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**WEB SERVICE SYSTEM MODEL FOR ECOLOGICAL AND ECONOMIC
MONITORING UNDER URBANIZATION**

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Today, most of the world's population lives in cities and towns. Therefore, the determining factors that affect the quality of life of people are the level of economic development of cities and the state of ecology of cities and adjacent territories. To conduct research and build models of ecological and economic monitoring and forecasting the development of cities and the state of ecology, it is necessary to collect, process and analyze huge amounts of various data. Based on the results of such studies, there is a need to build computer systems for collecting and processing significant amounts of information - databases and data repositories, which have practically no analogues today.

The main task of this work is to develop an alpha version of the web service for environmental and economic monitoring of databases. At the stage of development of the alpha version of the software product, the main economic indicators regarding the development of the city and environmental factors that affect it were worked out and grouped. The author has modeled a software model for individual services of ecological and economic monitoring, which are part of the future applied software product. In the future, the author plans to continue research on this topic, collecting empirical data on the cities selected for study, and to develop further software and hardware modules of the presented web service.

Keywords: *urbanization, economics, environmental and economic monitoring, web services, distributed systems, databases*

Introduction. The trend that began in the 20th century and moved into the 21st is the development and resettlement of people to cities, which began to play a significant role in shaping the level of economic development of territories and the development of states, as well as their restoration in the post-war period in Ukraine. At the same time, they present many challenges and give rise to many diverse challenges. The process of studying urbanization is very important, because the pace of development and directions of development of cities and adjacent territories depend on it. The attraction of resources is a key factor influencing the development of the city and the level of urbanization. Among the important factors it is necessary to highlight monetary resources, labor and available territories. In addition, in order for the city to supply itself with a variety of resources, such as various sources of energy (electricity, heat, etc.) and food and daily use, it is necessary to use all new territories adjacent to large cities to plan and locate modern energy facilities on them, to attract new land plots to the cultivation and cultivation of agricultural products, as well as to build new enterprises for the processing of waste and garbage. All actions necessary for the life of cities in the process of urbanization, and the above, lead to significant consequences for ecology and the environment, both in the short term (for a period of 1-5 years) and in the long term (for a period of more than 20+ years).

Analysis of recent researches and publications. To collect, systematize and analyze environmental and economic data, the author conducts a brief review of existing scientific publications, publications, and monographs. The author conducted a general analysis of the state of ecology in various cities [1, 2, 3, 4, 5, 6, 7]. For the analysis, the most common parameters and publicly available data related to emissions, garbage, and the state of green spaces, etc., were selected. Based on the study, it can be argued that the size (area) and number of populations in cities have an impact on the ecological state: the larger the size of the city, the more significant its impact on the environment. A similar situation occurs with a significant concentration of production areas (factories, etc.) and an extensive transport infrastructure. Harmful emissions have a particularly dangerous impact on the environment and ecology. It is for this reason that there are monitoring

services in cities that collect and transmit relevant information on environmental factors - levels of emissions, air or water pollution, and others.

Purpose. The aim of the study is to systematize the author's previous research on environmental and economic monitoring of the impact of urbanization processes on the development of cities and suburban areas, and to develop a model of a web service for environmental and economic monitoring in the context of urbanization. The proposed service is part of the general software products and solutions for the implementation of the Smart City system. It should be noted that one of the important areas of application in the field of environmental and economic monitoring of the consequences of the urbanization process.

Methods. According to the results of the author's research and detailed analysis of their results in Fig. Figure 1 shows the Model of the impact of urbanization as a complex process on the state and options for the use of land resources and territories. The effects of urbanization and related processes on the environmental situation in the city and land resources can be divided into two categories [1-5] - those related to the city and those related to the impact on the general condition of the land cover.

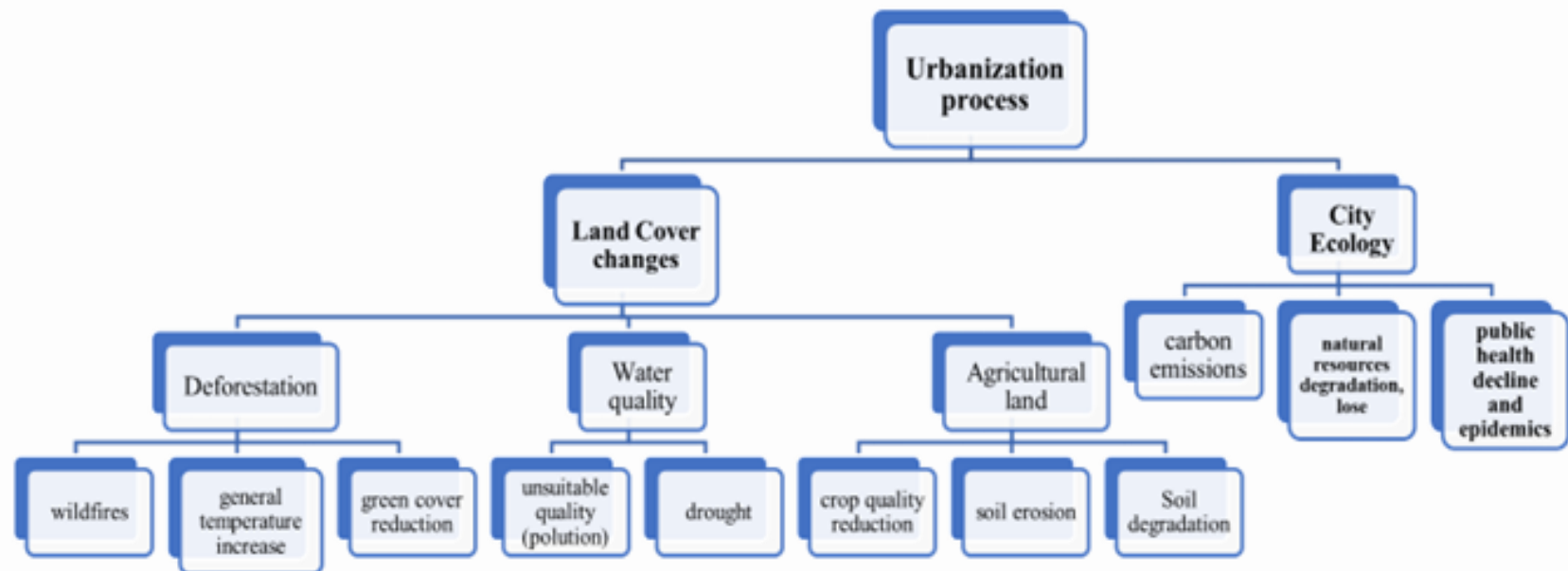


Fig. 1. Model of the impact of urbanization as a complex process on the state and options for the use of land resources and territories

For further research and system modeling, an analysis and systematization of ecological processes influenced by urbanization were carried out. In Table 1, the author presents the results of the classification of ecological processes that are interrelated with the process of urbanization. As a result of the classification, six factors were identified - the level of forest cover, the state of water quality, harmful emissions into the air, waste, and public health.

1. Classification of ecological processes affected by urbanization*

Factor	Data	The factor acts on	Act on the factor
Forest Cover Level	Rate of deforestation, km ² /year Area (variable), ha Cross-border index, points Forest renewal area, km ² /year Restoration, UAH/ha	Carbon dioxide emissions Soil erosion Flood/Drought Changes in the water cycle Damage to the ecosystem and natural habitat	Expansion and construction of the city Land Use of Agricultural Land Woodworking industry
Water quality	Demand-to-delivery ratio, % Drought Intensity Index, Points Water pollution, tones/cubic m Drinking Water Quality Index, Points	Drinking water supply to the population and livestock Crop Cultivation and Soil Use Freshwater status and health effects	Use of agricultural groundwater Energy consumption of objects Industrial, personal non-consumable use

Harmful emissions (into the air)	<p>Volume of emissions, per 1 population and per 1 area, km²/tones³ per year</p> <p>Cost of 1 ton of emissions in n-time, UAH</p> <p>Expenditures to reduce emissions, UAH per tonne, % of GDP</p>	<p>General health of the population</p> <p>Changes in air temperature and land cover</p> <p>Changes in the quality of water resources and soil</p>	<p>Transport</p> <p>Agricultural Livestock</p> <p>Waste storage</p> <p>Power Generation</p> <p>Industry</p>
Waste	<p>Cost of transportation, UAH per ton or m³</p> <p>Proportion of waste, kg per capita</p> <p>Cost of waste maintenance, UAH per ton</p> <p>Cost of waste recycling, UAH per ton</p>	<p>State of Fertility and Soil Restoration</p> <p>Air condition and air pollution indicators</p> <p>State of water in open and closed reservoirs and seas</p> <p>Greenhouse Gas Emissions</p> <p>The state of health of the population of cities and suburban areas</p>	<p>Industry</p> <p>Trade</p> <p>General Public</p> <p>Agriculture</p>
Public Health	<p>National or city expenditure on health care, UAH per capita, % of GDP</p>	<p>Expenditures of the city budget</p>	<p>The presence of carbon in the air and its amount</p>

	Investments in sustainable development programs, UAH of investments, % of GDP	The level of health and well-being of the population Social situation and demographic data Level of economic development	Condition of drinking and technical water Air pollution Food Quality Spread of viruses, epidemics, pandemics, etc.
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* The materials are prepared based on the materials of the author's dissertation and research data [5, 6, 7, 8, 11].

Results. Conducting the research, we focused on the aspects of urban resource management (namely land) and determining the parameters of sustainable development of territories (city zones, adjacent territories, and the surrounding region). The dependence of options for sustainable development of territories on the types of land use objects is modeled in Figure 2. As a result of the study, important components of sustainable land management have been allocated. Important environments are those that affect the overall level of quality of life of the urbanized population, the level of restoration of natural resources and expedient options for the intended use of land use objects.

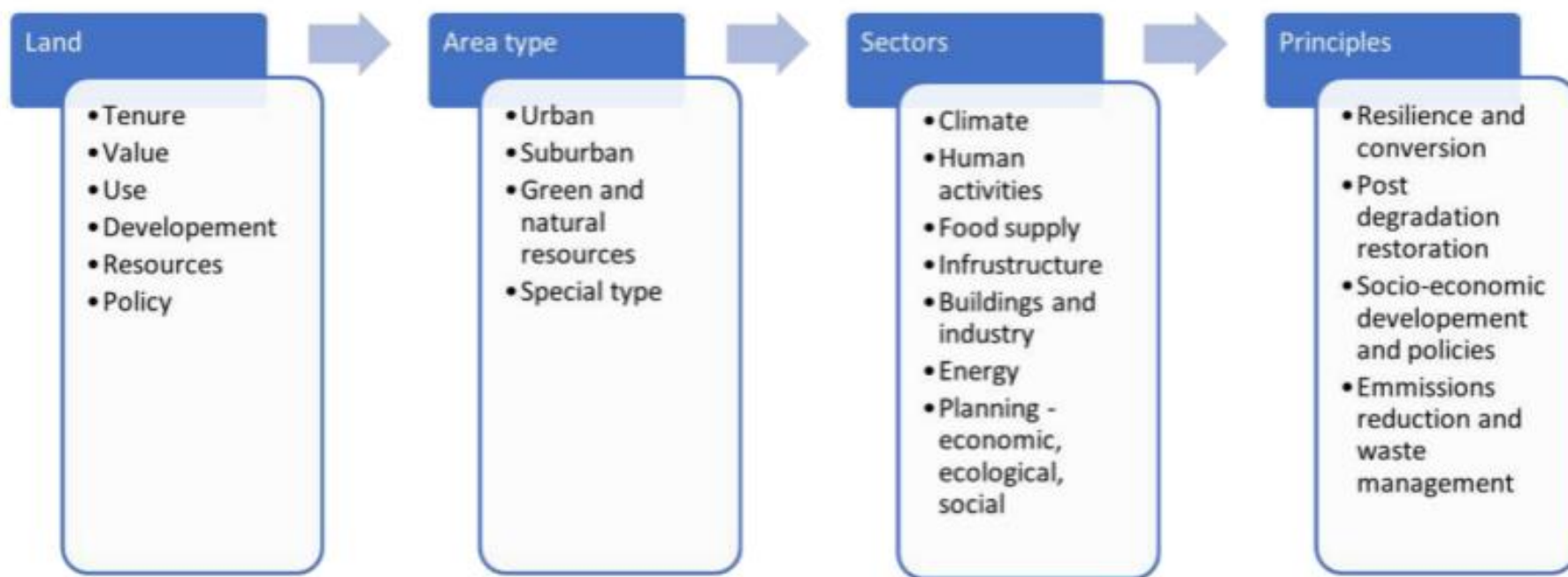


Рис. 2. Dependence of Options for Sustainable Development of Territories on the Types of Land Use Objects [9,

It should be noted that in the modern world there is a next stage in the development of urbanized settlements, it depends on the ecological state. “In this regard, various measures are constantly taken by international public organizations, trade unions and inter-municipal summits, as well as relevant documents are adopted, such as the Kyoto Protocol, the Paris Agreement, etc” [11]. Table 2 presents some of the main data related to the environmental component of urbanization. It is determined that data such as climate agreements, environmental fees, green taxes, energy sources used, waste management systems, existing waste processing and disposal enterprises, etc., should be used for analysis. As for the categories of environmental components of urbanization, legal regulation systems, financial indicators, ecosystems, the presence and amount of waste in cities, natural resources, etc., should be included. Based on the collection and analysis of data and their distribution into categories, the characteristics of the environmental components of the urbanization process and their impact and the further development of cities are systematized. Such characteristics include plans for sustainable development of territories and cities, restoration of natural resources, systems and measures to improve the environment, planning and implementation of renewable energy sources, new approaches and policies for waste management, availability of waste sorting and recycling systems, as well as a system of measures to improve the quality of life of the urban population.

2. Environmental components of urbanization*

Main factors	Type	Example
Signed climate agreements	Legal Regulation	Plan for Sustainable Development of Urbanized Areas and Common
Environmental taxes Green Taxes	Financial data Legal Regulation	Restoration of natural resources

<p>Distribution of modern energy sources, their availability and distribution by region, technical indicators</p> <p>Costs of introducing the latest "know-how" or technology</p> <p>Fiscal fees on various types of renewable energy sources</p>		<p>Improving the environment</p> <p>Planning (including financial) for the implementation of renewable energy sources</p>
<p>Waste Management (Transportation and Storage)</p> <p>Recycling and disposal of waste</p>	<p>Waste</p>	<p>National or municipal legal regulation of governments.</p> <p>Waste</p> <p>Law (act) on waste sorting</p> <p>Development of technologies for waste collection/recycling</p>
<p>Total harmful emissions into the air</p>	<p>Harmful emissions</p> <p>CO2 emissions</p>	<p>Air Quality Studies</p> <p>Investigation of urban facilities and potential sources of pollution</p> <p>Legal Regulation of</p> <p>Overcoming and Minimizing the Effects of Pollution</p>

<p>Quality of drinking and technical water, its purification, post-treatment, and transfer to the consumer</p> <p>Soil: its fertility, quality and degree of contamination and depletion</p> <p>Green zones, forest and park areas, forests, green spaces: their number, density of plantations and specific share in the total area</p>	<p>Different types of natural resources</p>	<p>Supply of the population and provision of organizations and enterprises</p> <p>Economic indicators of urban life, their analysis and for the future - planning, supply, processing, etc.</p> <p>Monitoring of various indicators and their regulation</p> <p>Collection of economic data for calculations, planning and recovery of sources of supply and resources</p> <p>Indicators of the quality of life of the population</p> <p>Information Collection, Processing and Regulation</p>
<p>The state of the biosystem and biological species</p>	<p>Ecosystem</p>	<p>Monitoring the state of biosystems</p> <p>Policy & Regulation</p>
<p>Geographic Location</p> <p>Territorial Location</p> <p>Territorial Zoning</p>	<p>Spatial information</p>	<p>-</p>

* The materials are prepared based on the materials of the thesis and research data [11].

In the future, it is planned to assess and analyze the options for the development of environmental situations with its subsequent forecast for the future, as well as to highlight positive trends in environmental situations in large cities and vice versa.

Figure 3.1 schematically depicts the representation of the concept of environmental monitoring in the city; Figure 3.2 shows a model of the web service and its components of environmental and economic monitoring in the city. The figures show the main components of each of the systems and their interconnection. Components include data warehouses, data from monitoring devices, statistical data, connections to external software systems and user interfaces for system management.

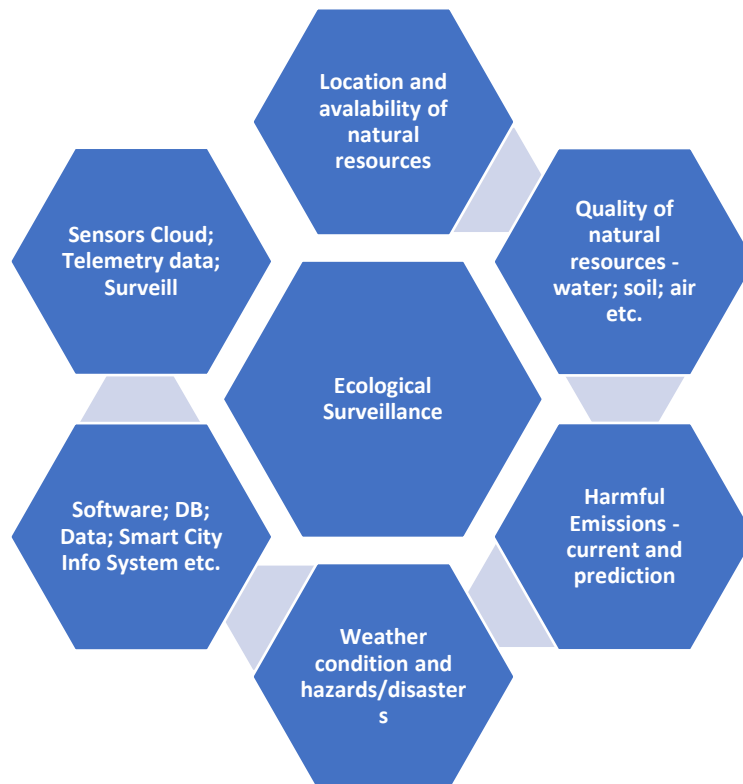


Fig. 3.1 Schematic representation of the concept of environmental monitoring in the city

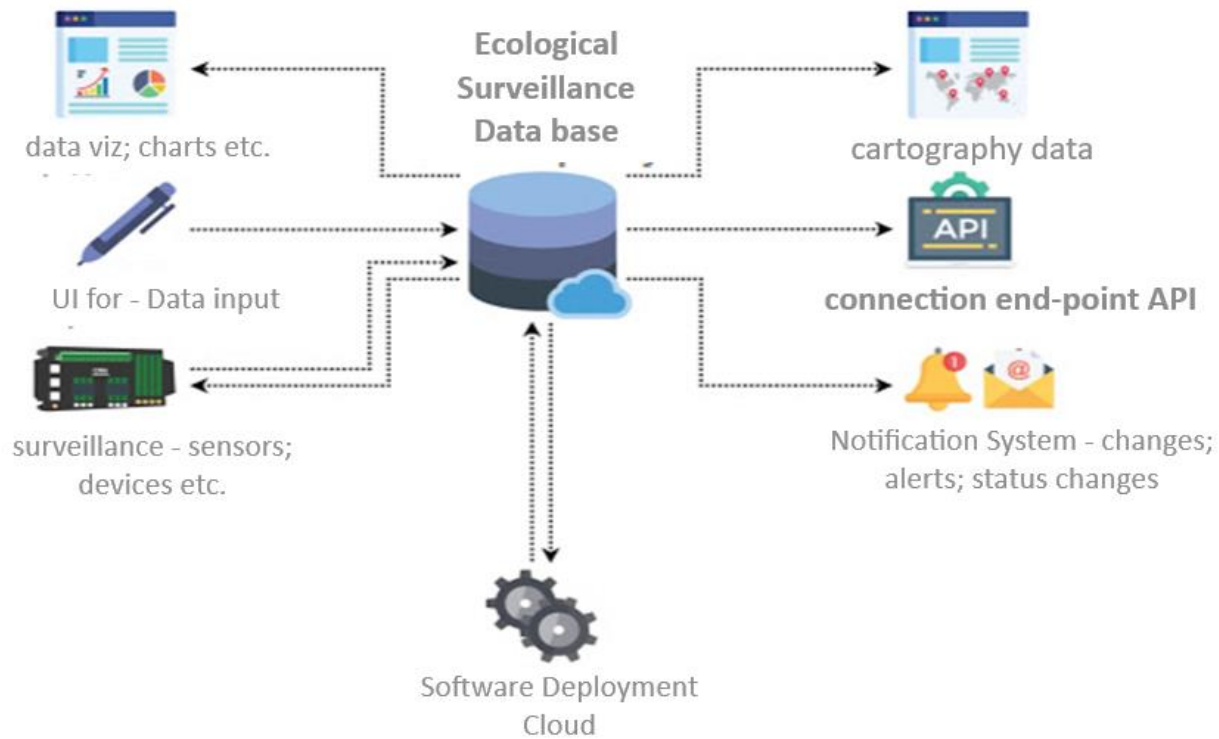


Fig. 3.2 Model of the web service and its components of environmental and economic monitoring in the city

Discussion. The presented model of description of processes associated with urbanization, built based on system modeling of applied software and processing of research data. Among the main data sources, key economic and environmental indicators were used. The main factors were collected, analyzed, processed and structured, which became a prerequisite for the development of a model of a web service, which is designed to systematize and forecast changes in the ecological state of territories under the influence of urbanization. Based on the built web service and using the basic methods of ecological and economic modeling, the author presents a general concept of environmental monitoring in the city. In the future, to test the presented models and verify the results obtained, as well as to build ecological and economic models for calculating the cost of the consequences of the development of large cities, it is advisable to select several cities for analysis and build a program part of the conceptual system of environmental and economic monitoring.

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МОДЕЛЬ ВЕБ-СИСТЕМИ ЕКОЛОГО-ЕКОНОМІЧНОГО МОНІТОРИНГУ В УМОВАХ УРБАНІЗАЦІЇ

На сьогодні більша численність населення світу проживає у великих та малих містах. Тому, визначальними факторами, які впливають на якість життя людей є рівень економічного розвитку міст та стан екології міст та прилеглих до них територій. Для проведення дослідження та побудови моделей еколого-економічного моніторингу та прогнозування розвитку міст та стану екології у них необхідно зібрати, обробити та проаналізувати величезні масиви різноманітних даних. На основі результатів таких досліджень виникає потреба у побудові комп'ютерних систем для збору та обробки значних за обсягом інформації - баз та сховищ даних, аналогів яких на сьогодні практично не існує.

Головним завданням даної роботи є розробка альфа-версії веб-сервісу для проведення еколого-економічного моніторингу за базами даних. На етапі розробки альфа-версії програмного продукту було опрацьовано та згруповано основні економічні показники стосовно розвитку міста та екологічні фактори, які впливають на нього. Автором змодельована програмна модель для окремих сервісів еколого-економічного моніторингу, які є частиною майбутнього прикладного програмного продукту. У подальшому автором планується продовжити дослідження за даною тематикою, зібравши емпіричні дані щодо обраних для вивчення міст, та розробити подальші програмно-технічні модулі представленого веб-сервісу.

Ключові слова: урбанізація, економіка, еколого-економічний моніторинг, веб сервіси, розподілені системи, бази даних.