, but the role of conscious, rational beginnings in such interaction is growing. In other words, human is gradually beginning to understand the perniciousness of the "Conqueror of nature" ideology and the need to transform it into an ideology of coevolution with natural systems.

The most progressive scientists from different countries united within the Club of Rome in the middle of the last century to warn humanity about the danger of global environmental catastrophe. Their ideas have been ingrained in the public consciousness for decades for the world community to finally adopt the concept of sustainable development as a real path to the future. Today, when the global socio-environmental crisis has become a reality, everyone understands the inevitability of the main choice for humanity: either we will radically change our attitude to nature or perish. A balanced nature-centric approach in environmental management that introduces parity of interests of all species on the Earth must be replaced.

The main contradiction of the biosphere (between the biological and social human's essence), should be not antagonistic but dialectical one under the influence of intelligent human activity. Because it should stimulate the progress of the global social and geographical system (Fig. 1.3).

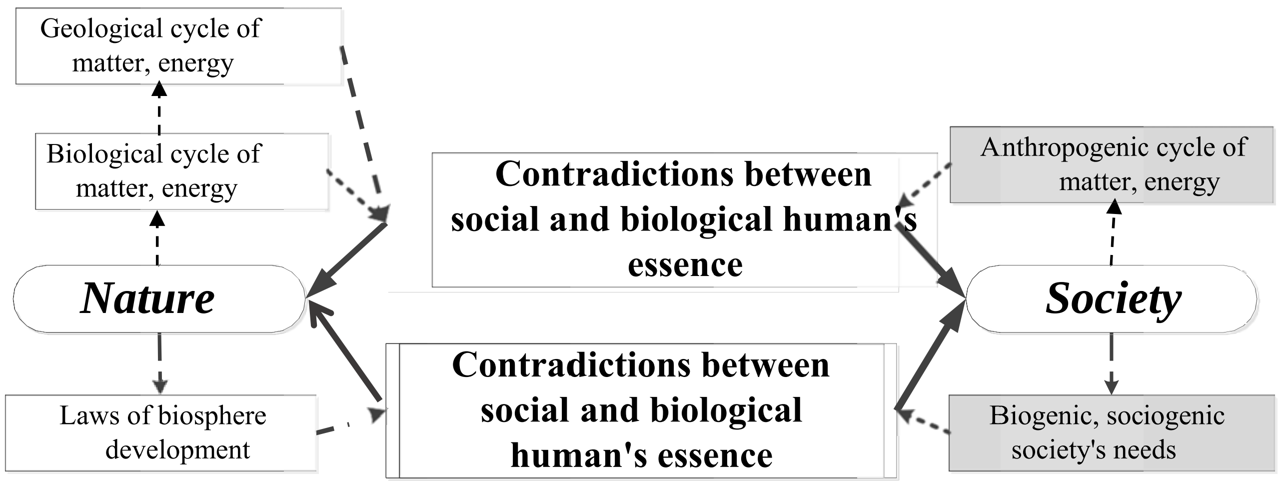

Fig. 1.3. Contradictions between society and nature

Perhaps V.I. Vernadsky dreamed of this interaction between social and natural systems, developing the noosphere concept. The main idea of the noosphere is proper management (harmonization, optimization) of the interaction between society and nature. Implementation of this idea becomes possible in the social management of all processes in the Universe from the standpoint of nature-centrism.

The global social and geographical system remained open until the 1980s. The end of the twentieth century was an important milestone in its development due to the beginning of the globalization processes, reflecting the closure of the global social and geographical system. G.O. Bachynsky firstly expressed the idea of global socio-ecosystem development, but it can be fully applied to the characteristics of the global social and geographical system development (Niemets L.M., 2003).

There are two generally accepted theories of self-organization and self-development of existence in contemporary philosophy and science: dialectical and synergetic. In contrast to the dialectic one, which was formed as a philosophical theory long ago, synergetics emerged in the XX century at the junction of natural sciences (physics, chemistry, biology, etc.) and further acquired a worldview status. G. Haken and I. Prigogine are considered to be the founders of synergetics. The term

"Synergetics" comes from the Greek *sinergia* - "cooperation", "assistance". Synergetics is currently the most common theory of self-organization and studies the patterns of these phenomena in all types of material systems. The basic principle of synergetics is the difference between processes in open and closed systems (Table 1.1).

Table 1.1

The difference between processes in open and closed systems

Process	***Open Systems***	***Closed systems***
Functional differences	Able to reduce entropy by its transfer to the environment	Due to lack of the possibility of reducing the entropy, its level can only increase
Orientation of the vector processes	Under certain conditions, new ordered structures emerge from chaos arbitrarily Structures	From order through equilibrium to chaos
Main characteristics of the processes	Imbalance and nonlinearity, Instability	Equilibrium and linearity
Opportunities for self-development	Self-improvement	Self-preservation

Unlike classical science, which considered closed systems as an absolute type of order in the world, synergetics chooses open systems as the subject of its study. According to the creators of the synergetic theory, the open systems are universal, and the processes taking place in them contribute to the self-organization of the world. The main property of open systems is instability. Based on this knowledge, synergetics offers the following explanation of the mechanism of order emergence from chaos. While the system is in a state of thermodynamic equilibrium, all its elements behave independently of each other and are not capable of creating ordered structures. At some point, when the balance is disturbed, the behavior of the open system becomes ambiguous. The point which reveals the ambiguity of changes is called the *bifurcation* point (branching). The role of external influences in the system changes at the bifurcation point: scanty influence leads to significant and unpredictable consequences.

Therefore, so-called coordination effects appear under the influence of energy interactions with the environment in open nonequilibrium systems when different elements begin to behave in unison with each other. Such coordinated behavior is synergistically defined as *a coherent one.* As a result, ordering processes occur, and new structures emerge (called dissipative). This is a process of self-organization. Therefore, external interactions are a factor in the internal self-organization of systems, which, in turn, contribute to the self-organization of other systems, etc. Nonlinearity, the presence of reverse links, which opens up great opportunities for managerial influence, characterizes direct self-organization processes.

To date, seven basic principles of synergetics have been formulated, namely two principles of existence (state) and five principles of formation (development).

Principles of existence:

1. ***Homeostatics*** is maintaining the state and functioning of the social and geographical system so that its development trajectory corresponds to the selected attractor. The urgent task of optimizing the trajectory in public administration is to ensure the achievement of the attractor with the least cost of resources and time. The efficiency and competence of governing bodies play an important role in this issue.

2. ***Hierarchy*** is the presence of the hierarchical structure of the complex system when higher-order subsystems consisting of lower-order subsystems transfer parts of their freedom degrees and functions to the last and create a new quality (emergence). The subsystems of the highest hierarchical level form management parameters (order parameters), which determine the functioning of these subsystems, including the lower level (according to the principle of subordination). Smooth changes in the order parameters in the social management process determine the coherent (coordinated) action of the lower-level subsystems, which is a manifestation of the self-organization of the social and geographical system as a whole. If changes in the order parameters lead to a crisis state in the lower-level subsystems, this subsystem goes into a bifurcation state. Accordingly, the social and geographical system of the highest hierarchical level has the order parameters that determine its attractor and behavior at all hierarchy levels.

Generating principles of formation:

1. ***Nonlinearities*** is violation of the superposition principle, when the result of the sum of causes is not the sum of the causes results. Nonlinear effects always occur near the boundaries of the homeostasis of the social and geographical systems. In other words, nonlinearity manifests near the borders of the existence of the social and geographical systems as critical values of homeostasis parameters are reached. These parameters can destroy the social and geographical systems (eg, revolutionary situation, humanitarian, demographic or environmental catastrophe, etc.). Thus, nonlinearity is a prerequisite for the transition of the social and geographical system to a chaos state. This state causes the emergence of a new structure.

2. ***Openness*** is the active interaction of the social and geographical system with the external environment through exchanging matter, energy, or information. In accordance with the second law of thermodynamics, the absence of such an exchange in the system fosters a constant increase of entropy. It gradually turns into a chaotic state, e.g., disorganizing. Therefore, openness of the social and geographical systems provides the possibility of their evolution and self-development, namely movement from simple to complex, complicating the structure and functioning, formation of more efficient subsystems, etc. in case of increasing information of the social and geographical system (and environmental entropy). Otherwise, the social and geographical system degrades in case of increasing entropy. Non-equilibrium large social and geographical system can form effective stable nonequilibrium structures, which do not reach the maximum entropy and do not support the organization through the exchange of matter, energy, and information with the external environment. Examples are the formation of free economic zones, Euroregions, international economic clusters, etc.

3. ***Instability*** is the possible exit of the social and geographical system from homeostasis in the case of the implementation of the nonlinearity and openness

principles. Unstable states of the social and geographical system associated with certain points in the space of the managerial parameters (order parameters). They are, in fact, bifurcation points. They mark the emergence and development of a new quality, structural and functional restructuring of the social and geographical system, the boundary between the old and new history of its development. These points of instability enable to move to a new quality under the weakest informational influence without using force factors.

Constructive principles of formation:

1. ***Emergence (dynamic hierarchy)*** is the emergence of a new quality, and formation of the order parameters in the interaction of at least three adjacent hierarchical levels of the social and geographical systems (e.g., village - district - region). In this case, in contrast to the hierarchy principle, the order parameters are fleeting and "chosen" (re-formed) from several alternatives depending on the new properties of the social and geographical systems of the lower levels.
2. ***Observations*** is a relativity of results and means of observation of different levels of the social and geographical systems. In other words, it is the dependence of the observation result on the scale of the observation "window". If we perceive something as chaos at the macro level, this is a structure at the micro level. For example, the average value of a specific statistical parameter for a district is the center of fluctuations of parameter values for individual settlements, the average value for a region is the center of fluctuations of values for districts, etc. Thus, a holistic description of the hierarchical social and geographical system consists of descriptions of observers of different hierarchical levels. It is necessary to take into account the subjective characteristics of observers.

In addition, various experts additionally formulate the following synergetic principles:

1. ***Self-organization*** – a system is considered a set of processes that create, maintain, reproduce or improve the system's structure and aim at maintaining its integrity. Self-organization is an attributive property of all complex open systems, regardless of their nature.
2. ***Self-reproduction*** *is* preserving the parameters of a complex self-organizing system is its problem and task since all its internal functions are ultimately aimed at self-reproduction, inhibiting entropy growth and mitigating entropy processes. It means a certain internal antientropic tendency in the system itself.
3. ***Resonance impact*** helps to understand how to manage self-organizing systems effectively. According to it, the main thing is not the force of influence but its optimal topological orientation: if you correctly determine the point of influence and the algorithm of behavior, you can obtain extremely effective results and save time, effort and resources with a weak, insignificant (but appropriate structure of the system) action.
4. ***Constant fluctuations*** – each system experiences, perhaps, insignificant but constant influence of external and internal factors, which cause weak deviations of the system parameters (*fluctuations*). But the system becomes most sensitive to them only at certain stages of its development, namely in periods of instability over the stability of its structure. It occurs when the system has already been objectively forced to give

up the old way of development and chooses the new one only from several possible alternatives.

5. ***Development bifurcations*** – *the system is faced with numerous options for further evolution in* certain moments of self-organization when the old structure of the system and its development cease to be adequate under the influence of objective circumstances. It becomes the most sensitive, even for the weakest influences in such periods.

6. ***Constructiveness of chaos*** – chaos is not only a destructive but also a creative principle, a constructive mechanism of evolution. The system itself forms a new organization in critical periods, moving to another stage of development.

7. ***Entropy corridor*** – according to synergetic ideas, the main dynamic indicator of a complex system is *entropy*, which is defined as the degree of the system's disorder. It depends on the level of entropy and identifies the state of the system at any given moment (organized or disorganized, mostly stable or mostly dynamic) at the stage of bifurcation, in the exacerbation mode, etc.

8. ***Irreversibility of changes*** – the emergence of new order parameters is an event that has no return movement. Elements that have merged into a new form of cooperation are gaining some new properties. Similarly, their separation leads to qualitative changes in the system's structure. The original initial state can not be returned, and the process of self-organization is directed exclusively forward. But it only sometimes leads to better system.

9. ***Actions of attractors*** – attractors (development goals) exist at all stages of the system development, but their action is strongest in bifurcation periods. At this time certain stable attractive structures become microcenters, which attract all possible trajectories of evolution, and building a new structure of the system is conducted around them. The dynamic system acquires stability after the emergence of fundamentally new characteristics in the gravity area of the attractor.

10. ***Cooperative effects*** – transition from a chaotic state to a certain order with the emergence of stable dynamic structures occurs as a result of coherent, coordinated interaction of the elements of this system. Consistency of the elements of the system acting for the common goal causes a synergistic effect. The results of their collective action are not equal to the algebraic sum of the actions results of the individual elements but exceed it. The development of any large, complex and open system depends on its imbalance. Thus, when the system is in equilibrium, drains and sources are absent in it. That is, gradients and flows of matter and energy in it and between it and the external environment is absent, and the total entropy reaches the maximum value (Fig. 1.4).

When the system goes out of equilibrium, gradients of matter and energy arise between it and the external environment. As a result the substance-energy and information exchange starts within the system and with the environment. These flows are linear in a weakly unequal state, and the mechanisms of the reverse negative links inhibit the fluctuation of system parameters and the external environment. As a result, the system retains a certain sustainability of the structure and functions with minimal entropy production. The flows become nonlinear in the non-equilibrium state (described by nonlinear equations) and mechanisms of the positive reverse links begin to function noticeably. Finally, the mechanisms of positive reverse links prevail in a highly unbalanced state (far from equilibrium). As a result, parameter fluctuations are not suppressed but accumulated. When they reach critical values at bifurcation points, the system undergoes a phase transition, i.e. it abruptly transits to a new state (new structure, properties, behavior, functions, etc.).

There are often (but not always) many possible options for further development of the system (new states) at the bifurcation point. The most likely option at the moment is accidentally "chosen". Then the system continues to develop according to the "chosen" option to the next bifurcation state. Therefore, the development trajectory of nonequilibrium systems is an alternation of bifurcation points, where the revolutionary version of development changes to an evolutionary (calmer) development (Niemets K.A., 2017, Fig. 1.5).

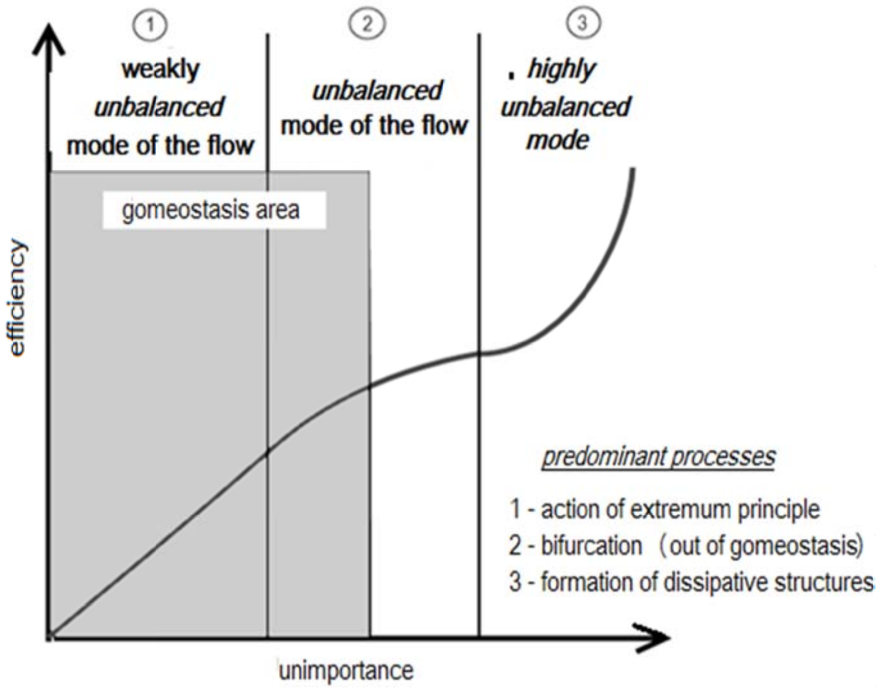

Fig. 1.4. Imbalance of social and geographical systems

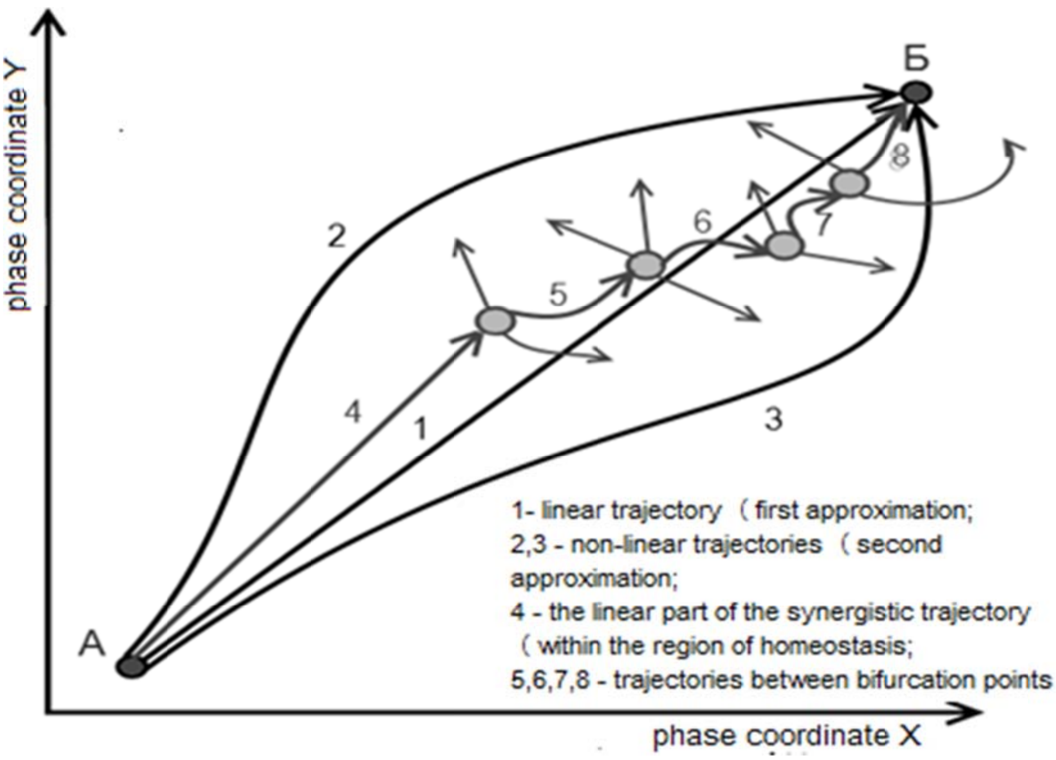

Fig. 1.5. Theoretical development trajectories of social and geographical systems

The system can move to the area of attraction of another attractor at the bifurcation point, which leads to a radical change in the purpose and goals of development. Such a development scenario is unacceptable for social and geographical systems because a new attractor may involve destruction or undesirable transformation. The order parameters are formed in hierarchical nonequilibrium systems. They determine the behavior and properties of systems at the macro level because they have a much more substantial impact compared to the current factors of lower hierarchical levels. Due to the stochastic nature of the behavior of the nonequilibrium system at the bifurcation points, forecasting the whole system's development becomes problematic.

I. Prigogine demonstrated in the 60's of the last century that the highly unbalanced states of the system form another new invariant of development, namely dissipative structures are established. It ensures their resistance to environmental disturbances due to self-organization and self-development of such systems.

Transferring the above to the subject-object area of human geography, it is necessary to consider the methodological possibilities of applying the basic principles of synergetics in studying social and geographical systems. First of all, we note that all, without exception, social and geographical systems of different hierarchical levels have one robust universal order parameter, namely the purposeful managerial influence of one of the subsystems (society). However, it doesn't contradict the principles of synergetics, because, parameters of order are also formed in nonequilibrium systems of another nature. There are not any reservations or restrictions for these parameters. The difference is the following. The system of the highest hierarchical level sets the attractor for non-social systems, and society, according to its socio-political guidelines, sets the attractor in social and geographical systems. The development of social and geographical systems (socio-geographical process) is considered their movement in the phase space, making it possible to use the scientific apparatus of analytical geometry for its study (L.M. Niemets, 2003).

The synergetic approach allows answering the question of why the world demonstrates a high degree of organization and order contrary to the law of entropy. In addition, since synergetics states that the laws of self-organization apply at all levels of existence, it helps to bridge the gap between animate and inanimate nature and explain the origin of life as a process of self-organization of inorganic systems. The conceptual power of the synergetic approach is significant and determines its use as an interdisciplinary tool for describing complex systems.

From the point of view of the information model of society development, globalization is a sign of approaching the trajectory of environmental management to a critical area of the natural environment. It indicates the exhaustion of the society's current strategy. This new phenomenon in history of humanity has threatened the formation of different global crises, namely geoecological, political, demographic, social, etc. Whereas previously environmental crises were local and regional and affected individual countries and regions, now the emissions from ozone-depleting gases in North America, for example, are leading to global changes in the ozone layer. As global studies have shown, the need for a radical change in society's mentality has become more acute, especially concerning nature. The members of the Club of Rome proved the need for such changes in the second half of the twentieth century. Their influence to some extent, prepared the public consciousness for globalization.

Therefore, the development level of science in society becomes the most important criterion for assessing the latter's progress. The whole course of the development of the global social and geographical system demonstrates that the role of science and information in society is constantly increasing. A significant number of researchers call this phenomenon an *information revolution*, which is further justified by the rapid development of means of communication. This is the essence of the information society formation. The development of scientific knowledge is influenced by external causes, such as the manifestation of society's needs and the formation of the social order, as well as due to the presence of the diverse system of internal contradictions of science.

Questions for self-control:

1. To reveal the essence of the concept of "geographical space", coordinates used in geographical space.
2. The essence of the concept of "socio-geographical space", blocks of coordinates in socio-geographical space.
3. The essence of the concept of "information-socio-geographical space", blocks of coordinates in the information-socio-geographical space.
4. Synergetics as a science of interaction.
5. Synergetics as a science of the systems self-development.
6. Features of the synergetic paradigm in geographical science.
7. Features of the information and synergetic paradigm in human geography, its innovative potential.
8. Chaos and dynamic chaos as a possible state of systems.
9. The concept of organization and structure of systems.
10. Information indicators of organization (heterogeneity) of systems: information entropy, reduced information entropy, information.

LECTURE NO. 4.
INFORMATION RESOURCE OF SOCIETY

Plan:

1. The concept of socio-actogenesis as an active way of society interaction with other systems, the role of information in it. Determining compromises in socioactogenesis. The concept of the executive system. Information flow in the actogenesis process.
2. The epistemological criterion of environmental management.
3. Information exchange and types of information in the environmental management.
4. An information resource, its role in society.

Given that information is closely related to the purpose of the social subject, we consider the process of socioactogenesis in general. The initial position (motive) of the socioactogenesis is a social need, and its ultimate goal is to meet this need. Therefore, having realized the need as an objective necessity in interaction with the natural or social world, the subject begins to analyze information related to the object of the future action. First, the *mechanisms of individual and social memory* begin to work.

Under the *individual memory,* we understand the manifestation of mental activity, namely the ability of the individual to reproduce past experiences, long-term storage of information about the events of the outside world, and their reactions to them.

Social memory represents the generalized memory of all individuals in a given society. Therefore, social memory describes as some generalized experience (to the level of knowledge) of previous and existing generations. Each individual masters some of this knowledge in the education system during socialization and further improves during their development and complexity of their activities.

V.A. Kartashov (1995) considers *social knowledge* as a general one, reflecting the surrounding world as a whole, and special knowledge, which is directly related to the meeting specific needs.

Theoretical knowledge determines possible general approaches or mechanisms for meeting social needs. A striking example of this is development of the sustainable development concept, formulated based on the *deductive approach*. However, the problem of obtaining and analyzing specific information based on the *inductive method* remains topical. The amount of empirical information received, as a rule, characterizes the current state of natural systems, and it is used to determine the dynamic parameters of their development. There are several essential points in the process of obtaining and processing this information:

– during the study of natural systems, the research subject turns to the memory of the studied systems, i.e., receives and deciphers the structural information accumulated and stored by them in the process of evolution. Using information about the current state of the systems development, the researcher seeks to restore the history of their development, i.e., to deciphe their "genetic" information. *Society includes not only information about the current state of natural systems in its general and special knowledge, but also part information which they stored in phylogeny or ontogenesis;*

– effectiveness of the analysis and synthesis of empirical information largely depends on the level of general and specialized knowledge, methodological "maturity" of science, the dominant paradigms, and several other factors, including subjective ones. Referring to the concept of *information value*, we can say that only that part of the information assimilated by society is valuable in the sense as mentioned above. It determines the efficiency of environmental management and harmony of the relationship between society and nature.

1. Other information that society cannot comprehend and summarize in the form of scientific knowledge due to its limited capabilities in the knowledge of the natural world is not taken into account when planning the environmental management. The *epistemological contradiction of environmental management manifests in this feature of the information interaction of society and nature* (Fig. 1.6). It can be formulated as *the mismatch of general and valuable information received by society from the environment*.

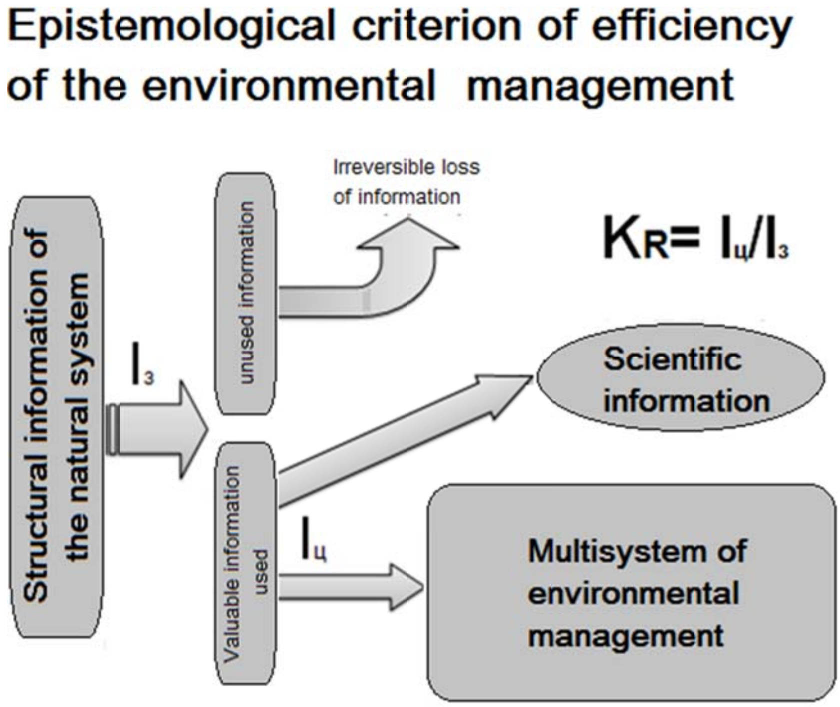

Fig. 1.6. Epistemological criterion of environmental management efficiency

The ratio of the volume of the potential total *(Ip)* and valuable *(Iv)* information can serve as an epistemological criterion for the effectiveness of environmental management.

As *Kr* approaches one, ie, the increase in the amount of valuable information, the effectiveness of meeting social needs and environmental management, in general, should increase. It follows that a society with a large amount of valuable information has greater competitiveness (sustainability). Because it can more effectively meet this social need with less perturbation of the environment.

Consider general and special knowledge as *a set of three components:* tools, methods, and conditions for meeting social needs. The *tools* are any material systems or objects that can be used to meet current social needs. *Methods* of using tools are the knowledge of the laws of interaction and change of those material systems that fall within the scope of tools in meeting social needs.

The conditions of obtaining the desired result are limitations of the methods from the natural system. At the same time, they determine the degree of its perturbation by methods and tools of meeting the need. Awareness of the need, analysis of accumulated scientific information, and empirical information obtained are links in goal setting. The need in actogenesis is a motive, motivation, and cause of action.

The *executive system* (ES) must achieve the desired result. Goal setting is variable, ie, one social need can generate several systems of goals that determine the formation of different ES and create a situation of choice. Selection criteria are often determined by informational assessment of different options, availability of management resources, the state of natural systems, society's readiness to implement specific ES, etc. At the same time, two compromises are accepted in purposefulness.

The first compromise is a problem solution of "desirable – possible". If the awareness of the need leads to the desire to meet it best, analyzing available resources limits the choice. The range of solutions to this problem is quite broad, namely from the development of new tools (generalization and synthesis of new scientific information) (they limit the choice to a lesser extent), to the transformation (limitation) of needs. The first compromise determines the strategy of the socio-actogenesis (environmental management) and resolves this contradiction by finding a temporal optimum. It follows that as the means and methods (general and special knowledge) improve, the strategy of environmental management changes.

The analysis of the history of environmental management provided below demonstrates that *the growth of social needs and information accumulated and assimilated by society are interrelated and occur with constant acceleration.*

Around the middle of the twentieth century, the biosphere coped with the effects of all environmental management strategies based on the anthropocentric approach. But the development of the global socio-environmental crisis at the turn of the second and third millennia has shown that the biosphere is close to transitioning to a crisis mode of operation. It can be argued that a generalized order parameter for the global biosphere in the last 50–70 years became the intensity of economic activity of society. When this parameter exceeds a certain threshold value, a global system begins to restructure, which can change the trajectory of the biosphere development and direct it to the gravity area of another attractor. In this case, from the point of view of the stability of the biosphere, it is not necessary to preserve all existing biological species, including Homo sapiens. Therefore, there is a need *for fundamental change in all environmental management strategies associated with the formation of a nature-centric approach* and the corresponding transformations of the integrated mentality of society at all levels.

The second compromise (goal-setting) reflects the problem of using opportunities and probably determines the tactics of environmental management. If there are several options for combining tools and technologies to meet the needs, the conditions of their implementation are crucial. Suppose it is possible to control the conditions of implementation. In that case, the subject has a little more freedom of choice because the possibility emerges from combining all three elements of the ES. If the conditions are uncontrollable and determined by the allowable degree of disturbance of the natural system, the selection criteria are the most stringent. In this case, the optimal combination of tools and methods should ensure minimal system perturbation. Therefore, a formally more independent (and thus determining) selection factor is the conditions for the implementation of technologies and tools of environmental management.

We note that the formation of tools, methods, and conditions for implementing socio-actogenesis, as components of social knowledge, requires different information. Thus, the tools and technologies of environmental management are universal. Therefore they are formed mainly as general knowledge as a result of generalizing information about a large number of natural systems. Their improvement is possible under the condition of mainly increasing general knowledge. The requirements for achieving the result reflect special knowledge, as it results from generalizing empirical information about a particular natural system. The special role of the conditions for achieving the result and the high error cost in the selection procedure require that this element of knowledge have the necessary information support. It is achieved by the necessary detail of the study of the natural system, ie, obtaining the required amount of valuable information.

Improvement of special knowledge is possible continuously following the receipt and analysis (assimilation) of monitoring information. This feature demonstrates that the amount and "quality" of special knowledge depend on the subject of environmental management because it determines the program and scope of the natural system research. Unfortunately, economic efficiency issues are often more convincing than environmental safety requirements in the current practice of environmental management.

As a result, the amount of empirical information is insufficient, and the conditions for achieving the result are not fully understood. It ultimately leads to unforeseen direct and indirect consequences of socioactogenesis. It also convinces of the need for radical changes in society's attitude to nature, in the fundamental restructuring of society's mentality and the transition to a position of nature-centrism.

Therefore, *information elements* of the ES are the tools, methods, and conditions for achieving the result. Another information element should be added to this. It is a monitoring subsystem, as the ES will work blindly without it.

Note that the monitoring subsystem receives primary (raw) information about the behavior of the natural system and the ES functioning, its primary analysis, processing, synthesis, storage, and communication. At the output of this subsystem, the information is initially generalized and filtered (K.A Niemets, 2005).

A managerial subsystem requires to organize the work of the ES. It performs the functions of predicting the behavior of the natural system and the ES, preparation, and decision-making, their expert evaluation, development of managerial signals and influences, and general organization of the ES. The streams of generalized operational information dominate in this subsystem, reflecting the natural system's actual and possible (forecast) response to perturbations (Fig. 1.7).

At least *two aspects,* namely natural and social, can be distinguished in the information interaction of social and natural systems.

The natural aspect covers the receipt and processing (assimilation) of information produced and circulated in natural systems, providing the necessary interaction and stability. This aspect is related to the study of the natural environment for the choice of the strategy and tactics of environmental management. The research aims to clarify the laws of functioning of natural systems and the processes which take place in them. As well as it is related to the patterns of information production in these systems to predict changes in their state and management. Such information is necessary for constructing the ES, which can optimally lead to meeting the current needs of society. Given that the latter focus on environmental management, information about natural systems is central in planning and implementing various environmental management acts.

The essence of *the social aspect* is the following. An active participant in environmental management, namely, society, should produce information that would form an optimal system of goals, and find such methods, tools, and conditions for its implementation that would "fit" in natural processes without significant changes in the natural balance. The efficiency of environmental management, its focus, and balance depend on the degree of responsibility awareness by society for the consequences of its actions in the natural environment. The mentality of society plays a major role in this.

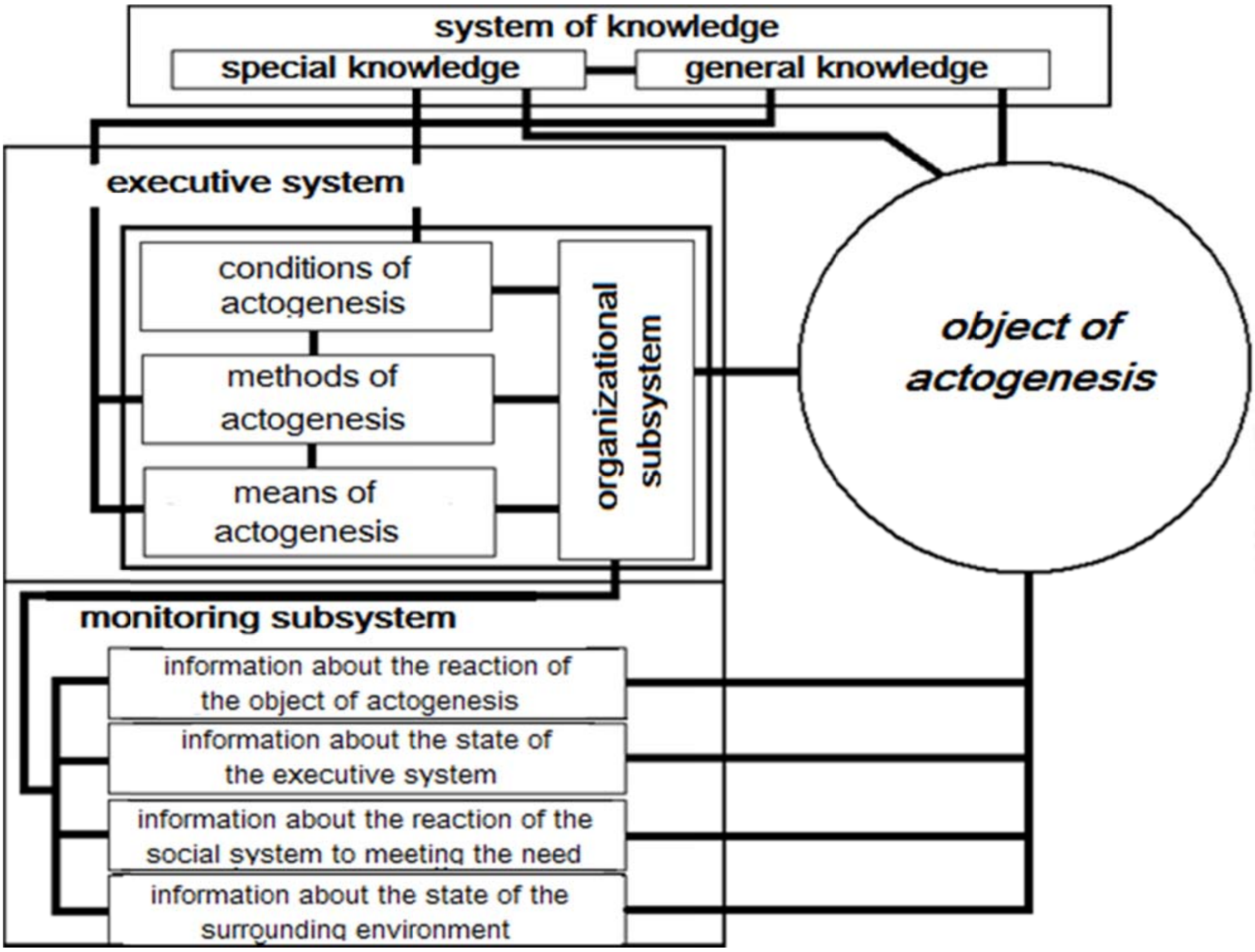

Fig. 1.7. Information flows in the multisystem of environmental management.

Thus, *the social aspect* includes the study of patterns of society development to assess its state and forecast possible changes in structure, mentality, behavior, moral values, etc. In this case, the problem of extracting the *objective (invariant)* information from the various information flow is significant. It reflects society's current state rather than the interpretation of various sources. This information should influence the formulation of social needs so that their satisfaction corresponds to the potential of the natural environment.

The correct use of methods and tools, as well as the creation of conditions for environmental management in terms of preserving the natural balance of social and geographical systems, is manifested in the state of the environment, quality of life and ultimately reflects the "maturity" degree of society in effective interaction with nature.

In principle, three types of information exchange are possible in social and geographical systems (L.M. Niemets, 2003):

1. ***The adaptive exchange*** **–** interacting systems change their structure, functions, and properties under the influence of matter, energy, and information exchange to achieve a balance between them. This type of information exchange is typical for natural systems and, partly, for social systems. Mechanisms and directions of the adaptive information exchange is completely determined by the general laws of the material world development (conservation of matter, energy, momentum, etc.).

2. ***The managerial exchange*** is carried out only in the presence of goal-setting and is possible with the participation of active (managerial) systems, namely social systems. The difference from adaptive information exchange is the following. The subject of management determines the direction, intensity, and sometimes mechanisms of information exchange. Therefore, it doesn't coincide with the fundamental laws of natural systems in many cases, which creates contradictions in social and geographical systems. Therefore, managerial information exchange is the most important in environmental management because it purposefully determines the trajectories of natural systems governed by society and the prospects for the development of society itself.

3. ***The cognitive exchange*** involves the mandatory use of human intelligence; therefore, it is possible only in the social subsystems of the social and geographical systems. Its main essence is to transform the structural information of natural and social systems into the social (scientific) information or information resource of society, which becomes accessible and understandable to all members of society. Further it is used to meet social needs. *Computer science* studies the distribution, territorial distribution, preservation, and accumulation of social information. The cognitive information exchange is divided into passive (observation) and active (experiment) subtypes depending on the method of extracting the input structural information. It should be noted that the intensity, effectiveness, and importance of social progress of cognitive information exchange increase over time.

In these types of information exchange, the main active substance is different types of information, which can be classified differently according to various criteria. For example, according to different geospheres, there are ***lithospheric, hydrosphere, atmospheric, technospheric, and social information.*** Each of these types of information is classified separately.

Given that society is the only subsystem in the social and geographical system able to purposefully change the properties and qualities of all components of the social and geographical system, it is risky to society itself. Let's consider the management process in the social and geographical systems. It can be proved that the environmental management and implementation of the managerial information exchange characterize meeting every social need through a chain of intermediate actions. At the same time, regardless of the content of environmental management, a complete cycle of information transformation occurs according to the scheme: ***structural – monitoring – operational – management–- structural***.

Mandatory elements of the management system are direct and reverse channels for transmitting control and monitoring information. Functionally, two interrelated vectors determine the system management process: input one, which contains managerial information, and output vector, reflecting the current state of the managerial system in the form of monitoring information. The input vector ideally reflects such an essential property of the system as *controllability*, i.e., the sensitivity of its state under the influence of managerial signals that make up the input vector of the system. The output vector reflects *the observation* of the system as the maximum possible influence of system parameters on the elements of the monitoring system. Optimization of the management system is a search for the "Best" ratio of these vectors, considering the possibility of restoring the controlled system (R.F. Abdeev, 1994).

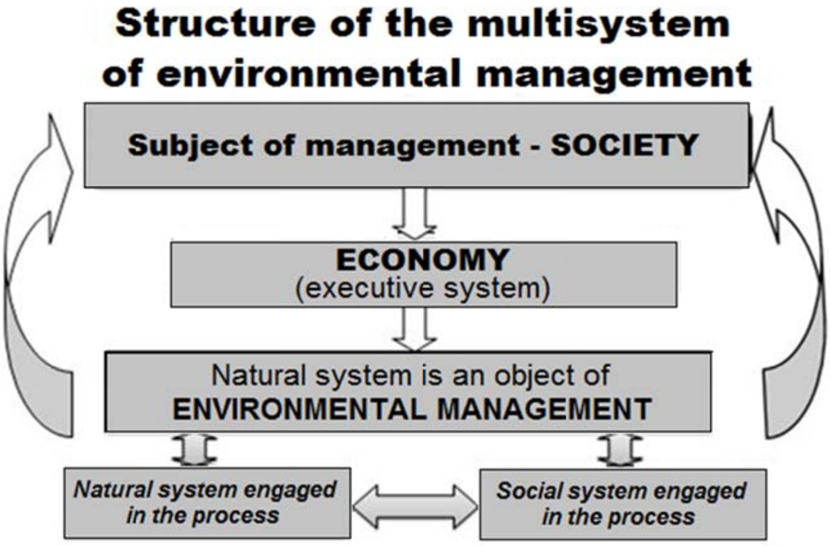

Fig. 1.8. Scheme of interaction between society and natural systems in the multisystem of environmental management

Considering the interaction between society and the environment as a management process, we should adopt the following provisions, illustrated in Fig. 1.8.

From the point of view of the management theory, the functioning of the social and geographical system of any hierarchy level is the implementation of the system of management with the following elements:

The subject of management is society because it is the initiator of environmental management and the primary consumer of its results. Otherwise, society is an active participant in environmental management, determining almost all the parameters of interaction within the possibilities of the natural environment. Society, in different situations, is a transmitter, a receiver, and a channel of information transmission in the information exchange.

The object of management is the natural environment, which is a source of meeting social needs. The natural systems are controlled (passive) participants in environmental management. However, in supercritical disturbance, they can actively resist the influence of society changing their properties and state. Natural systems in different situations are transmitters, receivers, and information transmission channels in the information exchange.

Economic structures of society are channels of direct and reverse links between the subject and the object of management. Further, they are generally considered the executive system of society, which is a tool for its environmental management impact. It should be noted that controllability and observation of objects of management determine the effectiveness of management. It provides perfection of direct and reverse links of channels. Therefore, the state and properties of the executive system of society, in many cases, determine the level of social needs and changes in natural systems. The economic systems in different situations are transmitters, receivers, and information transmission channels in information exchange. Each of the above elements of the controlled system can generate, transmit, receive, accumulate and store information through channels of direct and reverse links.

Each element of the system of management can adapt to the information received.

Information interaction between the elements of the system of management creates complex information flows of different types of information fields characterized by content, saturation, structure, and branching. They interact with the information fields of other elements (subsystems) of social and geographical systems that are not directly involved in this environmental management process and change relevantly. Society perceives these changes as side effects of environmental management. In this regard, a complex dynamic system consists of elements of management, natural and social systems involved indirectly through the material-energy-information exchange. It is defined as a multisystem of environmental management.

But the choice and implementation of the correct managerial decisions are possible only in the presence of the necessary information resource, which is formed in the process of passive or active cognitive information exchange. As mentioned above, society in the social and geographical system is the most active in managing the subsystem. As you know, management of the system is a purposeful transition and keeping it in a particular state through managerial impacts. At the same time, the management process has a crucial substantive aspect, defined as achieving the goal. Therefore, the purposefulness in the management process is mandatory, and any impact on the object in the system of management must have a positive effect on achieving the goal (Niemets L.M., 2003).

To do this, the channel of the direct link (from the subject to the object of management) must receive *the managerial information* in the form of impulses of material resources and forces. They, in turn, affect the controlled system and change its state, namely the *structural information*. Next, the *monitoring information* goes through the channels of reverse links to the subject of management. It is filtered from the grit errors, strong random influences, etc., and converted into *operational information*. The latter is submitted to the subsystem of management, where it is analyzed and used to justify and make managerial decisions for the next management phase. The adjusted managerial information is fed to the channel of direct links, and the management cycle is repeated. Of course, the duration of such cycles in real social management is determined by the discrete action of channels of direct and reverse links.

Recently, the inefficiency of the managerial activities of society has become increasingly apparent. Society, taking on the function of the system and regime-forming factor in nature has not provided adequate information exchange. In particular, it can be argued that the channels of reverse links in the giant management mechanism of the multisystem of environmental management are very far from perfect.

Questions for self-control:

1. Socioactogenesis, its elements, information essence.
2. Socioactogenesis as a process of interaction between society and nature.
3. The main compromises of socio-actogenesis, their role, and importance in environmental management.
4. An executive system, its formation, functioning, and efficiency.
5. An epistemological criterion of environmental management, its essence, and significance.
6. Managerial information exchange, examples in real social and geographical systems, multisystem of environmental management.
7. Adaptive information exchange, its examples in real natural and social systems.
8. Cognitive information exchange, its examples in science and education.
9. Managerial information and its role in management systems.

10. Adaptive information, mechanisms of its generation, and its role in the mutual adaptation of systems.
11. Monitoring information, its role in management processes, and environmental management.
12. Operational information, its features, and differences from monitoring information.
13. Structural information in natural and social systems as a reflection of the history of the formation and evolution of systems.

LECTURE NO.5.
SOCIAL INFORMATION

Plan:

1. Quantitative and semantic evaluation of information.
2. K. Shannon's formula and its use in the applied information analysis.
3. Types of social information and its functions.
4. The role of social information in the development of society and social management.

American engineer K. Shannon introduced the concept of "amount of information" in 1948. He proposed the following formula for estimating the amount of information:

$$I = -N \sum_{i=1}^{M} p_i \, log_2 p_i, \qquad \text{where} \qquad (1.1)$$

I is amount of information, bits;
N is the number of characters in the text message;
M is the number of letters in the alphabet to spread the message;
p_i is the probability of the symbol appearance;
i is the letter in the message.

Despite the fact that K. Shannon analyzed text messages, his formula was used to analyze other objects (systems) with distributed elements. Thus, in the general case, any text can be evaluated as a result of choosing (memorizing) a specific variant of the alphabet. By analogy, any system can also be considered a kind of "text", composed of structural elements – "letters". Then, the amount of information is determined by the formula (in case of random or non-random selection of one variant and structure from *N* possible ones):

$$I =- \sum_{i=1}^{N} p_i \, log_2 p_i, \qquad \text{where} \qquad (1.2)$$

pi is a priori probabilities of variants.

The amount of information determined by the formula (1.2) is a convenient estimate of the degree of the system diversity or heterogeneity. It indicates the widespread use of Shannon's information in the system approach and applied research. The use of quantitative information measures allowed introducing the concept of "*information capacity*" to compare the ability of systems to store information.

However, estimating the amount of information is only sometimes sufficient for scientific systems analysis. Most often, a researcher is interested not only in the quantitative side of information but also in its value, closely related to the purpose of the subject of activity. The value of information depends on the probability of achieving the goal with its assistance. The variability of ways to achieve the goal allows determining the value of information used, for example, based on the conditions of optimization of resource costs. It compares the a priori (P_n) and a posteriori (P_k) probabilities of achieving the goal:

$$V = \log_2 \frac{P_k}{P_n} \qquad (1.3)$$

As a rule, a posteriori probability is higher than the a priori one, ie, the information used is valuable because of the probability of achieving the goal increases. If they are equal, the value of the information (which is not received in this case) is zero. In the case where $P_n > P_k$, the value is negative, and the information is misinformation. In our opinion, it is more convenient to use a normalized estimate of the value of information, where the value of V varies from 0 to 1:

$$V = \frac{P_k - P_n}{1 - P_n} \qquad (1.4)$$

A priori (preliminary) information, ie, available information about the object, is called *thesaurus*.

Note that the value of information is a subjective indicator because it is determined by the probability of achieving the goal of the subject of the activity. The same information for one subject may be as valuable as possible and not for another.

Social information, as a specific and crucial factor of social development in light of the above mentioned, significantly influences the development of society and social systems, the formation and change of their properties, value systems, goals, social needs, etc.

Social information *is a set of knowledge, information, data, and messages that are formed and reproduced in society and used by individuals, groups, classes, and social institutions to regulate social interaction, and the relationship between humans, society, and nature.* According to A.D. Ursul's ideas (1975), social information acts as an aspect and result of any social reflection, as a specific feature of the social form of the matter motion. Social information can be open to all or confidential, ie, intended for individuals. Therefore, there is a need to encrypt and protect social information. Security of information space and cyberspace (taking into account communication channels, information infrastructure, etc.) is today the most essential component of national security, so it is receiving increasing attention. Computer science studies the possibilities of transmission, protection, dissemination, storage, and accumulation of social information.

There are several approaches to the classification of social information. We note that there are such types of social information in the literature as *political, economic, scientific, legal, ethical, aesthetic, religious,* and others. Each of these types of information reflects a particular area of human activity and form of social consciousness. Some authors consider it necessary to reveal social information in a cybernetic aspect, drawing its importance in the management of society. All the listed types of social information form information flows at all levels of the hierarchical organization of society.

Social information has some essential properties. In particular, the amount of information reflects the amount of information circulating in society. This characteristic is significant in assessing information redundancy, but it is too general. The properties associated with obtaining social information, such as truthfulness, objectivity, reliability, completeness, depth, accuracy, and certainty, are more useful for analysis. All these properties reflect the content and value of social information and its importance for the subject which uses it, especially in the field of cognitive activity.

Such properties of social information as persuasiveness, validity, evidence, and obviousness, are also essential for information processes characterized by the massive nature (for example, the functioning of the media). They complement the meaningful side of messages and contribute to more effective mastery of information. For some types of social information (for example, scientific one), an important property is a novelty, which is a sign of information by definition but refers to its content.

Significant characteristics of social information are promptness and relevance, reflecting its effectiveness and usefulness over time. It assumes a unique role in management processes, where the timely and prompt transfer of information is a reliable basis for making and implementing managerial decisions. At the same time, information should have another useful property, namely, it should be optimal. It should combine best all the components of the properties of information. It determines the integrity of the information system with the optimal organization of the information movement.

Factors such as the competence and objectivity of the source of information, decision-makers' psychological state, mentality, moral norms, and behavior play an equally important role. It reflects the "human factor" in the system of management. Ideally, the effect of this factor should not be manifested.

Society should pay special attention to the organization of mass processes of education and upbringing, the formation of public opinion, and objectivity of coverage of various events (N.V. Bagrov, 2005). The formation and transformation of the mentality of individual societies and society, on the whole, should be guided and built on universal values, considering national traditions and ethnic features. All these features and properties of social information determine its functions:

Communicative function means that the information consists of transmitting information from the source (transmitter) to the recipient (receiver) through the communication channel. This cybernetic understanding of the communicative function of social information has the greatest spread and significance in management processes. Currently, it extends to all types of information systems of organic and inorganic nature. There is no longer any doubt that the evolution of systems of any nature is closely related to the information exchange between them and the external environment. Evolution is closely related to the amount of information accumulated and stored in the structure of developing systems. Moreover, progressive development is possible, provided that the increase of the amount of information outpaces the increase in the system's mass and the growth in the number of its components of homogeneous elements. Consequently, the progressive accumulation of information as a result of information exchange between systems is a fundamental condition for developing systems at all hierarchical levels. The communicative function of information plays a crucial role in this. It is possible to distinguish the transmission of information in space (this is a usual idea of information exchange) and in time due to its storage with further updating.

The managerial function characterizes the information support at all stages of the management process. The initial stage is preparation and decision-making. It is impossible without information about the object of management: its state, properties, possible changes and deviations from the desired development trajectory, etc. At this stage, the information is important which embodies experience in solving such situations, reflects the state of management resources, the system of goals and other necessary information. At the next stage, organizational information is required when the managerial decision is implemented. Monitoring (accounting and control) information is necessary to assess management quality (for reverse links). Governance with the participation of society includes two fundamentally different aspects:

- management to adapt to the environment without its changing;
- management to transform the world

The first aspect reflects mainly the one-way movement of information, namely from the external environment to a person. This type of information interaction on the scale of society is constantly observed. Still, it is more typical for the early stages of human history, when adaptation to the natural environment prevailed. The second aspect more fully reflects the essence of human activity in society and nature in later history, when the transformation of nature began by society. In this process, a person not only receives information from the environment but also returns it in a changed form (as managerial information) to direct the environment's transformation.

The managerial function is closely related to the communicative one, so the effectiveness of its implementation significantly depends on the perfection of communication channels. This is especially relevant in managing large systems with a complex hierarchical structure, which includes a multisystem of environmental management and social systems.

Scientific and cognitive function characterizes the generation and dissemination of scientific information that allows knowing the environment. This function is implemented in conjunction with the communicative one, as communication in generating and disseminating scientific information is crucial. The role of the scientific and cognitive function of social information in social progress is difficult to overestimate because it provides the extraction and mastering of information from the external environment, the formation of scientific knowledge, and information resources of humanity. As shown below, this determines the levels and effectiveness of the information interaction between society and nature, the completeness of meeting social needs, and, ultimately, the possibility of humanity moving on to the trajectory of sustainable development and further to the noosphere.

The regulatory function duplicates the managerial function somewhat, but the difference is the following. The primary purpose of its implementation is to keep the object of management in a given state. It is important because preserving the state of social and natural systems that have not yet entered the critical mode of functioning is extremely urgent for contemporary society. The importance of this function of social information is likely to grow, and it will become decisive in the era of transition to the noosphere.

Educational and upbringing function reveals the information provision for the individual's socialization, the transfer of social knowledge and experience from generation to generation, the formation of a worldview, a system of moral values and attitudes, public ethical norms, etc. Unlike the cognitive function, educational and upbringing one reflects the process of mastering the already accumulated "refined" knowledge by the individual. In connection with the future transformation of society's mentality, the influence and importance of this function will increase.

It can be seen from a brief description of the main functions of social information that various information flows are formed and function in society. They determine all the events of social life. Against the background of the growing desire of society for democratization, traditional command and administrative methods of management are increasingly becoming ineffective and begin to inhibit social progress. Therefore, the role of information management increased dramatically in the second half of the twentieth century. It is characterized by implicit, indirect information managerial actions, which represent the complete information picture of reality to the object of management. As a result, the object analyzing this picture independently chooses the line of behavior.

The primary means of achieving the goals of information management are the media. The main mechanism of information influence is implemented with their help. It is based on the manipulation of the consciousness of the masses and introduction of purposeful reliable information or disinformation. Under its influence, a certain psychological attitude is formed in the public consciousness, which leads to expected actions. The saturation of society with communication channels, print media, development of television and computer networks turn information management technologies into an effective, flexible, operational, and selected method of managing society.

Questions for self-control:

1. Quantification of information, methods and approaches.
2. Semantic analysis of information.
3. The concept of valuable information, its subjectivity and correlation with publicly available information.
4. Social information, its role and significance in the life of society.
5. Types of social information.
6. Functions of social information, peculiarities of their implementation in society.

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CHAPTER NO.2. INFORMATION MODELS OF SOCIAL SYSTEMS AND ENVIRONMENTAL MANAGEMENT

Concepts being studied: *actogenesis, targeting, means, methods, conditions of actogenesis, executive system, direct, reverse links in the management system, controllability, and observability of systems, thesaurus, types of information exchange: managerial, adaptive, cognitive (active and passive), types of information: control, adaptive, monitoring, operational, structural, valuable information, social information and its functions, information resource, mechanisms of information exchange in biological systems, mechanisms and means of information exchange in social systems, perturbation criterion, the evolution of systems, multi-system of environmental management, multi-trajectory of evolution, information criteria of evolution, systems of management of society: anarchy, democracy, authoritarianism, information thresholds, phase transitions of the global social and geographical system, lithogenesis, biogenesis, sociogenesis, noogenesis.*

Competencies concerning emerging skills: *ability to analyze system of goals, means, methods, and conditions of actogenesis, to build input and output vectors of the controlled system, to distinguish types of information exchange and types of information in specific situations, to be able to quantify information in simple processes and phenomena, mechanisms of information exchange in natural and social structures, ability to analyze social and geographical systems in terms of information criteria of evolution, to apply information criteria to optimize the environmental management.*

TOPIC NO.1.
THE ROLE OF INFORMATION IN THE INTERACTION OF SYSTEMS OF DIFFERENT NATURE-DEVELOPMENT FEATURES

LECTURE NO.6.
INFORMATION EXCHANGE IN NATURAL AND SOCIAL SYSTEMS

Plan:

1. Information exchange in natural mineral and biological systems: levels, mechanisms, consequences.
2. Information exchange in social systems: individual, social levels.
3. Basic principles of information interaction of social and natural systems.
4. Information concept of interaction between society and nature.

Natural systems (Fig. 2.1) are divided into biological and mineral by the nature of metabolism, energy, and information; biological subsystems, in turn, are divided into plant and animal subsystems, and mineral subsystems are divided into local, regional, and global ones.

Levels of information interaction of biological subsystems:

- *genetic and biological*, which reflects the transfer of species' biological information through the mechanisms of inheritance, and it is typical to the same extent for plant and animal subsystems at this level of commonality;

- *psycho-biological*, which reflects the exchange of information in animal subsystems; an individual acquires the information during his life, and some of this information is probably transmitted through gene carriers.

Mineral systems define:

- distribution of various chemical elements in the Geoversum, conditions of their migration and accumulation, differentiation of the substance, interaction and formation of chemical compounds, etc.;
- distribution of various mineral resources in the earth's crust and conditions for their extraction;
- dynamics of the properties of the natural environment of human existence;
- parameters and dynamics of mutual adaptation of social and natural systems.

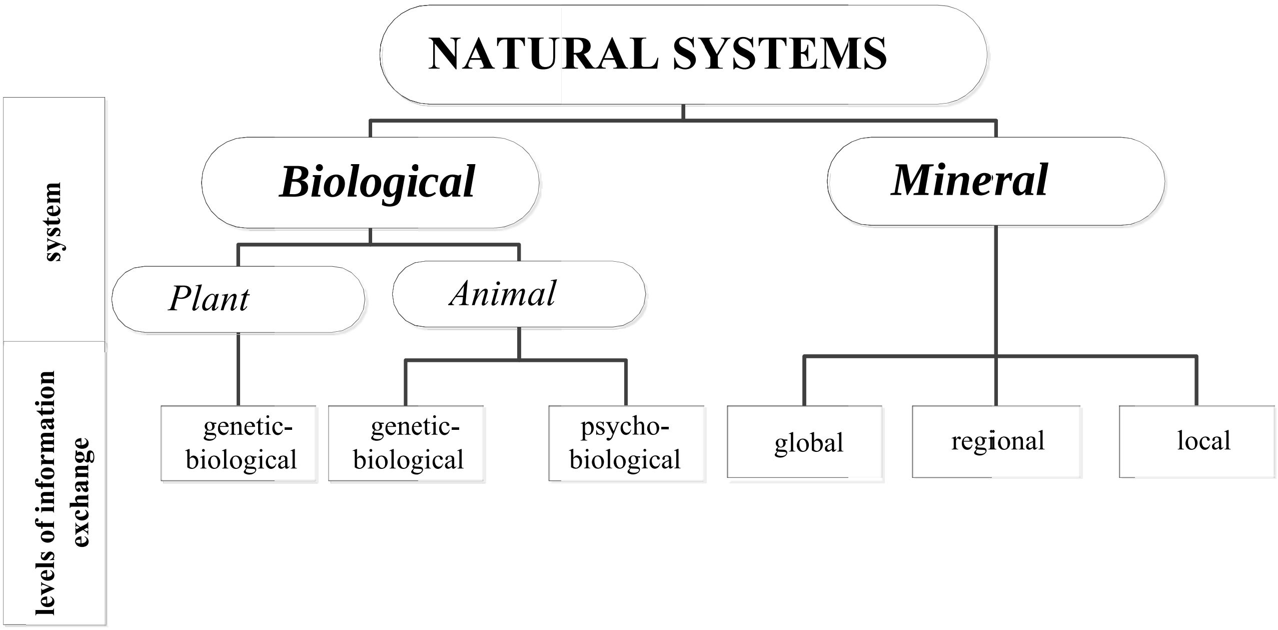

Fig. 2.1. Levels of information exchange in natural systems

In terms of the scale of information systems that are formed in the inorganic world, the following levels of information interaction are distinguished in the first approximation:

– global;
– regional;
– local.

The global level of information interaction covers the most general information flows due to global heterogeneity. This is the presence of oceans and continents with appropriate types of crust, differences in the receipt of solar radiation, and caused heterogeneity of the atmosphere, global climate-forming factors, etc. These elements of global heterogeneity, for example, the geological structure, represent the most ancient information structures formed in the differentiation of the Earth's substance.

The regional level of information exchange corresponds to the flow of information within the large mineral systems, namely continents, oceans, geological structures (plates, plateaus, crystal shields, etc.), and large river basins. Information structures of regional geological systems differ by less information capacity and contain structural information on the differentiation of the geological history of their development. The near-surface parts of the considered systems are actively involved in the economic activity of society. Therefore, they are characterized by intensive information exchange with complete transformation of information in the management cycle. Their structural information has been partially changed and supplemented under the influence of managing and adaptive information. The information structures of the mineral components of regional geographical systems are more dynamic, as they are more prone to the impact of the economic activity of society. Currently, virtually all of these systems are in a state of management (perturbation) of society.

The local level of information exchange is the most diverse, as it covers the information flows in mineral systems from individual geological bodies (layers) to systems (large stratigraphic units, artesian basins), in river basins of a different order, etc. Local geological systems' information capacity is lower than at previous levels, and their information structures contain information differentiated by geological time. These systems are almost entirely involved in the production cycles of society. Therefore, their structural information has been significantly changed by anthropogenic activities. In general, a full cycle of transformation of information is observed almost everywhere at this level of information exchange – from structural to monitoring, operational, management, and new structural ones.

The levels of information exchange in social systems. Information exchange in social systems (Fig. 2.2) is characterized by high dynamism and tremendous diversity.

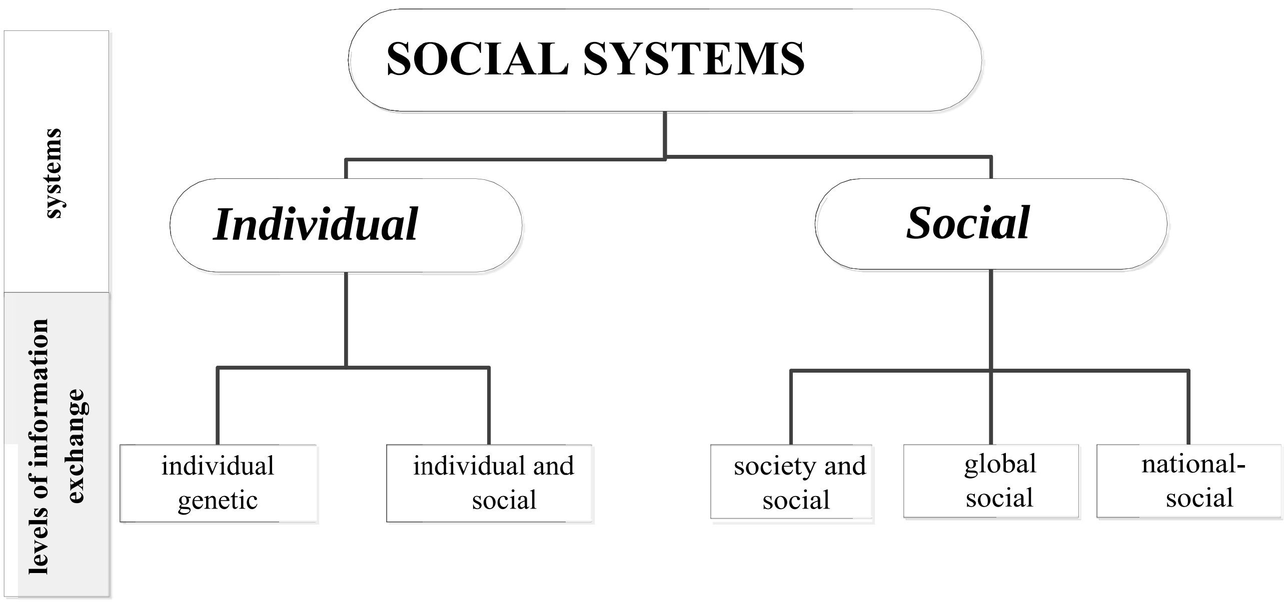

Fig. 2.2. Levels of information exchange in social systems

Contemporary human exists in the global information space, including the current political, economic, entertainment, professional, domestic, cultural, religious, and other types of social information, which to varying degrees affects the mentality and behavior of people, social groups, and society as a whole.

The determining factor in the perception and understanding of information is the subjective need for a particular social element in a specific type of information.

A considerable amount of diverse information is generated, transmitted, and accepted in the process of communication (exchange of information) between individuals and societies. It is aimed at achieving various goals. *The presence of the goal*, i.e. the expected result of the information exchange, unites the diversity of information exchange in social systems or with the participation of social elements.

Targeting and conscious achievement of the goal is the main difference between information interaction and society's participation. The purpose determines the nature of the information generated, the way of its transmission, obtaining and transformation, and ultimately the receipt of the result. Therefore, *targeting* is the primary motivating factor in information exchange.

Targeting and setting a goal and determining its character in moral and aesthetic terms depends on the individual's or society's mentality. Depending on the goal and its "information support", the result of the activity can be constructive (aimed at improving or creating any social object, system or phenomenon), or destructive (aimed at destruction).

Thus, the mentality determines the meaningful side of the information influence of a human or society on social and natural systems. The mentality of society is formed based on the mindset of individual societies and individuals. It is obvious that the individual mentality reflects the needs of only one person and determines his decisions and actions only in a narrow field of activity in nature. The social mentality characterizes the approach and vision of solving the environmental management problems of the whole social group. In this case, as a rule, the principles and rules of relation to the natural environment are produced, which more or less people implement and can potentially significantly change the quality of the environment.

The greatest scale in nature-transforming activities are communities of countries united by one or similar ideas of environmental management or superpowers with their environmental policy. Therefore, in the social aspect of this problem, it seems necessary to distinguish several levels of circulation and production of information, differing in the scale and content of the goals formed by social elements.

According to the proposed hierarchical classification, social systems are divided into individual and social ones, in which the following *levels of information interaction are distinguished:*

- *individual-genetic level*, reflecting the transmission of biological information from generation to generation;
- *individual social level*, reflecting information interaction between individuals;
- *society and social level*, reflecting the exchange of information between individual societies, for example, professional, political, age, ethnic, religious, and other groups of the population;
- *national-social level* reflects the information exchange and interaction between individual countries, taking into account their national and state interests, needs, and goals.

Principles of information interaction between society and nature:

- compliance with the development level of the social system and the volume of its information resource;

- mutual acceleration of the social system development and accumulation of information;
- optimal correspondence between the satisfaction level of social need and the amount of accumulated and mastered by society information obtained from the environment;
- equivalent transformation of information in environmental management according to the scheme: structural – monitoring – operational – managerial – structural;
- the consistent growth of the share of valuable information;
- consistent increase in the efficiency of the executive system and reduction of natural systems perturbation based on the progressive accumulation of information;
- sequential discrete transformation of the executive system;
- cyclicality of meeting the social need caused by the transformation of the executive system and changes in the social request;
- sequential change of environmental management strategies based on the formation and gradual development of the global mentality of the society following general civilizational values, requirements, and standards;
- priority development of information support of environmental management based on the synergistic general scientific approach;
- information interference in the multi-system of environmental management;
- dependence of the cultural process development on the information resource of the society.

Questions for self-control:

1. Information resource of society, its components.
2. Value of information resources for society development.
3. Levels of information exchange in natural mineral and biological systems, its mechanisms, and consequences.
4. Information exchange in social systems: levels, mechanisms, consequences.
5. Basic principles of information interaction of social and natural systems.

TOPIC NO. 2. INFORMATION MODELS OF SOCIAL SYSTEMS AND ENVIRONMENTAL MANAGEMENT

LECTURE NO. 7. INFORMATION CONTRADICTIONS OF ENVIRONMENTAL MANAGEMENT

Plan:

1. Perturbation of the environment and information. Perturbation criterion.
2. Linear and nonlinear information models of environmental management.
3. Optimal, risky, and inefficient trajectories of environmental management.
4. Information contradictions of environmental management
5. Ways to resolve dialectical contradictions in multisystem of environmental management.

In its development and interaction with the environment at each new stage, society begins to feel a new social need. The need is an objective category existing independently from the subject (society) and reflects its dependence on the surrounding world.

Having realized the need, the subject moves to goal-setting, i.e. construction of the system of goals. In case of its implementation the need will be met. Information about the environment is necessary at this stage of the socio-actogenesis for assessing the subject's ability to achieve the set goals. Using the available scientific information, i.e. accumulated knowledge and experience, the subject compares its capabilities with the properties of the natural system, which is chosen as an object of environmental management. Further, the means, methods, and conditions for achieving goals are determined in the construction of the ES. The optimal choice of elements of the ES, i.e., the optimal scenario of interaction with the object of environmental management, requires detailed information about it. If the output information is insufficient or it is unreliable, the subject risks choosing even an incapacitated scenario. As a result, the process of socioactogenesis will be useless. The construction of the ES, as a tool for managing the object of socioactogenesis, represents a significant and responsible stage. The result directly depends on the amount and quality of the output information.

Therefore, the subject who can use more reliable information from the external environment is more likely to find the optimal trajectory of interaction with the object of socioactogenesis.

A crucial role in the information interaction between society and nature plays in meeting the society's needs at all levels of its hierarchy. The need for information arises when society forms the ES for implementing the system of goals generated by any need. At the same time, information is necessary at all stages of achieving the goal, starting from the initial search but in different volumes. The growth of social needs and information accumulated and assimilated by society is interrelated and occurs with gradual acceleration.

Different options for the trajectory of interaction between society and the environment can lead to the perturbation of natural systems with the appropriate mode of their functioning. We will understand the *Perturbation of the system* not only as the intensity of the influence of the external environment or the subject of management but more broadly as qualitative changes in its structure and mode of functioning. Therefore, it is essential to consider the impact of the external environment on the system near the critical point of its state when its qualitative changes are possible. This situation arises in the extreme conditions of implementation of the environmental management scenario. Regarding natural systems, *we use the quantitative criterion of the ratio* of changes in the parameters of the system and the external environment (formula 2.1):

$$Kr = dP / dt / dS / dt, \qquad \text{where} \qquad (2.1)$$

dP/ dt is the rate of change of the most dynamic parameters

of disturbing influence of the external environment (subject of environmental management);

dS/ dt is the maximum permissible change rate of the most sensitive parameters of the system to disturbance.

Depending on the specific content of the interaction between the external environment (or the impact of the object of environmental management) and the natural system, the criterion of the ratio of parameters K_r can reflect the rate (intensity) of metabolism and (or) energy.

As can be seen from the formula 2.1, fundamentally, there can be three characteristic values of the specified criterion (Table 2.1):

Table 2.1

System disturbance criterion

Kr Value	Mode	System response to disturbance
Kr< 1	Optimal	The system manages to compensate for the disturbance created by the environment (the subject of the socioactogenesis) at the expense of internal resources and continues to function sustainably.
Kr= 1	Critical	The internal resources of the system are fully spent on maintaining a steady state, and additional disturbance can lead to its instability and transition to a catastrophic mode.
Kr> 1	Catastrophic	The system does not manage to compensate for the environmental disturbance and goes into a catastrophic mode of functioning, which leads to its structural restructuring or destruction.

Thus, depending on *Kr* value, different modes of the system operation can be distinguished. The level of meeting the social need which caused this process of socioactogenesis, determines the degree of disturbance of the natural system. Based on environmental considerations, activities in critical and catastrophic zones are unacceptable since they lead to the natural system's degradation and destruction.

The degree of disturbance of the system also depends on the efficiency of the ES and the trajectory of environmental management. In turn, the effectiveness of the ES significantly depends on general and special knowledge, i.e., on the amount of accumulated scientific information and monitoring information about a particular system. Therefore, the latest technologies and tools for environmental management, developed based on more information, are always more effective than the previous ones.

The structure of scientific knowledge, as it accumulates and develops, significantly changes due to the enrichment and improvement of the scientific apparatus, the discovery of new laws and patterns, the development of more progressive theories, etc. Therefore, it is characterized by a nonlinear dependence of the border shift of the critical environmental management zone under the influence of changes in the volume of accumulated information (Fig. 2.3, formula 2.2).

$$P = (I/a)^n, \quad \text{where} \qquad (2.2)$$

I is the amount of accumulated information in conventional units;
R is the level of meeting needs;
n, a are dependency parameters.

Depending on (formula 2.2), the parameter *n* determines the degree of curvature of the described dependence. It can be interpreted as a parameter of the progress of the accumulated information, since as it increases, the shift of the threshold of the critical zone *PKR* raises. The value of this parameter is associated with the peculiarities of the development of scientific information, so it can be called the *progress parameter*. It is relatively invariant and depends mainly on general knowledge, so it can be assumed that its numerical value can vary as a function of *I*.

Parameter *a* can be interpreted as the degree of inertia of natural systems in meeting social needs. Its value varies depending on the degree and nature of the necessary impact on natural systems when satisfying social needs, and the features of the natural system used. It is determined mainly by the amount of special knowledge.

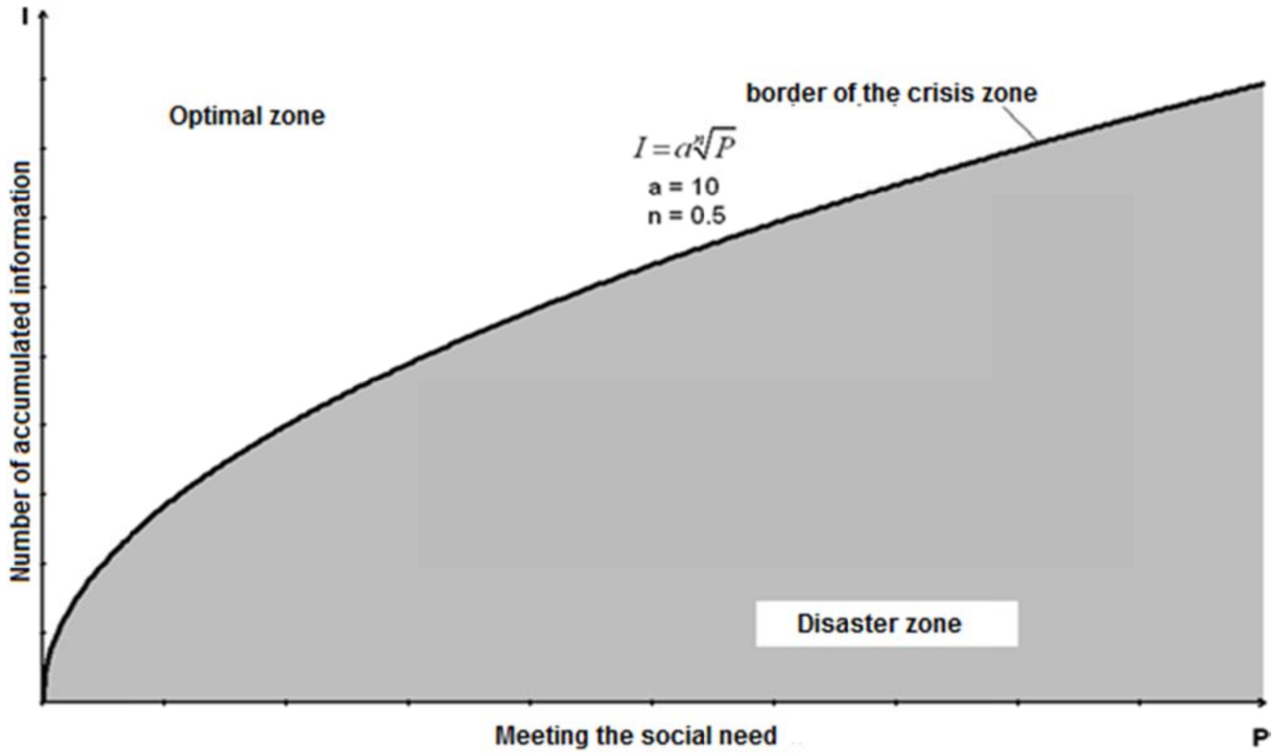

Fig. 2.3. Nonlinear model of the natural system perturbation

Special knowledge produced in the monitoring subsystem and the initial study of the natural system is of great importance when creating an ES and choosing a trajectory for meeting a need. In addition, the monitoring information should provide a reliable definition of the criterion *Kr* to assess the trajectory of the interaction process. Suppose there is a threat of the system transitioning to critical or catastrophic mode. In that case, increasing the amount of monitoring information is necessary for the more significant correction of the ES. This feature of the information interaction of the subject and the object of socioactogenesis is manifested only when the social need expressed through the system of goals forces the natural system to a critical limit.

Taking as a basis the dependence between the required amount of information, the level of meeting the social need, and the law of information interaction between society and nature, we will determine the information model of environmental management in the following way (Fig. 2.4, formula 2.3):

$$I = I_0 + kP, \quad \text{where} \qquad (2.3)$$

I is the integral amount of accumulated and processed information obtained from the environment;

I_0 is the initial amount of accumulated information at the beginning of this cycle of the meeting need;

P is the social need, or the level of its satisfaction, presented in concrete terms;

k is the coefficient of this need's information capacity, indirectly reflecting the ES's efficiency.

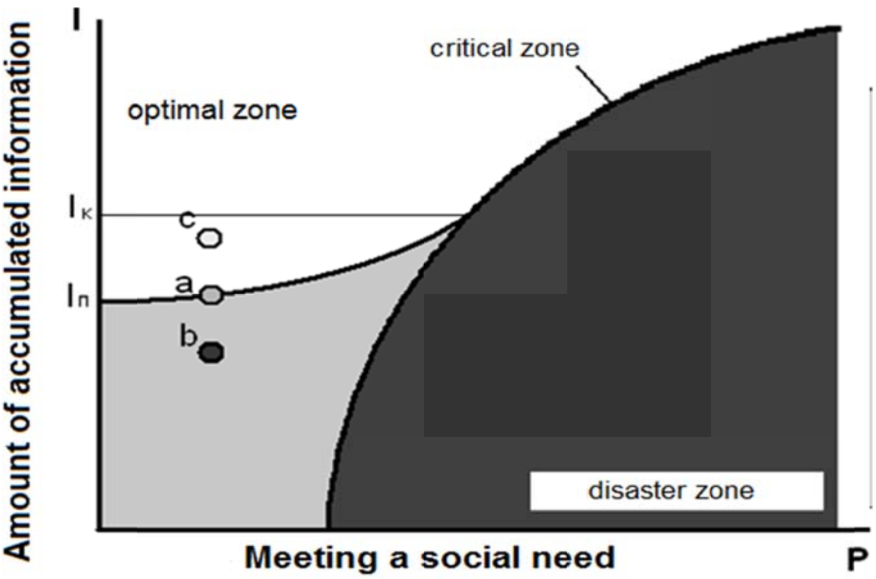

Fig.2.4. Non-linear environmental management mode

Three characteristic situations can arise in the process of environmental management when the current point of the process is located at the optimal (*equilibrium) trajectory (a), below (b) or above (c*) it.

1. *The current point* of meeting the need is located on the optimal (equilibrium) trajectory. In this case, the correspondence of the values *I* and *P*is is strictly fulfilled, so this situation is perfectly optimal. The increase in meeting the need is accompanied by the corresponding increase in information extracted from the natural environment using the monitoring subsystem. This information passes through the processing stage into a new quality, namely *special knowledge*, after scientific analysis and generalization. A fairly long monitoring process (accumulating a fairly large amount of information) or obtaining new empirical scientific facts cause summarizing and transference of the monitoring information and the corresponding special knowledge to *general knowledge*. The new general and special knowledge allows, in particular, to expand the understanding of the functioning of this natural system, clarify the forecast of its development, assess the effectiveness of the ES, and determine ways to improve it. The limit of meeting the need for this trajectory is the point *a* of the intersection of the trajectory with the limit value of the critical zone *Pкр*.

2. The current point of the interaction process is below the optimal trajectory. The condition of the values compliance *I* i *P* is violated, and *P* more *I* in the equivalent form. The increase in the meeting the need outstrips the increase in the amount of information. This situation can be interpreted as a deficiency of information for the optimal implementation of the mechanism of meeting the need. In this regard, the subject of environmental management does not have the opportunity to make a complete forecast of the change of the natural system in different scenarios of interaction with her.

The lack of information complicates the choice of the optimal trajectory of the scenario. As a result, the scenario may be sub-optimal or crisis.

Uncertainty in the response of the natural system to resentment provides a risky nature to environmental management since uncontrolled interaction factors can bring the system into a critical mode regardless of attempts of the subject of environmental management to correct the situation. Adjustment of the ES is possible only if the lack of information is filled to the level of compliance with this need, i.e. to the transition of the entire multi-system of environmental management to the optimal state *(a).*

The history of interaction between society and the natural environment knows more examples of the destruction of natural systems and their catastrophic changes under the influence of human factors than the harmonious organization of environmental management. A typical example is the tragedy of the Aral Sea. It can be concluded that the situation considered conceals the risk of acceptance of the suboptimal option of environmental management. It can lead to significant material losses and irreparable damage to nature.

1. *The current process point* of the interaction is above the optimal trajectory, i.e., in the equivalent of I more than P. The growth in the amount of information outstrips the growth in the satisfaction of the need, and part of the information turns out to be surplus. As a result, it partially loses value. Interaction is possible in the optimal mode in such a situation as in situation *(a).* Still, the subject of environmental management spends unjustifiably more resources on extracting information from the environment.

Fig. 2.5. demonstrates the effect of the dialectical law of the transition of quantity to quality: dialectical contradictions arise and continuously develop between the ES (or rather, the consequences of its implementation) and the current amount of information about the natural environment. They require changes in the ES. These contradictions emerge when some limited values are reached and achieve a maximum in the area of limited values. The first contradiction corresponds to the previously considered situation (c), when the amount of accumulated information exceeds the equivalent level of meeting the need and reaches the maximum at the beginning of the functioning of this ES. As the ES approaches the point of maximum efficiency (B), this contradiction decreases to zero, and the second contradiction develops. It means the inadequacy of this ES to the natural environment. This contradiction is decisive since environmental management is the riskiest in the situation *(b),* which corresponds to this contradiction. When this contradiction reaches the limit tension, the discrete change of the ES within the current strategy occurs. This strategy allows the existing contradictions and creates conditions for their development at a new turn of the ES. The limit values of the contradictions above and below the optimal trajectory of the environmental management make it possible to build the permissible limits of deviation of the ES from it, which form the zone of acceptable risk.

The considered situations of real correlation of the amount of information and the level of meeting the social need demonstrate that the situation *(a)* is optimal, situation *(b)* is dangerous with the possibility of making an inadequate decision. Situation *(c)* indicates that additional resources are spent on obtaining excess information.

It is possible to classify the trajectories of meeting social needs as follows:

- the optimal trajectory is in the situation *(a);*
- *the risky* trajectory is in the situation *(b);*
- *the ineffective* trajectory is in the situation *(c)*.

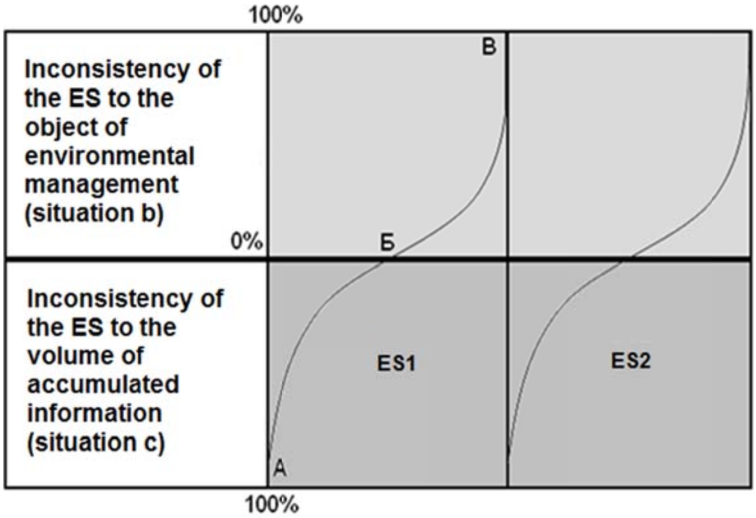

Fig. 2.5 Dynamics of dialectical contradictions of the executive system in environmental management

The different slope of the trajectories in Fig. 2.4 indicates the different effects of the BC potential.

The efficiency of ES is the increase in information extracted from the environment and processed by the subject of environmental management per unit of an equivalent increase in the level of meeting the need. Otherwise, the efficiency of the BC is its information capacity (scientific capacity), which can be quantified (formula 2.4) as a proportionality coefficient k:

$$k = (I - I_0) / P \quad \text{where} \qquad (2.4)$$

R is the level of meeting needs;

However, the high efficiency of the trajectory does not guarantee its unconditional choice for implementing the mechanism of meeting the need. Therefore, the optimum ES is taken as corresponding to this trajectory. When choosing the trajectory and its optimal ES, the subject of environmental management considers various criteria reflecting the economic efficiency, payback, and scientific and technical security of society.

Since the parameters of the optimal trajectory are not known in advance, the real trajectory of the implemented scenario is determined in practice with small deviations from the unknown trajectory.

Questions for self-control:

1. The relationship between the degree of disturbance of the environment, the degree of the meeting social need and information.
2. Criteria for environmental disturbance.
3. The dependence between the amount of information learned by society and the efficiency of environmental management.
4. Optimal, risky, and inefficient trajectories of environmental management.

LECTURE NO. 8. STRATEGY AND TACTICS OF ENVIRONMENTAL MANAGEMENT. THE ROLE OF DETERMINISTIC AND RANDOM PROCESSES IN THE EVOLUTION OF SOCIAL AND GEOGRAPHICAL SYSTEMS. APPLIED INFORMATION ANALYSIS OF SOCIAL AND GEOGRAPHICAL SYSTEMS

Plan:

1. Strategy and tactics of environmental management in terms of information exchange.
2. Information resource of society and the choice of environmental management strategy.
3. Tactical features of environmental management.
4. Transformations of the executive system as a necessary element of environmental management.
5. Scientific and technical "breakthroughs" and changes in the environmental management strategy.
6. Stages of formation of information exchange in the multisystem of environmental management.
7. The role of information in the evolution of social and geographical systems. Information criteria of evolution.
8. Deterministic processes and their role in systems development.
9. Totalitarianism and autocracy as a result of the predominance of deterministic processes in society.
10. Correlation of deterministic and random processes in the evolution of social systems.
11. Use of applied information analysis in social management.

Scientific information is accumulated discretely, namely in small portions, as empirical data are extracted and processed. The ES is also transformed discretely, but much less often, consistently forming a number of contradictions with the amount of accumulated information (Fig. 2.6).

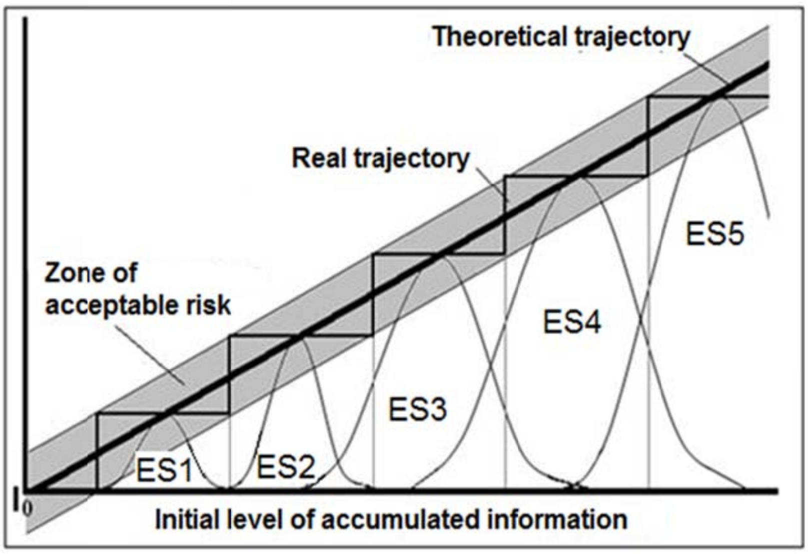

Fig. 2.6. Change of the executive system

Before considering the transformation of the executive system (Fig. 2.7), we clarify some key concepts.

We will understand the strategy of environmental management as a result of the first compromise in environmental management – between the desired and possible.

This is one of the mechanisms of society's adaptation to the changing state of the biosphere. As for the transformation of the ES, the interpretation of the concept "strategy" provided above means the opportunity chosen at a certain level of accumulation of information to meet a social need.

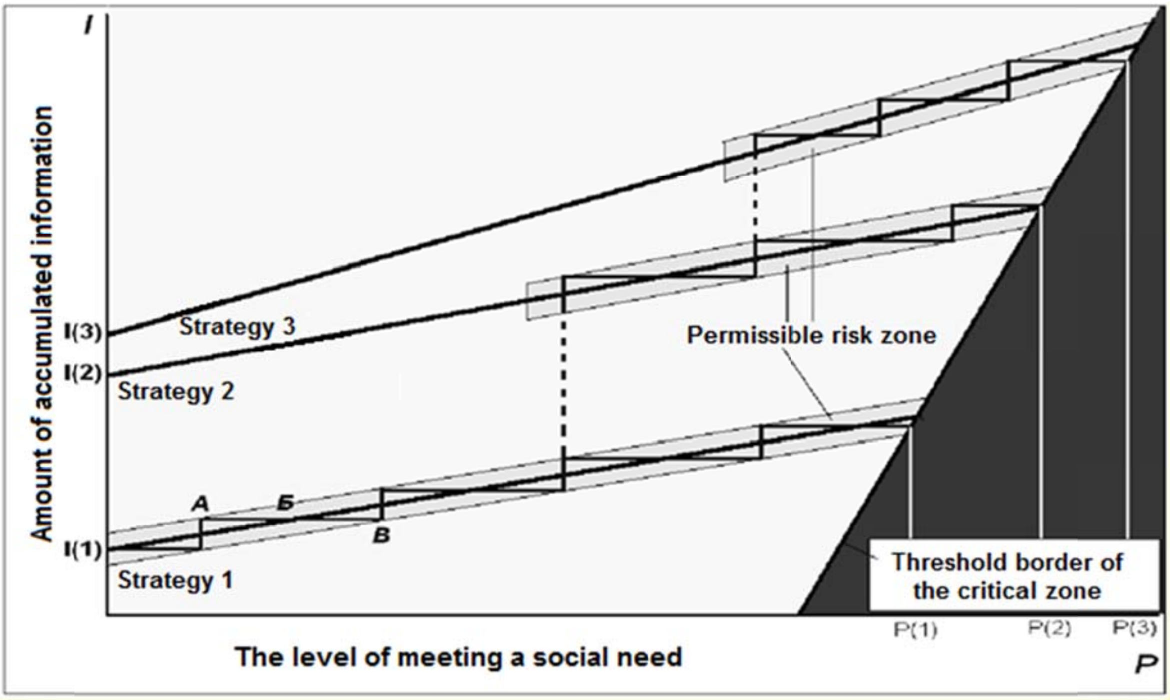

Fig. 2.7. Transformation of the executive system

In the situation shown in Fig. 2.7, trajectory 3 is the most effective. Still, it can be discarded, for example, due to a lack of necessary funds or insufficient technology processing. Understanding its prospects and planning to switch to it in the future, the subject of environmental management is forced to start meeting the need with less effective trajectories 1 or 2. Based on this, it is possible to formulate *such a law of information interaction between society and natural systems*: when the scientific information is accumulated and developed, the efficiency of the ES in environmental management increases, and the perturbation of natural systems decreases. However, at present, this provision largely depends on society's mentality since environmental considerations often have a subordinate importance in choosing the effective trajectory and ES. The ES has a certain inertia; it cannot be continuously transformed following the growing amount of accumulated information.

Each subsequent strategy, developed on the basis of more volume of scientific information, implements wider opportunities in environmental management. Therefore, it is more progressive. Thus, different strategies correspond to the trajectory defined at varying levels of accumulated information.

Tactics of environmental management is determined within one strategy, and it is a sequence of stages of adaptation of the ES to the changing properties of this natural system. Tactics reflects the result of the second compromise, namely between the available means, methods, and conditions for achieving the expected result. Tactical requirements are reduced to the fact that the ES optimally corresponds to the current amount of accumulated information. But since the ES cannot change continuously, its changes occur in a jump-like manner within the same strategy. Here we can see the effect of the dialectical law transition from quantity to quality.

The dialectical contradictions discussed above (Fig. 2.5) arise and continuously develop between ES and the current information about the natural environment. They require changes in the ES.

Analysis of the change in the effectiveness of the ES during the cycle of its functioning allows to imagine the adaptation of the ES from the standpoint of the transformational theory of systems development. According to this theory, any system's adaptation occurs by successively changing the structure states, which are currently best adapted to the external environment. Since the greatest efficiency of the ES is achieved near the optimal trajectory of environmental management, it is obvious that the characteristic curves of these structures should have a dome-like shape. These curves underline the dependence of efficiency on the required level of meeting the need.

Expanding society's opportunities to meet social needs is associated with developing and implementing new promising strategies for environmental management. This is because each environmental management strategy has a limit in meeting the social need, i.e., each strategy has an interval of retaining usefulness for meeting the need. Strategies 2 and 3 are depicted in Fig. 2.7.

The development of new strategies requires, first of all, a more profound knowledge of the patterns of the natural systems functioning, the availability of new, more advanced means of environmental management, and the possibility of developing progressive technologies able to ensure environmental safety and minimize damage to the natural environment. In the future, more stringent requirements will be imposed on environmental management technologies, including restoring the properties of natural systems lost due to anthropogenic impact.

The presence of promising environmental management strategies and society's readiness to proceed with their implementation foster the transition of the ES to a new trajectory. A drastic change in the ES supports it following new ideas and attitudes in the new environmental management strategy. Since each higher-level strategy has a longer interval of meeting needs, as shown in Fig. 2.7, a consistent transition to more effective strategies ensures progress in meeting this need.

Consequently, the information extracted from the environment through the monitoring systems is necessary not only to control the trajectory of the scenario but also to develop increasingly effective options for the executive system in the future. Thus, new special and general knowledge is accumulated in the process of functioning the ES. This is a consequence of the generalization of monitoring information with the participation of existing knowledge. After a certain time, the increase in the subject's level of knowledge causes opposition between him and the operating ES. It means that this ES becomes ineffective in terms of new knowledge, it is morally aging and leads to a change in the ES and a significant change in the trajectory of environmental management. This is no longer an adjustment of the trajectory in the old zone of assumed risks. This is a choice of a strategically new, more effective trajectory corresponding to the greater amount of information received and processed by the subject in environmental management. Then this cycle repeats, but with great acceleration, since new knowledge accumulates faster.

Thus, it can be argued that the main content and consequence of the scientific and technical progress is the continuous updating of the ES in the entire range of social needs of the community.

Involvement and transformation of information in the process of environmental management.

The elements of information exchange between society and the natural environment, which have been considered, form a single consistent flow of information in a multisystem of environmental management. The following stages can be distinguished in its formation:

1. *Generation stage of the request information:* Society is aware of the existing social need and formulates the main goal of environmental management. The content of the need within the terms of modern knowledge is clarified, and possible ways of its meeting are planned to obtain a certain resource from natural systems, their use for specific economic activities, etc.

2. *The formation stage of the preliminary information (thesaurus*). Using general knowledge, society determines the range of natural systems able to become a source of meeting this need. Based on a priori information, one or more systems are pre-selected as objects of the future environmental management process, and an array of preliminary information is formed.

3. *Special Knowledge Acquisition Stage*. A detailed study of the selected natural system is carried out taking into account the previous information to obtain the structural information contained in it, assess its state and prospects of operation, and forecast behavior. The degree of transformation of the structural information depends on the level of information accumulated and mastered by society.

4. Stage of *strategic information* formation (strategic planning). Here the first compromise of environmental management between the desired and the possible is implemented based on general and special knowledge. As well as it implies the development and substantiation of the strategic perspectives of environmental management. These perspectives determine the primary approaches, system requirements, and criteria for optimization of all parameters of the future environmental management process. Also, a forecast assessment of the natural environment change is carried out.

5. Stage of formation *of tactical information* (tactical planning). The structure and parameters of future ES (main and alternative) are determined based on the special knowledge and strategic information obtained. They ensure their efficiency and a wide range of adaptations to the conditions of the natural system, which are constantly changing. After analyzing the alternative options of the ES, a decision is made on the implementation of the optimal or most promising ES.

6. Stage of accumulation, analysis, and mastering *of monitoring information*. The process of meeting the social need begins with the implementation of the chosen strategy. The natural system is subject to the controlling influence of society and changes in its parameters, adapting to perturbation. Information on its changes is recorded and analyzed by subsystems of monitoring and management. Based on this information, managerial decisions are made, and managerial influence is exercised on the ES, which

keeps it close to the optimal regime. If the strategic trajectory reaches the threshold limit of the critical zone of the natural system or there is a lack of the expected progress in meeting the need, society moves the process to the next strategic level.

Monitoring information obtained during the operation of the natural system is subject to scientific analysis. It becomes a new element of the general knowledge system after generalization and transformation into special knowledge. Several features can be distinguished at this stage in converting information.

Firstly, the structural information is extracted in the process of its operation using observations of its current state and changes in parameters.

Secondly, each new portion of current information received in the next active monitoring phase is identified with available general and special knowledge. Depending on the scientific novelty, it complements the thesaurus or confirms already known facts, concepts, etc.

The role of deterministic and random processes in the evolution of social and geographical systems. Applied information analysis of social and geographical systems

Usually, the evolution of systems is represented as a cyclic process consisting of several stages, repeated each time at a higher level, forming a developmental equilibrium. The evolution trajectory represents a line on the cone's surface in the three-dimensional rectangular coordinate system (Fig. 2.8).

The dependence of the properties of the system on time allows for considering evolution as a non-stationary process. The properties of the system can be consistent in time in some development periods, i.e., the process of evolution can go into a steady state. Then the evolutionary trajectory is a line on the surface of the cylinder. By combining the described variants of evolutionary development, the trajectory of evolution can be imagined in the form of a complex screw line on the surface of cylinders and cones that change each other.

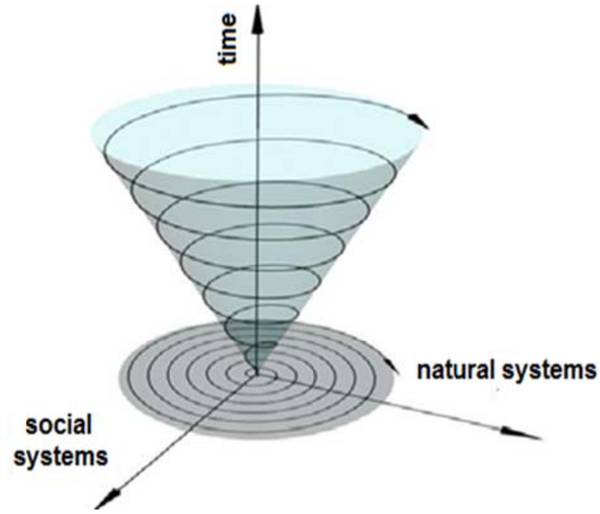

Fig. 2.8. The developmental cone

Conical sections of the evolution trajectory correspond to periods of the intensive system property change. Cylindrical areas characterize "stationary" periods of evolution, when the system, adapted to the external environment, functions relatively stably. A similar trajectory can be called a multitrajectory of evolution. Such a complex curve can reflect the evolution of any system, regardless of its nature. For example, it is known that periods of accelerated development alternate with periods of relaxation in the history of the development of mineral systems (large geological structures, regions). Similar development features are characteristic of biological systems, which should respond to the uneven evolution of mineral systems.

Certainly, all events and processes occurring in mineral, biological and social systems are interrelated and interdependent. The synchronism of their changes is distorted by the different degrees of inertia and stability of systems in different time dimensions in which they function. Therefore, it is possible to find "information" traces of events that took place in the social and geographical system many hundreds of years ago in the current global socio-ecological crisis of society. Likewise, our distant descendants will receive the information signals of contemporary society, preserved in mineral, biological and social structures.

To build a model of the multisystem of environmental management, we will use a model of the evolutionary development trajectory. We will get a basic model by taking positive and negative changes in social and natural systems due to their interaction as horizontal coordinates.

The coordinate "social systems" characterizes the degree of change of the social system in environmental management; the coordinate "natural systems" characterizes the degree of change in the natural system. The projection of the evolution trajectory on a horizontal plane with the same intensity of changes in the social and natural system is an isomeric spiral. When analyzing the evolution, we can consider positive changes in the systems (in the positive direction of the respective systems) or negative (in the opposite direction). If positive changes prevail, then this system progresses. Otherwise, it degrades.

The above models demonstrate three possible options for the development of social and natural systems in the multisystem of environmental management:

1. social systems are being developed more intensively (Fig. 2.9);
2. natural systems are being developed more intensively (Fig. 2.10);
3. both types of systems are being developed proportionally (Fig. 2.11).

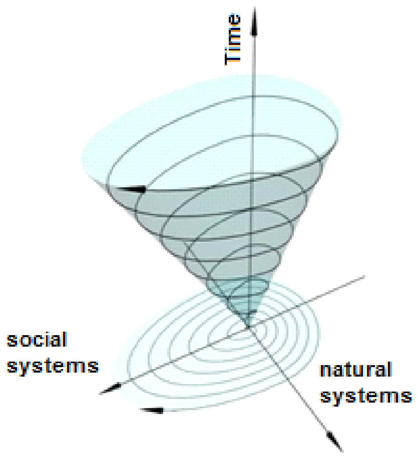

Fig. 2.9. The trajectory of uneven development with a predominance of the social system

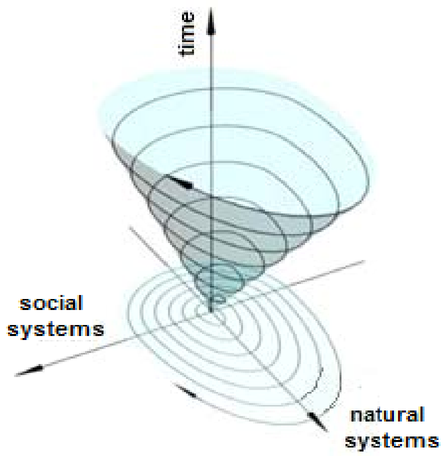

Fig. 2.10. The trajectory of unequal development witha predominance of the natural system

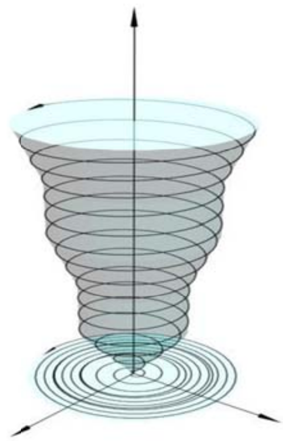

Fig. 2.11. The complex trajectory of evolution

Further, we can figuratively imagine the progressive development or degradation of systems as deformation (elongation) of the evolution trajectory projection in the positive or negative direction of the axes. The system's evolution is a process of accumulation of structural information, accompanied by improvement of the system's structure and expansion of its functionality. In each fixed point of the trajectory, the development directions are conditionally shown according to alternative options, which are possible under these conditions.

Deterministic and random relationships between elements and subsystems operate simultaneously in social and geographical systems. Deterministic links create a rigid activity frame of the structure of the social and geographical system, and random ones create its possible fluctuations. Random links determine the adaptive capabilities of social and geographical systems.

Therefore, the ratio of randomness and determinacy of systemic links is significant in the evolution of systems, as it determines the limit of their development (Fig. 2.12). When the trajectory deviates into the area of amplification of deterministic links, the probability of free choice decreases as the natural process is more clearly manifested. When the trajectory moves away from the optimal position into the area of strengthening random connections, the probability of random choice of the option increases, as the uncertainty degree increases. Orientation of changes in the trajectory in the direction of growth of information (vertical axis) corresponds to the progressive development phase; inverse orientation indicates degradation of the system.

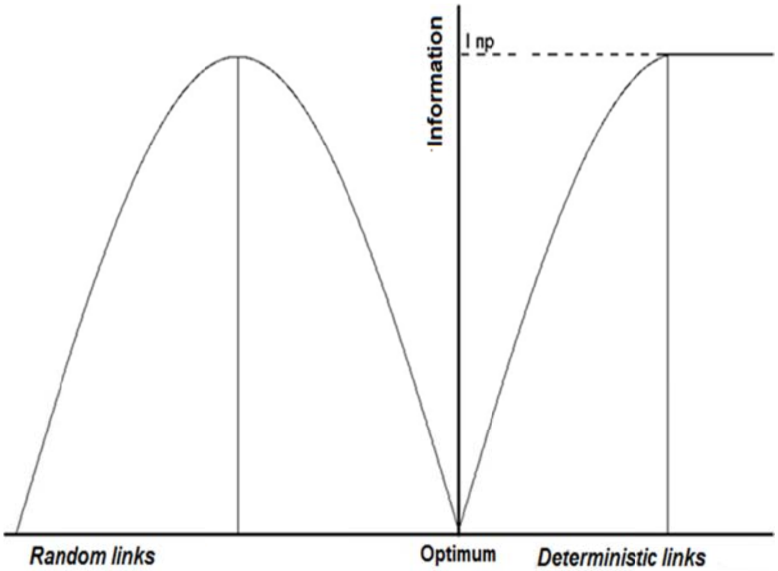

Fig. 2.12. Ratio of random and deterministic systemic relationships

The curve indicates the limited development trajectories of the management system of the social system. When the trajectory deviates into the area of deterministic systemic links, authoritarian governance prevails, which leads the social system to the development limit and further standing at the achieved level. Deviation of the trajectory towards random system links (anarchy) after passing the peak of information accumulation leads the social system to degradation and return to the initial state of chaos. Then the next cycle of development follows.

Excessive centralization of management determines the development of clearly deterministic system links. The social system with this type of governance has the characteristic features: full subordination of the peripheral authorities of the center, planned nature of the economy, ideological uniformity of society, intensification of bureaucracy and nomenclature personnel policy, demonstrative democracy.

The opposite type of society management, based on the absence of stable deterministic links, leads to the anarchy of public life, the uncertainty of the future, the chaotic economy market, and the absence of promising programs and development plans.

Democratic options for developing the system of management of society represent a combination of different forms, methods, mechanisms, and ways of influencing society based on the priority of universal values, principles of social justice, and respect for human rights. National, cultural and historical, religious traditions, and other social development factors play a significant role in developing a democratic society.

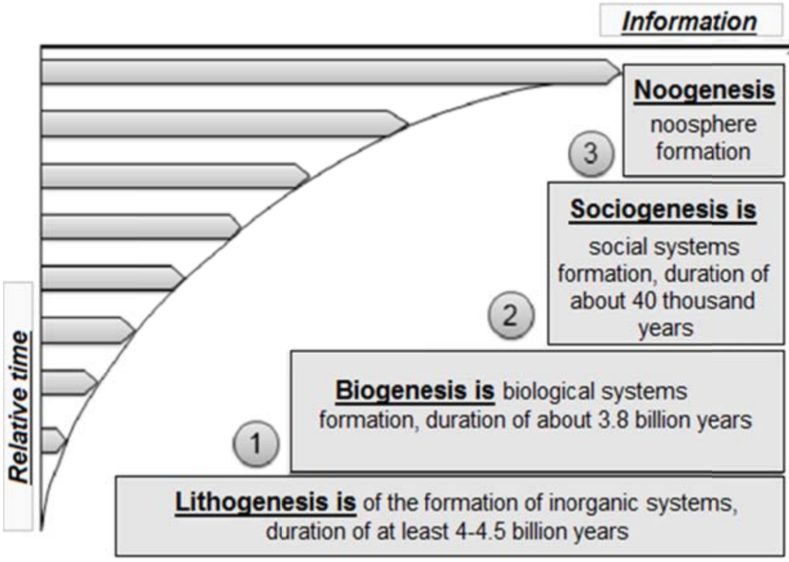

Fig. 2.13. Evolution of the global social and geographical system

The effect of increasing diversity is demonstrated in the generalized example of the evolution of social and geographical systems (Fig. 2.13).

The starting material for creating material systems on Earth is quite limited and includes atoms of chemical elements and elementary parts. Therefore, the information capacity of mineral systems was quickly (in geological time) exhausted, and increasing the complexity of the created systems (the growth of accumulated information) required creating more capacious media of structural information. A natural synthesis of organic matter occurred as a result of the evolution of the primary solutions of mineral matter. It became the basis of biological systems with a much greater diversity than mineral systems. It was the first phase transition of the global geographical system from synthesizing mineral matter to creating biological systems.

The first simplest living substance continued to develop in the direction of increasing complexity, diversity, and orderliness. As a result of evolution, more complex living organisms emerged, which possessed more advanced adaptive capabilities and could receive more and more information from the external environment. New biological species, long-term specialization, and differentiation of biological systems emerged, and they became more diverse.

It is important not only that the improvement of the biosphere caused the strengthening of the information exchange between mineral and biological systems and the mutual enrichment of structural information. As a result, the total amount of information in the global system increased. The crown of the evolution of biological systems was the appearance of a human endowed with reason. Development of the social essence of the human fostered the second phase transition of the global social and geographical system, namely to the sociogenesis (L.M. Niemets, 2003).

Social systems have practically solved the problem of information accumulation by creating artificial media with virtually unlimited information capacity. But this is already an accumulation of social information, not a structural one. Therefore, it is possible to wait for the continuation of the evolution of organic matter in the future in the direction of complicating the structure and accumulation of structural information, perhaps even in combination with mineral systems. It can lead to the third phase transition of the global social and geographical system into a new state, namely the noosphere.

Therefore, nature has created a diversity of systems from a relatively limited number of source elements over billions of years of evolution. These systems are not quantifiable today.

The completeness of the consideration and analysis of the interaction of geographical objects is proportional to the number and informativeness of the fields of their features. The more parameters of objects are used for quantitative analysis, the more reliable result is. This thesis implies that the parameters of geographical objects should characterize the maximum possible number of various features, which coincides with the requirements of the synergistic approach. In addition, it becomes necessary to assess the informativeness of the set of object features using applied information analysis methods.

Let us consider in more detail the evolution process of the system and the role of information exchange in it. In particular, E.O. Sedov (1965) performed the philosophical analysis of the evolutionary process and proposed to consider development as a process in which the increase in the amount of information in the system outpaces the growth in the mass of the system and the rise in the number of its components of homogeneous elements (Prigozhin's evolutionary-information criterion). These evolution conditions can be represented in the form of the following inequalities:

$$\frac{\partial^2 I}{\partial M^2} > 0; \qquad \frac{\partial^2 I}{\partial N^2} > 0; \qquad \text{where} \tag{2.5}$$

I is amount of information;
M is system weight;
N is the number of homogeneous elements making up the system.

It can be concluded that the total amount of information exceeds the total amount of information of the source systems in the progressively developing system. In other words, the indispensable condition for evolution is the growth of information links (diversity) within the system due to the information interaction of its subsystems and elements. In addition to self-organization, which increases the complexity and diversity of the system, open systems receive a part of the information from the external environment in the process of information exchange with it.

However, the growing orderliness of the system also means an increase in the determinants of internal relations, which hinders the system development and reduces its adaptive capacity. In particular, the complete determinability of any structural level of the system makes impossible its transition to a higher level. Therefore, dialectical contradiction always exists in a developing system between the level of the connection determinability of its elements and possibility of evolutionary development of the system. Information exchange with the external environment determines the dynamic equilibrium between these opposite trends. The constant equilibrium changes force the system to be in a state of mutual adaptation with the external environment. It supports the system's necessary level of stochastic links and enhances its evolutionary potential. The system achieves limited organization and loses the ability to develop in unchanged conditions since the internal resources of information generation are already exhausted, and there is no information flow from the external environment. This state corresponds to the equilibrium of the system in thermodynamics when the production of information approaches zero.

Questions for self-examination:

1. Environmental management strategy as a reflection of the information resource of society.
2. Environmental management tactics as a consequence of the growth of the society's
3. The information resource.
4. Information contradictions of environmental management and their importance in the improvement of executive systems.
5. Elements of executive systems.
6. Main compromises in environmental management, their importance in the choice of executive systems.
7. The role of transformation of executive systems in the periodicity of social phenomena.
8. Formation of information in the process of environmental management.
9. Information transformation in the process of environmental management.
10. Observability and controllability of systems, input and output vectors in the process of system management (environmental management).
11. Evolution of systems and information exchange.
12. Information criteria of the evolution of systems.
13. The concept of deterministic and random processes in social and geographical systems.
14. The role of random processes in the evolution of systems.
15. The evolutionary potential of the system as reflection of its information appropriation capabilities.
16. The integrated information model of environmental management.
17. The conceptual information model of society development.
18. Fundamentals of the information concept of interaction between society and nature
19. Usage of the applied information analysis in social management.

LECTURE NO. 9.
GEOINFORMATION TECHNOLOGIES. INFORMATION CONCEPT OF INTERACTION BETWEEN SOCIETY AND NATURE

Plan:

1. Fundamentals of geoinformation technologies (GIS).
2. Method of presenting discrete geographical objects in geoinformation systems.
3. Basic functions of spatial analysis in GIS technologies.
4. Methods of discretization and construction of GIS surfaces of the influence field.
5. The integrated information model of environmental management.
6. Conceptual information models of society development and cognitive processes.
7. Information concept of interaction of society and nature: stages of lithogenesis, biogenesis, sociogenesis, noogenesis and the role of information resource in the development of social and geographical systems.

Contemporary geographic information systems and technologies, in general form, represent hardware and software systems designed to receive, assemble, accumulate, process, analyze, and disseminate information about various objects on Earth's space. The basis of GIS is Database Management System (DBMS), in which various information is stored. To process information, the GIS includes analytical modules which implement a variety of data processing methods. In this respect, contemporary GIS can be considered a kind of generalization of approaches and methods used in spatial analysis. At the end of the twentieth century, GIS began to introduce expert systems and knowledge bases, which significantly expanded the capabilities of GIS, especially in the fields of automated control systems and decision-making systems. Contemporary GIS have developed communication means, allowing to exchange of data and providing information and reference services, etc. Another feature of GIS is the following: they are created to operate data with clear spatial (territorial) reference, so the results of their application, as a rule, are presented in the form of maps, which involves further cartographic analysis.

The universality of GIS has led to their widespread use in various fields of science, technology, management, etc. Along with general GIS, specialized geographic information systems are developed and used, focused on solving more narrow scientific and practical tasks related to spatial analysis. It should be noted that geoinformation systems and technologies were fundamentally originated in geography, came from geographical ideas about the spatial features of various processes and phenomena. Today they are used widely in almost all sciences that somehow solve spatial problems.

The GIS uses its *method of feeding discrete geographical objects,* which, in the context of spatial analysis, can be:

-*point* – they are represented as points with unambiguous coordinates in the territory or space;

-*linear*– they are as broken or curved lines with spatial binding;

-*planar* – they are part of the territory bounded by a closed, broken, or curved line.

In addition, the GIS uses so-called geo-information elements, namely text, and graphical frames containing descriptions, images, diagrams, graphs, etc., of the above-discrete geographical objects.

Those mentioned above discrete geographical objects (elements) create uninterrupted fields of parameters in space. These parameters are the main object of analysis in this case.

GIS pursues different geographical goals, from describing and getting a general impression about certain geographical objects to a detailed spatial analysis of certain territories. As a rule, *the basic functions of spatial analysis in GIS technologies* are reduced to the following:

1. Determination of geometric and linear parameters of geographical objects and geographical space (distance between objects, length of linear elements, perimeter and area of planar elements, etc.).

2. Determination of topological characteristics and spatial relationships between geographical objects (neighborhood, intersection, inclusion, etc.).

3. Isochores around all geographical objects limit construction of transition (buffer) zones. This task is crucial in human geography for organizing and optimizing all social and economic networks.

4. Analysis of networks (search for the shortest path according to different criteria, optimization of the route (path), analysis of the spatial distribution of resources, finding the "center of weight" and the geographical center of the network, search for the nearest neighbors, etc.).

5. Analysis of the spatial distribution of geographical objects (placement, spatial ordering, degree of concentration or dispersion, connectivity or inconsistency, etc.).

6. Analysis of surfaces (interpolation of "heights", determination of exposure of slopes, angles of inclination, construction of isolines and profiles of the given sections, modeling of the relief frame, calculation of volumes, generation of 3D images and many others).

7. Performing logical operations on geographical objects (elements), namely association, intersection, and difference.

8. Operational work with image layers (overlays) creates maps with the different meaningful loads.

The properties and characteristics of objects or points of space are essential when determining the main tasks of GIS analysis. Attributes of objects are classified into qualitative and quantitative ones. Various operations can be performed with quantitative characteristics; qualitative characteristics are mainly analyzed by comparison.

Let us focus on the technological features of GIS in performing spatial analysis, namely, modeling and approximating fields of parameters of geographical objects. The object of consideration will be a generalized algorithm for solving this problem using GIS.*, two methods of discretization and construction of the corresponding surfaces are* used to model, describe and represent these fields in GIS:

1. TIN *(Triangulated Irregular Network*) is an irregular grid of triangles. Its main advantage is the following: the density and placement of the points can be arbitrary, so that a set of flat triangles can display the surface of any complexity with the necessary detail. The maximum isometricity of triangles is considered when forming a grid of triangles for its greater representation. The Delone criterion formally depicts it. The vertices of triangles are nodes of the irregular grid, including the field parameter values. All nodes have continuous numbering, and each triangle is geographically (spatially) identified through its name, a list of nodes and nearest neighbors. Such a rather complex triangular addressing system is compensated by the topological convenience of the TIN surface, its flexibility, and mobility (changes are easily made to the grid), so this discretization method is widely used in spatial analysis.

2. GRID is a regular rectangular grid of nodes. Its convenience lies in the simplicity of the nodes addressing (a conventional rectangular coordinate system is used). Still, such a system of nodes is not optimal in terms of displaying the topology of the surface (it is displayed in flat rectangles). In addition, there is a technological problem with introducing new points into the grid, which requires restructuring the entire grid. On the other hand, GRID-model fully corresponds to the structure of the raster of the surface image (map), which is convenient for its visualization. Despite these shortcomings, the GRID model is more widely used in the spatial analysis than the TIN model.

After the formation of the grid of nodes, the values of the parameter are interpolated into the nodes. It should be emphasized that the surface of the parameter field can be constructed by interpolation methods or by approximation methods with appropriate analysis capabilities (for example, trend analysis, sliding statistical window, etc.).

Various cartographic means carry out visualizing the field surface of the parameter of the geographical object. As a rule, GIS includes various options for surface representation, namely maps in isolines, gradients, vectors, zonal maps, 3D surfaces, etc. It should be borne in mind that when creating a series of maps of the same content (for example, the state of the parameter at different points in time), it is necessary in all cases to use one method of interpolation or approximation, which determines the constancy in space of the analogy error.

It should dwell on the construction of maps of the density of geographical objects at the end of the review of traditional spatial analysis methods in three-dimensional geographical space. The reflection of density makes it possible to estimate the change in the concentration of certain geographical phenomena by area. To display the density on the map, it is possble to use

colored fills of areas based on the density of the distribution of quantities within them, or create a density surface.

Therefore, the density map demonstrates the degree of crowding or sparseness of objects within the studied area. At the same time, data on discrete (points), linear (lines) and planar (parts of the territory) objects can be used. There are different ways to calculate the density indicator displayed on the map. The generalized formula for calculating the density is as follows (formula 2.9):

$$G = \frac{\sum_{i=1}^{n} w_i o_i}{F}, \qquad \text{where} \qquad (2.9)$$

G is density;

O_i is the sum of objects or values of their properties within the representative area (it is a quantity for point objects, it is a length for linear objects, it is an area for planar objects);

ω_i is a weighting coefficient for calculating the weighted average;

F is the area for calculating the density (sq. km, sq. m, ha, etc.).

Suppose the calculation is performed on a uniform pallet. In that case, the simple number of objects or the sum of their inherent values is sometimes used instead of the density indicator.

A density map is created for planar objects (for example, administrative units, catchment areas, polygons, reservoirs, quarries, etc.), where zones are allocated by color. Maps of the density surface are created for point and linear objects; its "relief" can be displayed by isolines, zones, etc. Sometimes planar objects are replaced by points (the property value refers to the center of gravity of the planar object). The density surface is calculated, and symbols show the objects.

Suppose the creation of the density map is clear and does not require additional operations (the contours of planar objects are displayed on the map as painted with a certain color or covered with a dot or hatching). In that case, the calculation of density surfaces has a more complex algorithm that implements the method of local indicators. The size variability of the sliding statistical window is of fundamental importance. In addition, moving the window requires additional justification; when using a pallet, each cell is essentially such a statistical window. The windows do not overlap. In the classical method of local indicators, successive positions of the statistical window can overlap, contributing to additional surface smoothing.

Thus, density maps reflect the concentration of geographical objects (or values of their properties), that is, their territorial distribution in the general sense. Such maps are widely used in human-geographical research, because they make it possible to perform a comparative analysis of the placement and characteristics of planar and linear human-geographical objects. But their significant disadvantage is the complete lack of information about the interaction of these objects, which is taken into account in the method of modeling integral functions of influence.

To integrate the information interaction of society and the natural environment into a single linear model, it is possible to use the idea of building quadrograms. The environmental management quadrogram consists of four quadrants. The idea of its construction is that each quadrant reflects a certain segment of the information process (Fig. 2.14).

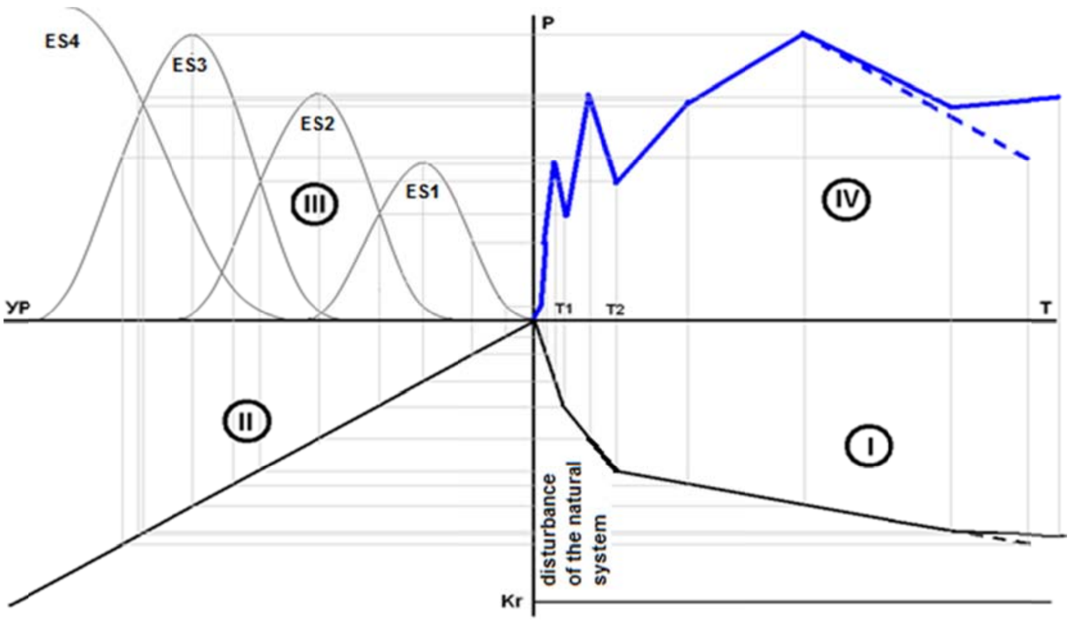

Fig. 2.14. Integrated Model of Environmental Management

Therefore, the disturbance dynamics of the natural system are reflected in *quadrant I*. This is a result of its operation. *Quadrant II* depicts a reflection of the state of the natural system by society. The mechanism of interconnection is quite simple. Society receives information about the current state of the natural system and, reworking it with available means of scientific analysis and generalization, turns it into managerial decisions through the monitoring system. *Quadrant III* manifests the impact of the ES structures that perceive managerial decisions and transform them into meeting the need. *Quadrant IV* reflects the dynamics of meeting the social need depending on the abovementioned factors. Therefore, the idea of the integrated information model of environmental management is to analyze and integrate four main subsystems determining information exchange jointly:

- meeting the need;
- disturbing the natural environment;
- reflection of changes in the natural system by society and transformational adaptation of the ES.

Many peculiarities of the behavior of the systems observed remain unknown. As a result, there are unforeseen side effects of anthropogenic influence, which society must predict and prevent.

Monitoring information on the state of the natural system forms a flow through the communication channel between the subsystems of monitoring and management. The scope of information and its content should contain data on at least the following four processes:

1. *The reaction of the natural system to the perturbation of society and the mode of its functioning*. Choosing the number and composition of the parameters of the state of the natural and human-made system for monitoring is extremely important. Examples of monitoring such systems in contemporary environmental management prove that it is often not optimal from this point of view.
2. *Changes in the state of the environment.* The monitoring system should ensure the removal of information not only from natural and man-made systems, which are direct objects of influence of the social system, but also from other natural systems in the multi-system of environmental management.
3. *Functioning of ES*. This process is important for environmental management because the ES should be in the optimal mode of functioning as much as possible to meet this need. Most often, the ES presents technical systems with rigidly determined connections. As a result, accidental changes in their properties or behavior can be caused only by accidental processes in the natural system. The persistent decrease in the efficiency of the ES can be considered a consequence of the impossibility for further adaptation of this structure of the ES. Therefore, it should be decided to modernize or radically rebuild it when moving to another strategic level.
4. *Social system response to meeting the need.* In this process, it is advisable to consider two aspects. Firstly, as the final element (consumer) of the environmental management process, the social system is an active generator of information about the level and quality of meeting the need. Its signals in response to the functioning of the ES provide valuable and necessary information for adjusting the process of meeting the need and assessing the effectiveness of the ES. Therefore, social information directly influences the formation of managerial decisions, and it is transformed into managerial information through them.

The second aspect concerns the social system's role in optimizing and harmonizing relations with the natural environment. Anthropocentrism concerning the natural environment for humanity has become the main approach. Perhaps, its principles became a part of genetic information since nature has been only a source of meeting society's needs for 40 thousand years of human history. This moral imperative, acquired by a long social consumption experience, could become a species feature. Society should take care that changes in the natural environment are minimal and do not lead to its degradation.

A more uniform meeting the need is possible *in two cases:* a more frequent change in the ES structures is tantamount to narrowing the zone of permissible risk and reducing deviations from the equilibrium environmental management curve. This extensive approach is possible if the change in the structure of the ES does not require large costs of resources.

When creating and using a universal ES with a wide interval of maximum efficiency. In this case, the increase in meeting the need is ensured by the intensive functioning of the ES, but the process trajectory will have a small slope and, therefore, low efficiency.

According to the pattern of information exchange, managerial information, excluding the meeting a need, is remembered in the object of management as a new portion of structural information, namely changes in the natural system. The monitoring subsystem records these changes in the monitoring unit, and the information conversion process is repeated.

Comparing the integrated model of information exchange described above with the model, which has the reduced line tilt angle of the reflection of the state of the natural environment by society, several consequences of this feature of the second model can be noted.

Firstly, the process of meeting the social need is accelerated by changing the reflection of society, which can be imagined as a change in the scale of time. At the same time, the change in the structures of the ES occurs faster. Secondly, at the same level of meeting the social need, the degree of change in environmental management is decreased due to reduction in the number of cycles of functioning of individual structures of the ES. These conclusions confirm the provisions on the nature of the impact of the amount of information accumulated by society on the environmental management. Indeed, progress in scientific cognition leads to a clearer and more informed choice of optimal governing decisions, which, in turn, accelerates society's response to changes in the state of the natural environment.

Questions for self-examination:

1. Fundamentals of geoinformation technologies (GIS).
2. Method of presenting discrete geographical objects in geoinformation systems.
3. Basic functions of spatial analysis in GIS technologies.
4. Technological features of GIS in performing spatial analysis
5. Methods of dicretization and construction of the influence field surfaces in.
6. The concept of phase transitions of social and geographical systems.
7. Stage of lithogenesis in the development history of the global social and geographical system, its information essence.
8. Biogenesis stage, improvement of storage media and information sources.
9. The role of the sociogenesis stage in developing the global social and geographical system.
10. Noogenesis as a future stage of development of social and geographical systems, its informational essence.
11. Qualitative changes in information processes in the evolution of the social and geographical system.

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PRACTICAL CLASSES

Chapter No.1. Information as a measure of uncertainty and heterogeneity of human- geographical objects

PRACTICAL CLASS NO.1.
BASIC CONCEPTS AND DEFINITIONS OF INFORMATION GEOGRAPHY

Recommendations for preparation and conducting the lesson. Based on the materials of *Lecture 1*, students should use the following options:

– to prepare a scheme of interrelationships of information geography with other fundamental and special fields of knowledge and briefly analyze in what exactly these or those relations are manifested;

– to prepare a scheme that would determine the place of information geography in the system of natural sciences;

– to draw up a table that would demonstrate the similarity and differences in the definition of the term "information" in different sciences and from the standpoint of different scientists, taking into account their subject and object area of study;

– to prepare reports on control questions for *Lecture 1.*

<u>*Questions for discussion:*</u>

To reveal the history of the study of information processes in nature and society.

a. To justify the definition of the term "information geography".

b. To identify and substantiate the object and subject of the information geography.

c. To characterize the connection of information geography with other sciences.

d. To determine the place of information geography in the system of natural sciences.

2. Definition of "information" as a set of data about a particular reality segment.

3. To describe the main differences between information geography and computer science.

4. Information as a measure of heterogeneity, diversity, organization, structuresness of systems, an indicator of the evolution of systems.

PRACTICAL CLASS NO.2.
THE CONCEPT OF SPACE IN INFORMATION GEOGRAPHY

Recommendations for preparation and conducting the lesson. To perform spatial analysis of the territorial organization of social, economic, and natural systems according to the project bachelor's paper following the plan:

1. Mutual location (mutual placement) of objects in the space of the earth's surface.
2. Presence of spatial connections between objects located on the earth's surface.
3. Existence of territorial social formations (combinations, systems, structures).
4. Functioning of territorial social formations in time. To prepare reports on control questions for *Lecture 2*.

Questions for discussion:
1. Definition and role of fundamental concepts of human geography:
2. The dimensionality of geographical space in spatial analysis.
3. Features of territorial organization of social, economic, and natural systems.
4. Multidimensional features (phase) space of the human-geographical process.
5. To substantiate relationships in the scheme of the semantic identification of the geographical space.
6. Coordinates of the phase space and their significance in information analysis.

PRACTICAL CLASS NO.3. THE ROLE OF INFORMATION IN DEVELOPING SOCIAL AND GEOGRAPHICAL SYSTEMS.

Recommendations for preparation and conducting the lesson. To prepare short reports on control questions for *Lecture 3.*
Questions for discussion:
1. To reveal the essence of the concept of "geographical space", identify which coordinates are used in geographical space.
2. The essence of the concept of "human-geographical space", to describe blocks of coordinates in the human-geographical space.
3. The essence of the concept of "information-human-geographical space", to describe blocks of coordinates in the information-human-geographical space.
4. Synergetics as a science of interaction.
5. Synergetics as a science of self-development of systems.
6. Features of the synergetic paradigm in geographical science.
7. Features of the information and synergetic paradigm in human geography, its innovative potential.
8. The innovative potential of the information and synergy paradigm.
9. Attributive concept of information, its main provisions.
10. The functional concept of information and its main provisions.
11. Chaos and dynamic chaos as a possible state of systems.
12. The concept of organization and structure of systems.
13. The patterns of transition of systems from a state of dynamic chaos to a state of structureness.
14. Information indicators of the organization (heterogeneity) of systems: information entropy, reduced information entropy, information.

PRACTICAL CLASS NO.4. THE VALUE OF INFORMATION RESOURCES FOR SOCIETY DEVELOPMENT.

Recommendations for preparation and conducting the lesson. Based on materials of *Lecture 4*, students should use the following options:

– to prepare an essay in which to give 2–3 examples of the managerial information exchange in real social and geographical systems and multi-systems of environmental management;

– to prepare an essay in which to give 2–3 examples of the adaptive information exchange in real natural and social systems;

– to prepare an essay in which to give 2–3 examples of the cognitive information exchange in science and education;

to prepare reports on control questions for *Lecture 4*.

Questions for discussion:

1. Socioactogenesis, its elements, information essence.
2. Socioactogenesis as a process of interaction between society and nature.
3. The main compromises of socio-actogenesis, their role and importance in environmental management.
4. The executive system, its formation, functioning, efficiency.
5. The epistemological criterion of environmental management, its essence, and significance.
6. Managerial information and its role in systems management.
7. Adaptive information, mechanisms of its generation, and its role in the mutual adaptation of systems.
8. Monitoring information, its role in management processes, and environmental management.
9. Operational information, its features, and differences from monitoring information.
10. Structural information in natural and social systems as a reflection of the history of formation and evolution of systems.

PRACTICAL CLASS NO.5. APPROACHES TO DETERMINING THE AMOUNT OF INFORMATION. HARTLEY’S AND SHANNON'S FORMULAS

Recommendations for preparation and conducting the lesson.

R. Hartley defined the process of obtaining information as a selection of one message from a finite set of *N* equally likely messages, and he identified the amount of information *I* contained in the selected message as a binary logarithm *N*. Hartley's formula *(formula 1):*

$$I = \log2\ N \quad (1)$$

Suppose you want to guess one number out of a set of numbers from one to one hundred. Using Hartley's formula, it is possible to calculate how much information it needs to do this: $I = log2100 > 6,644$. Thus, the message about the correct number guessed contains a quantity of information approximately equal to 6.644 units of information.

Let us determine whether the messages "*A woman will be the first to come out of the building door*" and "*A man will be the first to come out of the building door*" are equally likely. It is impossible to answer this question unambiguously. It all depends on which buildings we are talking about. For example, if it is a university, the probability of leaving the door first is the same for a man and a woman. If it is a military barracks, this probability is much higher for a man than a woman.

To solve this kind of problem, the American scientist *K. Shannon* proposed a different formula for determining the amount of information, which considers the different possible probabilities of messages in the set. Shannon's formula *(Formula 2)*:

$$I = - (p1log2\ p1\ + p2\ log2\ p2\ +. . + pN\ log2\ pN) \tag{2}$$

where *pi* is the probability that the *i*-th message is highlighted in the set of *N* messages. If the probabilities *p1, ..., pN* are equal, then each equals *1/ N*, and Shannon's formula is transformed into Hartley's formula.

According to *K. Shannon*, obtaining information is necessary for removing uncertainty. Uncertainty arises in a choice situation. The task is solved by removing the uncertainty – to reduce the number of options considered, as a result – the choice of one option from among the possible ones. Removing uncertainty makes it possible to make informed decisions and act. In this context, the managerial role of information is important. By *L. Briluen's* definition, information is negative entropy *(negentropy) (formula 3):*

$$Ht + It = H \tag{3}$$

From formula 3 it follows that when we say about *the complete removal of uncertainty*, *H* in them can be replaced by *I*. *In the general case*, the entropy *H* and the amount of information obtained as a result of the removal of uncertainty *I* depend on the initial number of options considered *N* and the a priori probabilities implementation of each of them *P (formula 4):*

$$\{p0, p1, ..., pN\text{-}1\}, \text{ T.E. } H = F(N, P) \tag{4}$$

In an individual case, when all variants *are likely different*, the entropy calculation is carried out *according to K. Shannon's formula*. As a result, there remains dependence only on the number of options considered – *H* = *F*(*N*). Shannon's formula is much simpler and coincides with *K. Hartley's formula*. Entropy in Shannon's formula is the average characteristic. This is a mathematical expectation of the distribution of a random variable {I0, I 1, ..., I n-1}.

To solve the task using R. Hartle's and K. Shannon's formulas for variants:

Let's give an example of calculating entropy using Shannon's formula. Let the composition of employees in some institution is distributed as follows: 3/4 are women, and 1/4 are men. Then uncertainty, for example, about who you will meet first when you enter the institution, will be calculated close to the actions shown in *table 1.*

Table 1

	p_i	$\frac{1}{p_i}$	$I_i = \log_2\left(\frac{1}{p_i}\right)$, bit	$p_i * \log_2\left(\frac{1}{p_i}\right)$, bit
Women	3/4	4/3	$\log_2\left(\frac{4}{3}\right) = 0,42$	3/4*0,42=0,31
Men	1/4	4/1	$\log_2 4 = 2$	1/4*0,42=0,31
à	1			H = 0.81 bits

We have already mentioned that Hartley's formula is a separate case of Shannon's formula for equally likely alternatives. It implies a dependence: The greater the number of alternatives (*N*), the greater the uncertainty (*H*).

Logarithmization by base 2 results in the number of information units, namely bits. Suppose it is known a priori that men and women in the institution are equal (two variants are probable). In that case, when calculating using the same formula, we should get an uncertainty of 1 bit. When we substitute it in the formula (2) instead of *pi* value (in the equally probable case does not depend on *i*), we get *(table 2).*

To solve inverted tasks, when uncertainty *(H)* or the amount of information obtained as a result of its removal *I* is known and it is necessary to determine how many equally likely alternatives correspond to the occurrence of this uncertainty, *the inverse Hartley's formula (formula 5)* is used:

$$N=2^H \tag{5}$$

Table 2

	p_i	$\frac{1}{p_i}$	$I_i = \log_2\left(\frac{1}{p_i}\right)$, bit	$p_i * \log_2\left(\frac{1}{p_i}\right)$, bit
Women	1/2	2	$\log_2 2 = 1$	1/2*1=1/2
Men	1/2	2	$\log_2 2 = 1$	1/2*1=1/2
à	1			H = 1 bit

For example, if it is known that 3 bits of information is related to the statement that Kolya Ivanov lives on the 2nd floor, then the number of floors in the building can be determined by the formula (4), as *N* =23 =8 floors.

Option #1. There are 8 floors in the building. How much information have we received, if we found out that Kolya Ivanov lives on the second floor?

Option # 2. How much information will contain a visual message about the color of the removed balloon if there are 50 white, 25 red, and 25 blue balloons in the opaque bag?

Option # 3. There are 16 balloons of different colors in the basket. How much information has the message if the white bullet has been removed?

Option # 4. There are black and white bullets in the basket. There are 18 black bullets among them. The message that the white bullet has been removed carries 2 bits of information. How many bullets are there in the basket?

Option # 5. A 5-character car number consists of capital letters (30 letters are used) and decimal digits in any order. Each character is encoded with the same and minimum possible number of bits, and each number is encoded with the same and minimum possible number of bytes. Determine the amount of memory required to store 50 car numbers.

Chapter 2. Information models of social systems and environmental management

Topic 1. The role of information in the interaction of systems of different nature

PRACTICAL CLASS NO.6. SOCIAL INFORMATION. INFORMATION EXCHANGE IN NATURAL AND SOCIAL SYSTEMS

Recommendations for preparation and conducting the lesson. Based on materials of *Lectures 5 and 6*, students should use the following options:

– to prepare an essay in which to provide 2–3 examples from history that prove the importance of the information resource in the development and viltal activity of society;

– to prepare an essay in which to provide 2–3 examples of the role and importance of social information in the viltal activity of society;

– to prepare an essay in which to provide 2–3 examples of the role and importance of public information in the viltal activity of society;

– and prepare reports on control questions to *Lectures 5,6*.

Questions for discussion:

1. Quantification of information, methods, and approaches.
2. Semantic analysis of information.
3. The concept of valuable information, its subjectivity, and correlation with publicly available information.
4. Types of public information.
5. Functions of social information, peculiarities of their implementation in society.
6. Information exchange in natural mineral and biological systems: levels, mechanisms, consequences.
7. Information exchange in social systems: levels, mechanisms, consequences.
8. Information exchange in social systems: individual, social levels.
9. Basic principles of information interaction of social and natural systems.
10. Information concept of interaction between society and nature

Topic No.2. Information models of social systems and environmental management

PRACTICAL CLASS NO. 7. MODELING THE EVOLUTION OF THE HYPOTHETICAL SYSTEM, AND DETERMINATION OF ITS DEVELOPMENT DYNAMICS BY THE INFORMATION CRITERIA OF COMPLEXITY

Recommendations for preparation and conducting the lesson. To perform *Practical task. Modelling of the evolution of the hypothetical system, and determination of its development dynamics according to the information criteria of complexity* according to these recommendations. The task is executed on a computer using the training program *SYSMODALL*. The main task of the task is to analyze the information indicators of the system evolution depending on the principle of the formation of the hierarchical level.

1. General characteristics of the SYSMODALL program. The program *SYSMODALL* is compiled in the algorithmic language of the higher level of Visual Basic 6.0 and implements the algorithm for calculating information entropy (and reduced entropy) in the sequential (step by step, namely by the sequential alternation of phases) formation of the multilevel system from the plurality of initial elements. The following parameters and initial data of calculation are provided in the learning version of the software:

1. The initial number of elements N = 10,000.
2. A number of hierarchical levels of the system S = 3.
3. A number of structural elements of the system:

– at the first hierarchical level M1 = 1000;
– at the second hierarchical level M2 = 100;
– at the third hierarchical level M3 = 10.

1. The principles of forming the system: random, deterministic, mixed. The mixed principle means a cycle of 2 phases when the coordinates of the next structural element (class) are determined using a random number generator for the first time, and deterministically (sequentially from the current phase number) for the second time.
2. Each subsequent hierarchical level is formed after the full filling of the previous level. Therefore, firstly, the first hierarchical level is formed from 1000 classes (subsystems), which sequentially distribute 10,000 initial elements. After that, the second level is formed from 100 subsystems, which sequentially distribute the subsystems of the previous level. Finally, the last level is formed in the same way from 10 subsystems that distribute the previous level's subsystems.
3. *Description of the calculation algorithm.* Modelling of the formation of the first level of the system is carried out by sequential distribution of the initial elements, which are supplied one at each step (phase). Following the principle of forming the system, the number of the class is determined. The current element is distributed into this class. To implement the random principle, a random number generator is used in which the setting is changed at each step.
4. For the deterministic principle, classes are filled with elements based on the conditions of the uniform distribution, i.e., in turn with the growth of step numbers. In this case, a uniform distribution of the elements with the greatest entropy is achieved. The mixed principle is implemented so that a random number generator and a deterministic approach are used in each cycle of 2 phases alternatively. In this case, intermediate distribution of elements is achieved. K. Shannon's formula calculates the informational entropy for each phase of the system's formation (formula 2). The reduced entropy (per class) is determined by dividing the entropy by the number of non-zero classes.

Program Procedures:

1. The program is started from file *sysmodall.exe.* After that, a window for setting the output data appears on the monitor screen.

2. Setting the output data. There are three managerial buttons in the lower part of the window: "INITIAL DATA", "BEGINNING OF CALCULATION" and "EXIT".

2.1. After "clicking" with the mouse on the "SOURCE DATA" button, a window for entering the source data appears on the form. In the upper window, the code of the method of forming the system is entered. This is a number from 1 to 3 depending on the selected principle of elements placement.

2.2. After that, click on the "SOURCE DATA" button and enter the number of hierarchical levels in the lower window. This number concerns the calculation of the information entropy, namely a number from 1 to 3 depending on the selected number of hierarchical levels. Click on the “SOURCE DATA” button.

Beginning of calculation. After setting the output data, you need to click on the button "CALCULATION START". After that the main application window is displayed. There are an information scoreboard on the bottom left part of the window, and four control buttons from left to right: "PREPARE THE GRAPH", "START. REPEAT", "NEXT LEVEL", "EXIT"

Calculation Management: to initialize the graphical mode of information output, you need to click the "PREPARE A GRAPH" button, while visually nothing changes on the screen. But the scale of the future schedule is set.

Then click on the "START REPEAT" button, which leads to the beginning of the calculation. The calculation dynamics are visually displayed by the process indicator at the bottom of the window and graphs of changes in information and reduced entropy in the main field of the window. Green dots indicate information entropy, and when all classes of this level are archieved, it is indicated by blue dots. Red dots indicate the reduced entropy. For the convenience of comparison, the first level of the hierarchy is numerically increased by 100 times, for the second level – by 50 times, for the third level – by 5 times on the graph. It should be borne in mind that the described graphs are built only to reflect the main trend of changes in the calculated parameters.

Calculation result files should be used for detailed analysis.

№XentB .rez (*No.* is a hierarchical level number, *X* is a code of the system formation principle, *B is* the calculation option number for this level), which are placed in the main program folder. The information is arranged in rows in the following order in these files:

– step (phase) number;
– number of classes with elements;
– information entropy;
– reduced entropy.

At the end of the calculation, the following information is placed on the information board:

– the number of the calculation option at the bottom left;
– maximum entropy of this option;
– number of non-zero classes at maximum entropy;
– final entropy;
– the final number of non-zero classes.

If it is necessary to repeat the calculation at this hierarchical level, click the "START. REPEAT” button. During repeated calculations, the graphs of changes in information and reduced entropy are superimposed. It makes it possible to see the difference in the trajectories of the formation of this level of the system with the random and mixed methods of formation. The file's name with the calculation results for each option is changed automatically.

The hierarchical level is changed by clicking on the "NEXT LEVEL" button. Then, all the actions described in the previous paragraph are carried out in sequence.

Exiting the calculation mode is done by clicking on the control button "EXIT". After that, a window for setting the output data appears on the monitor screen.

1. Exit the application is implemented by clicking on the "EXIT" button in the input data setting window.

2. To calculate other output data, you must restart the application.

*Design and basic elements of practical task***:** description of theoretical provisions and algorithm of task performance, peculiarities of task performance, analysis of the results obtained. Graphs of changes in information indicators for each hierarchical level and graphical annexes with the analysis results are attached to the report.

PRACTICAL CLASS NO. 8.
STRATEGY AND TACTICS OF ENVIRONMENTAL MANAGEMENT. ESTIMATION OF THE AMOUNT OF INFORMATION. PROBABILITY

***Recommendations for preparation and conducting the lesson*.**

1) To perform *Practical task # 3. Assessment of the amount of information. Probability.* According to the indicated recommendations. In contemporary technical systems, a statistical approach is used to quantify information. This approach implies information as a set of data, messages about the behavior of some system, which may accidentally be in one of the possible states. Such a system has some degree of uncertainty *(entropy)* and the actual state of it before receiving the message remains unknown. Report about the actual state of the system we are considering as information about it.

If the state of the system is determined and cannot be changed or all possible changes in the state are known before the message about them, then it makes no sense to transmit messages about the system. It is not of interest; it does not give anything new. That is, it does not carry this information (for example, "January is the first month of the year"). Obviously, the message about the actual unknown state of the system will carry the more information, the greater the degree of uncertainty of the system (greater entropy of the system), i.e., the greater the number of states that it can accept.

The situation *of the maximum uncertainty* implies the presence of several *equally likely* options. T*he more equally possible options* are observed, the more uncertainty, the more difficult to make an unambiguous choice, *the more information is necessary* for this purpose. This situation is described by the following probability distribution for *N* options: *{1/ N, 1/ N, ..., 1/ N}*.

The minimum uncertainty is 0, this is a situation *of complete certainty*, which means making a choice, and obtaining all the necessary information. The distribution of probabilities for a situation of the complete certainty looks like this: *{1, 0, ... 0}*.

Entropy (H) is *the measure of uncertainty* expressed in bits. Likewise, entropy can be considered as *a measure of the uniformity of the distribution of the random* variable. The amount of information I and entropy H characterize the same situation but from qualitatively opposite sides. I is the amount of information needed to remove the uncertainty H. *Fig. 1* demonstrates the dependence of entropy on the number of equally possible choices.

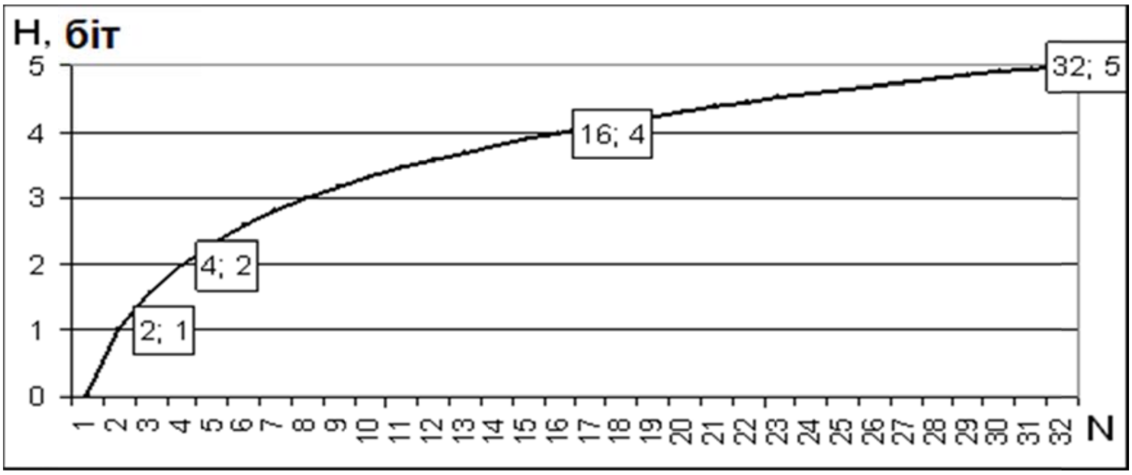

Fig. 1. Dependence of entropy on the number of equally possible choices (equivalent alternatives)

Example of the task. Two geographical zones are divided into four sectors:

– the observer of the first zone reported that a fire could occurs only in sector 3;

– the observer of the second zone reported that a fire is impossible in sector 4.

According to Hartley, calculations of entropy and the amount of information for systems with different probabilistic states will give inflated results. The statistical approach to quantifying information (Shannon's formula) is widely used in scientific research and in solving many important practical issues. For example, the tasks of optimal encoding messages in information transmission systems, determination of the capacity of channels with interference, calculating the capacity of storage devices for storing information, etc. In this case, the amount of information can be measured in bits.

To solve tasks by options:

Option # 1. When transmitting information in lines of 80 digits for every 25 lines, the digit 5 occurs 40 times, the digit 9 occurs 30 times, the number 59–20 times, 95–16 times. To determine the probabilities of the digits 5 and 9, the digits 59 and 95, the conditional probability of the digit 5, if the digit 9 appeared and the digit 9, if the digit 5 appeared.

Option # 2. Sources A and B have the probability distributions of the messages given below. The entropy of which source is greater? What is the maximum entropy of this source, and under what condition?

PA = {0.007; 0.003; 0.007; 0.003; 0.98}, PB = {0.007; 0.003; 0.007; 0.003; 0.98},

2) Based on the materials *of Lectures 7 and 8*, students should prepare reports on control questions.

Questions for discussion:

1. To determine the relationship between the degree of disturbance of the environment, the degree of the meeting social need and information.
2. To justify the dependence between the amount of information learned by society and the efficiency of environmental management.
3. Optimal, risky and inefficient trajectories of environmental management.
4. Environmental management strategy as reflection of the information resource of society.
5. Environmental management tactics as a consequence of the growth of the information resource of society.
6. Information contradictions of environmental management and their importance in the improvement of executive systems.
7. Main compromises in environmental management, their importance in the choice of executive systems.

PRACTICAL CLASS NO. 9. EVOLUTION OF SOCIAL AND GEOGRAPHICAL SYSTEMS. INFORMATION ANALYSIS OF THE EVOLUTION OF SOCIAL AND GEOGRAPHICAL SYSTEMS OF THE DISTRICT OR REGIONAL LEVEL ON A SET OF STATISTICAL INDICATORS

Recommendations for preparation and conducting the lesson.

To perform the *practical task No. 4 "Information analysis of the evolution of the social and geographical systems of the district or regional levels by a set of statistical indicators"* according to the master's project paper following these recommendations. To perform practical task No. 4, each student receives an individual task (object of study), finds statistical materials for a given period, and performs appropriate calculations on the computer using the studying software ***INFENTROP***. The main task of this task is to determine the trajectory of the development of the given system for each indicator separately and in the aggregate.

Based on the results of the practical task, a concise report is drawn up describing the conceptual provisions, calculation algorithm, and analysis of the results obtained.

PRACTICAL CLASS NO. 10. GEOINFORMATION TECHNOLOGIES SPATIAL ANALYSIS IN THE GIS ENVIRONMENT MAP INFO. SUMMING UP

Recommendations for preparation and conducting the lesson.

1. To perform *Practical task No.5. Spatial analysis in the GIS environment Map Info* according to the specified recommendations. Using the MapInfo GIS platform, we will conduct a spatial analysis of settlement systems' beveling in the districts of Kharkiv region according to the options.

To determine the bevel of the spatial distribution of the population in the districts of Kharkiv region, we use the *analysis of the nearest neighbor*. This an indicator based on the recognition of the distance of each point of the population to the nearest neighbor. This indicator is the arithmetic mean of the actual distances between each member of the population and its nearest *n*th neighbor. Use the *formula 1:*

$$\overline{r_n} = \frac{\sum_{n=1}^{p}(r_n)}{p}, \qquad \text{where} \qquad (1)$$

r_n is a distance between a point and its nearest neighbor;

p is a number of population members.

Connect the administrative centers of districts and the largest city councils of districts of Kharkiv region with conditional communication lines, use the Map Info program to measure these distances, and calculate their total number. Using formula 14, determine the optimal distance between the settlement units on the territory of the districts of Kharkiv region. Draw a conclusion about the peculiarities of the spatial organization of the population of districts of Kharkiv region.

Questions for discussion:

1. Method of presenting discrete geographical objects in geoinformation systems.
2. Basic functions of spatial analysis in GIS technologies.
3. Technological features of GIS in performing spatial analysis
4. Methods of discretization and construction of the influence field surfaces in GIS.

GENERAL INSTRUCTIONS REGARDING INDEPENDENT WORK ON THE COURSE

Independent work on the course "Information Geography and GIS" is an integral part of the educational process and aims to consolidate an in-depth study of lecture material, formation of skills, and methods of information processes research in social and geographical systems, obtained during practical classes. It is necessary to have a synopsis of the lectures for successfully mastering the educational material because the lecture materials are supplemented with literary sources according to the list of recommended literature and additional materials that the students find independently from other sources.

When learning the educational material, first of all, it is necessary to master the course's basic conceptual and terminological apparatus. It is recommended to carefully study the glossary (in the appendix) and independently understand the course's basic concepts. After successfully mastering the conceptual and terminological apparatus, it should clarify the logical connections between individual concepts and groups of concepts. At the same time, it is helpful to independently analyze various subsystems of social and geographical systems to establish and characterize the information relationships between individual objects, processes, or phenomena with a detailed description (oral or written) of the relationship of concepts.

The next stage of independent work is mastering laws and principles of information exchange and transforming information in social and geographical systems. Using the comparative method, it is expedient to analyze the differences in information processes in social life at the local, regional, and national levels.

Students can check their level of training at all stages of independent work with the help of control questions. With good mastery of the educational material, the student must answer all questions independently. To clarify unclear questions, the Department of Human Geography and Regional Studies regularly holds individual and group consultations by the lecturers who teach this course.

TOPICS FOR SELF-STUDY

1. Acquaintance with the structural information of natural systems – generation, storage, exchange
2. Characteristics of information exchange in natural and social systems.
3. Acquaintance with the information model of social processes.
4. Acquaintance with the information concept of interaction between society and nature.
5. Characteristics of the noosphere stage of information development of humanity
6. Multidimensional sign (phase) space and its application in human geography.
7. The worldview and educational status of geography in the information society.
8. The role of geography in scientific substantiation and practical provision of the rational environmental management and nature protection.
9. Geographical principles for optimizing the relationship between society and nature.
10. Evolution of geographical representations of the interaction of human and nature.
11. Society, socioactogenesis, social needs, target systems.
12. Testing the modes of functioning of the social and geographical system.
13. Approximation of fields of geographical parameters.
14. Methods of modeling the development trajectory.
15. Graphoanalytical methods of multidimensional classification.
16. Methods for assessing the evolutionary potential of social and geographical systems.
17. System and structural analysis of the social and geographical systems.
18. System and functional analysis of the social and geographical system.
19. Scheme of formation of the territorial hierarchy of goals.
20. Means and methods of socioactogenesis.
21. Analysis and evaluation of the emergence of social and geographical systems.

GLOSSARY

Actogenesis (Актогенез)	The chain of mechanisms for the preparation and implementation of the activity act.
Executive system (Виконавча система)	The system created by the subject of actogenesis (environmental management) and includes: means, methods and conditions for meeting the social need, as well as channels reverse links (monitoring system).
Epistemological criterion of environmental management (Гносеологічний критерій природокористування)	This is a quantitative assessment of the epistemological contradiction of environmental management, which means the discrepancy of general and valuable information obtained by society from the natural environment. Quantitatively defined as the ratio of the amount of valuable (learned) information to the amount of general information.
General knowledge (Загальне знання)	Knowledge reflecting the world as a whole, generalized knowledge of reality.
Means to meet needs (Засоби задоволення потреб)	Systems or objects that can be used to meet the actual social need.
Zone of optimal environmental management (Зона оптимального природокористування)	A zone where certain economically conditioned rules of human and society behavior in the natural environment are common.
Information exchange (Інформаційний обмін)	Transmission of information from the system, namely transmitter to the system-receiver, which is carried out in the process of material (substance-energy) interaction of these systems. The following types of information exchange are distinguished: – *managerial information exchange* – one of the interacting systems purposefully generates managerial signals that affect the other system and cause changes in its state; – *adaptive information exchange* - both interacting systems, one influencing the other, perceive the influence of the opposite system and cause its changes through their reaction; – *cognitive information exchange* – one of the interacting systems purposefully researches (studies) another one. *Active (experimental) information exchange* – when the system-researcher directionally changes the object's state and receives reactive information; passive *information exchange* – when the system-researcher acquires information about the object without active influence on it (observation).
Information resource (Інформаційний ресурс)	A new type of spiritual factor that interacts with the material factors and provides the dynamics of social systems. The increase of free energy in multisystem of environmental management by reducing their entropy.
Information-human-geographical space (Інформаційно-суспільно-географічний простір)	The space of the anthroposphere, where there is a society, economic and natural systems, territorial organization, properties, and connection (between themselves and the external environment. They characterize the complex interaction of fields of different features. Unity and optimization is carried out through the interference and interaction of their information fields.

Information (Інформація)	There are several groups of information definitions: – any information, data transmitted by different channels; – any information, or data that reduces the degree of uncertainty about the environment; – a measure of heterogeneity, diversity, orderliness, structuredness, and organization of systems (attributive concept of information); – memorized selection of one option from several possible equals.
Adaptive information (Адаптивна інформація)	Information continuously circulating through direct and reverse links between the systems found in the process of mutual adaptation.
Monitoring information (Моніторингова інформація)	Information entering the managerial system by reverse links channels and reflecting the response of the controlled system on the managerial influences.
Operational information (Оперативна інформація)	Monitoring information "cleaned" from random distortions, gross measurement errors, etc. and adequately reflects the current state and properties of the managed system.
Pragmatic information (Прагматична інформація)	Information focused on initiating a particular line of thought, behavior, state or action.
Semantic information (Семантична інформація)	Information suggesting the possibility of disclosing a message or content encoded in it.
Syntax information (Синтаксична інформація)	Information that represents a set of signs and the rules for constructing some messages from them.
Social information (Соціальна інформація)	A set of knowledge, information, data, messages formed and reproduced in society and used by individuals, groups, classes, public institutions to regulate social interaction relationships between human, nature, society. Important properties of social information are truthfulness, objectivity, probability, completeness, deepness, accuracy, certainty, reasonableness, evidence, obviousness, novelty, efficiency, relevance, optimality.
Structural information (Структурна інформація)	Information that is "remembered" in the structure of the system and reflects the trajectory of its development. The following types of structural information are distinguished: lithospheric (about geological systems), atmospheric (about the atmosphere), hydrospheric (about the surface and underground hydrosphere), biospheric (about biological systems), anthropospheric (generated under the influence of society), social (about social systems).
Managerial information (Управлінська інформація)	Information entering the system of management of the direct communication channel and actuating the material resources and forces, changes the state or properties of the controlled system.
Manageability of the system (Керованість системи)	Maximum sensitivity of each state of the system to the influence of the control signal. The set of control signals is the output vector *the input vector of the system*. The manageability of the system depends on: – perfection of the direct (managerial) communication channel; – properties and features of the controlled system (the managerial signal must be a stable and strong stimulus for it); – force and stability of the managerial signal; – attributive characteristics of the control signal, which should maximally correspond to the sensitivity of the control system.

The criterion of the perturbation degree of the natural system (Критерій ступеня збуреності природної системи)	The ratio of the speed of change of the most dynamic external disturbance factor to the maximum permissible speed of change of the most sensitive to disturbance parameters of the natural environment.
Methods of using tools (Методи використання засобів)	Knowledge of the patterns of interaction and transformations of material systems that fall within the scope of the means; technology of using specific means in achieving the expected result.
Multisystem of environmental management (Мультисистема природокористування)	A set of social, economic and natural systems directly or indirectly involved in the areas of economic activity of society.
Environmental management (Природокористування)	The process of interaction between social and natural components of social and geographical systems. Its essence is the involvement of natural systems (resources) for social production or meeting social needs.
System (Система)	A set of interrelated and interacting elements, which has the following features: integrity, stability of the structure emergence, etc.
System natural (Природна система)	All elements of the system are natural objects.
Natural and technological system (Природно-техногенна система)	A natural system that contains at least one human-made element
Social system (Соціальна система)	All elements of the system are socials.
Social and geographical system (Соціогеосистема)	A heterogeneous system that contains social elements or subsystems, as well as human-made abiotic and biogenic elements (subsystems) different by the level of generalization and hierarchy, which are in interaction through the flows of matter, energy and information in the geographical spatial and time continuum.
Socio-geographic process (socio-geoprocess (Соціально-географічний процес)	A consistent natural change of situations in the development of different societies in the historical and geographical context, or as a change in the social components of social and geographical systems in the spatial and temporal continuum.
Special knowledge (Спеціальне знання)	Knowledge relating directly to meeting a specific social need, knowledge of the specific features of a particular system.
System Observability (Спостережність системи)	Maximum impact of each state of the system on the measured signal. The set of such measuring signals is the output vector of the system. For an external observer, the observability of the system depends on: – selection of the most informative components of the output vector of the system; – creation of optimal channels of the reverse links; – selecting a method for measuring output signals; – selection of methods of primary processing of output signals; – selection of methods for saving monitoring information
Human-geographic process (Суспільно-географічний процес)	Consistent and natural change and sequence of human-geographical phenomena.

Conditions of meeting needs (Умови задоволення потреби)	Limitation of methods on the part of natural systems that require adaptation (optimization) of means and methods to meet the need
Management (Управління)	Purposeful Transfer Process and hold of the object of management in a given state.
Functions of social information (Функції соціальної інформації)	Communicative (transfer of information from the source to the receiver), managerial (information support of all stages of the management process), scientific and cognitive (generation and dissemination of scientific information), regulative (maintenance of the object in a given state), educational (information support of socialization of personality, transfer of social knowledge and experience from generation to the generation).

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