

GIS-maintenance of environmental management of territories

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Abstract. A brief overview of the key elements of the geo-information maintenance of environmental management of territories is presented in the article. The subject of systems of environmental management, an interaction between such definitions as environmental management of territories, strategic planning, and management of territorial development are examined. A specificity and principles of making and use of geographic information systems in environmental management of territories are described. The main features of the structure of geographic databases for the purpose of environmental management are revealed. A number of cartographic visual representations of geo-information databases are presented.

Keywords: environmental management, territorial management, territorial development, GIS, geographic information databases, strategic management.

System of environmental management (SEM) is an actual approach to determine priorities in the sphere of environmental protection when planning and implementing activity of organizations, an integral part of modern system of its management. SEM is used by industrial and service organizations, organs of government and educational institutions. The principles of SEM are suitable for management of territories and regions. **Geo-information systems and technologies** GIS are especially important at the territorial local and regional level when implementing the system of environmental management.

In the public administration establishments, industrial companies and firms and project organizations process of transition from simple adherence to the environmental conservation legislation to strategic perception of ecologically rational activity takes place. Strategic planning plays a significant role here [5, 7, 9]. The effectiveness of strategic planning as an element of the system of environmental management at the regional level is determined by availability of intersectoral and interdisciplinary **geo-information databases** [6, 8, 11].

The principle of «following legislative requirements» is necessary, but not sufficient enough. The reason for it is that current market dictates a necessity of more dynamic development and perfection of systems of environmental management as systems of «step-by-step improvement». Companies must be recognizable, gainfully differ from each other [18]. Projects of regional development must become attractive for investments, technological, transparent, demonstrate «amicable interface in relation to environment». This touches upon not only accordance to environmental conservation legislative requirements but systematical review of achieved results, setting ambitious tasks and solving them. Besides, an access to geographical and environmental information, information sharing with society about goals set and results achieved become especially important. Business circles work hard on developing methods of open corporate reports including economic, ecologic and social effectiveness of strategic planning of companies and establishments activity [18]. WEB-technologies, open geo-information databases, GIS-portals, open systems of environmental monitoring using materials of Earth remote are of key importance here.

The leading role of «the principle of step-by-step improvement» (brought in for the first time as part of international standards of systems of management in ISO 14001: 1996 [20]) was taken as a basis of reframing of standards in the sphere of systems of management of quality (standards ISO series 9000 [21, 22]). In the variant of 2000 it is said that conse-

quential improvement (perfection) becomes an indispensable goal of any organization. It was stated that anything that affects productivity of an organization and effectiveness of its activity inside and out of the organization is within the sphere of management attention and responsibility [22]. Consequently, ideas of environmental management were not just accepted and framed in the form of series of international standards prescribing particular rules of systems of management development, but they seriously affected development theory and practice of management in general.

The use of modern GIS-technologies is a necessary technological requirement for successful implementation of systems of environmental management for companies, organizations, plants and factories which exploit natural resources or essentially affect environment.

The role of principles of environmental management and tools developed for their implementation is better seen at the macro-economic level. Countries, regions, administrative and industrial establishments of different levels begin to further outspread of environmental management among plants and organizations and to achieve significant results. In different regions the approaches of SEM are used for adoption of environmental policy, setting realistic goals, tasks and their solutions, analysis of achieved results and choosing the main directions of development in the future. Therefore, SEM can be considered as a total of methods applicative for development of sustainable business; the perspective of such approaches in environmental management in the context of sustainable development of a region in general is also important.

All of modern models of systems of management are based upon the Deming cycle – a cycle of periodical planning, implementation, appraisal and review of an activity [18]. The Deming cycle is also known as «PDCA cycle» (Plan Do Check Act). William Edwards Deming, the first who applied the idea of the cycle into practice of management of quality, named the cycle as «The Shewhart's cycle» since the idea of it was probably first described in the Shewhart's book in 1939 [23]. Its main principle is planning; if there is no weighty reasons for deviation, plans for a certain cycle must be prosecuted. Therefore, the appraisal and correcting of erroneous and ineffective actions, perfection of models and mechanisms of planning for achieving new, consequentially developing goals become possible. Besides, such an approach enables to set regular successful activity, to reduce dependence on mistakes and concrete people. The idea of the Deming cycle corresponds to the principle of «step-by-step» improvement [18].

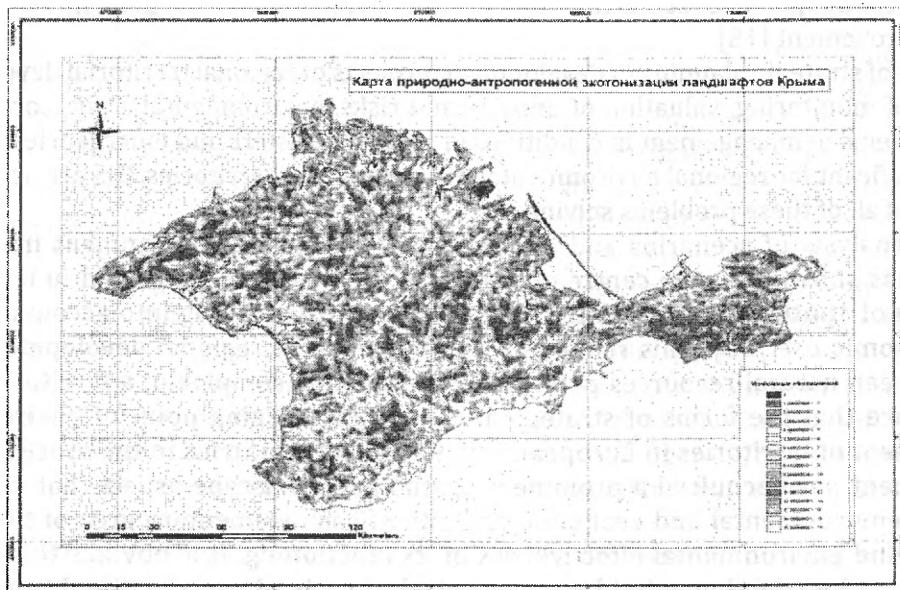
Tasks of strategic planning of development, projects of regional territorial development, systems of monitoring, valuation of impacts and risks, environmental audit, correcting of plans, systems of management in conditions of natural disasters and emergencies are especially significant for regional environmental management of territories. GIS are used for the purpose of all of these problems solving.

The analysis of scenarios and strategies of sustainable development in different regions has shown that the centre of gravity of the problem is situated in the field of **planning of spatial development** of different territories taking into account their future economic use [18]. This reflects the fundamental of regional development – relation between natural resources potential and economic complex of a territory. It is no coincidence that the forms of strategic planning as a staging point of environmental management of territories in European Union member countries in the process of their development have acquired a prominent spatial and landscape aspect that enables to evaluate environmental and economic capacity of each elementary area of the type of land use and environmental effectiveness of its functioning. It is obvious that such relations must be complemented by an appraisal of roles of social and political factors, which influence sustainability of development of objects at the macro-regional (national) and global levels of the organization of society.

Except the spatial relations, the system of methods of complex analysis, intersectoral synthesis and valuation of integral trends of development of territorial social environmental economic systems is significant for development of systems of environmental management of regional development. Such methodological apparatus and practical experience are within the interests of Geo-ecology which in the synthesis with Social [3; 19] and Physical Geography can be considered as «constructive geographical engineering» which integrates intersectoral information for organs of state and regional environmental management (picture 1 [25], 2, 3, 4 [26], 5 [26], 6 [26]). Geo-ecology is one of the basic world outlook disciplines that shapes complex perception of natural anthropogenous interactions in human environment.



Picture 1 Cartographic visual representation of GIS of modern landscapes of Crimea made for the purpose of territorial environmental management [25]



Picture 2. Geo-information model of natural anthropogenic ecotonization of landscapes of Crimea [25]

The maintenance of transition of regions to the track of sustainable development is impossible without rise of effectiveness of the systems of environmental management in management of territorial development as well as without fundamental change of its information-methodic basis. The role of geographic information and methods of spatio-temporal analysis in management of development of territorial systems is very important. Analysis of applicative management tasks allocated as a part of realization of national program of creating systems of information-analytic maintenance of organs of territorial management has shown that nearly 20 % require cartographic visual representation and 1/3 of management decisions require application of spatio-temporal analysis methods which improves quality of apprehension and effectiveness of perception of results [9].

Revolutionary changes in the conceptual and technological base of Geography related with development and active GIS implementation into the activity of management of geo-information systems organs prove real improvement of the information basis (which provides effective accumulation, processing and support of management decisions) of system of territorial management and planning.

Generally GIS (geographic information system) is a complex of program and technical means which provide automate spatio-temporal analysis of any coordinated (in the system of geographic coordinates) data. GIS-technologies have acquired colossal development and began to pretend to the position of the main «means of production» in data processing and holding.

We may agree with A.M. Berlyant [4] that «GIS development gives a unique and perhaps only chance throughout the history to become a fundamental of advanced technologies in Earth Science, a conceptual backbone way of society informatization at each level from a scientific lab to organs of state government».

The trend of GIS development is a part of general geographic development that transforms into industrial field which completely maintain processing, holding and cartographic representation of data in systems of environmental management of territories. The transformation of GIS into the main «means of production» of geo-information has led to commercialization of this field, to development of global and national infrastructures of spatial data [14], to development of geographic information standards and to a possibility of its free selling via the Internet [24]. In such situation an essential raise of quantity, quality and effectiveness of the use of geographic information in the system of environmental management of territories should be expected.

The use of GIS technologies in environmental management of territories is determined by the specific of management objects at this spatio-organization level (picture.1). When studying territorial management objects which may include several subsystems – natural, technical, social – it is important to consider a number of their particularities [5, 8, 10].

The hierarchic manner of organization levels – presence of spatio-temporal levels of territorial differentiation of nature, economy and society.

Presence of organization levels (elements, components, complexes) which demonstrate a degree of complexity of territorial systems. Thus, spread of a certain substance in the air (nature element), atmosphere condition (nature component) and landscape condition as a territorial system that combines all the nature components within the territory can be studied. The organization levels pierce all social, productive and technical systems of different hierarchies except natural ones.

Poli-structural manner of territory organization when systems and subsystems which refer to different genetic types and organization levels interact at a certain point. However the vector of systems development may not be congruent. Thus, a pedogenic system (soil contour), an agricultural field, a piece of land attached to an owner according to the cadastre, a part of administrative unit, a geomorphological system (slope), a meliorative subsystem (ground waters) etc may interact at the same point and the same time [5, 10, 11].

In modern GIS technologies used in environmental management of territories there are different approaches for allocation of elementary operation units which occur at the confluence of

landscape structures and types of modern territory usage and compose spatial basis of regional natural economic database. An appropriate methodological base for classification of units of territory management may be the conception of natural economic territorial system (NETS) which represents a complex of economic and economic subsystems which make an integral unity, and the anthropogenic influence is an inner factor of their integral development [5].

The structure of geo-information database of environmental management of territories is determined by a classifier of management objects. The approaches for making an integral classification of territorial management objects at the regional level can be represented as a sequence of stages [5, 10]:

1. The system of objects of administrative-territorial and economic regional division is being allocated. Within the units of administrative division different types of local natural economic territorial systems completely covering its territory are being allocated next. They are being set apart on the ground of confinedness to elementary natural economic contours which represent functionally integral and all-sufficient cells of land use types; mutual confluence with borders of elementary morpho-dynamic units [15] which compose the basis of landscape territory organization.

2. The allocated local natural economic territorial systems NETS may implode into bigger communities of the regional level (picture 1).

3. Objects of the local level which itemize a compound and peculiarities of territory functioning (parameters of technical constructions, plants, forest sub-compartments) (picture 3) refer to attributes of local NETS defining the structure of their database [5].

The information basis of databases renewal is existing monitoring and information accumulation nets (рис. 5). Among them the following types may be distinguished: cadastral geo-information systems (forest, land, water, natural reserved fund, mineral resources, engineering communications etc) (pictures 3, 6), environmental monitoring (pictures 2, 4, 5) systems and 4 groups of departmental information systems:

1. resource-surrounding (condition, use of different natural resources objects which are not included into the existing state cadastres), for instance solar resources (picture 7) [27];

2. sanitary-hygienic (condition, public health, sanitary epidemiological situation, dangerous infections);

3. social-economic – regional subdivisions of the State Statistics Service are organization cores (demographic situation, environmental economic aspects, natural resources use, productive forces activity);

4. statutory and regulatory (notariat, systems of estate registration etc).

The most essential task of development of the information accumulation block as an element of system of environmental management of territories is overcoming of inter-departmental barriers and substantial integration of departmental monitoring nets into the integral system.

Models of regional systems of environmental management of territories enable to plan sustainable development through a substantiation of complex of environmentally acceptable management decisions. The system of geo-information substantiation of regional systems of environmental monitoring include the following blocks:

– geographic information (data about management objects as poly-structurally and poly-hierarchically cooperating territorial systems at the element, component and complex levels of organization which appear in the process of mutual penetration of society, nature and economy);

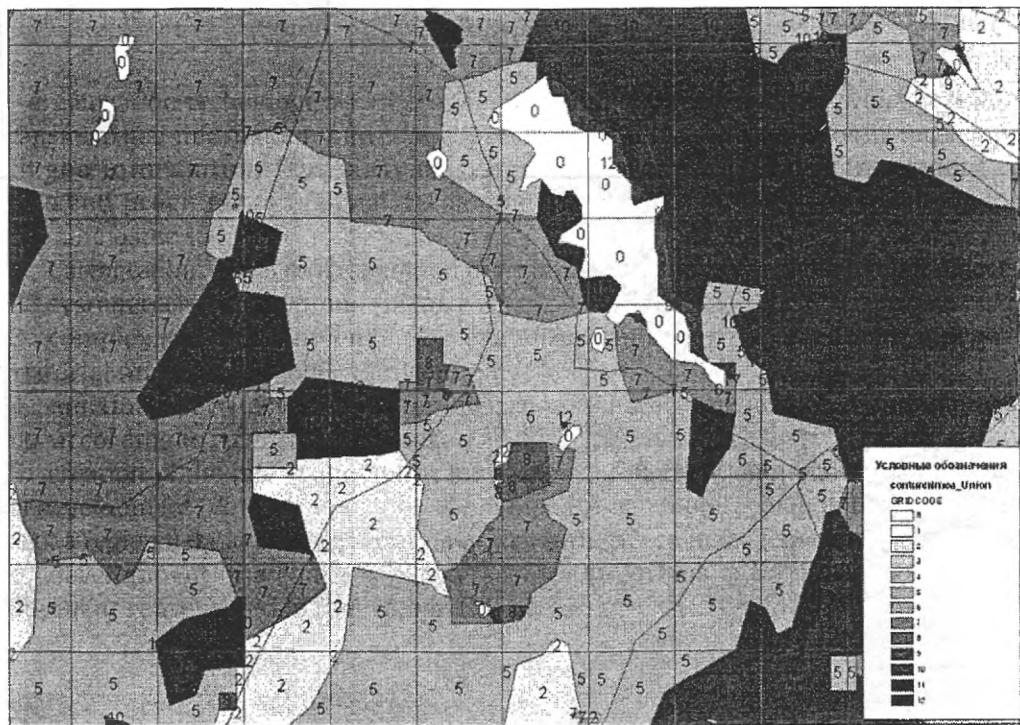
– theoretical and methodic basis (methods of spatio-temporal analysis and geo-ecologic appraisement of geo-information, and its transformation into the form needed for substantiation of management decision);

– statutory and regulatory basis (regulated by effective legislation – from a law to methodic instructions, prerogatives of organization structures activity including accumulation processing, holding, transformation, transfer and use of geo-information);

– organization-technological block (organizations or their subdivisions which receive, transfer, transform geo-information, and complex of program-technical means for its receiving) [5].

In **geo-information feasibility of systems of environmental management of territories** and programs of regional development a number of functions reflecting tasks at hand can be listed [5]:

1. Cartographic visual representation of results of perception of management objects data.
2. system territory mapping (picture 8);
3. complex geo-environmental, social environmental and geo-economic appraisement of territorial management objects condition.
4. functional territory zoning (for allocation of homogeneous areas and management objects according to a certain criterion)
5. creation of the information basis for systems of the environmental management of regional development (data accumulation about management objects of monitoring nets, maintenance of a regional database, organization of change between management subjects);
6. development of a complex of intersectoral programs of territorial social economic development represented in the from of GIS-projects.



Picture 3. An example of complex selection of operational territorial units (OTU): of a regular net and contour of modern landscapes for the purpose of ecologic appraisement

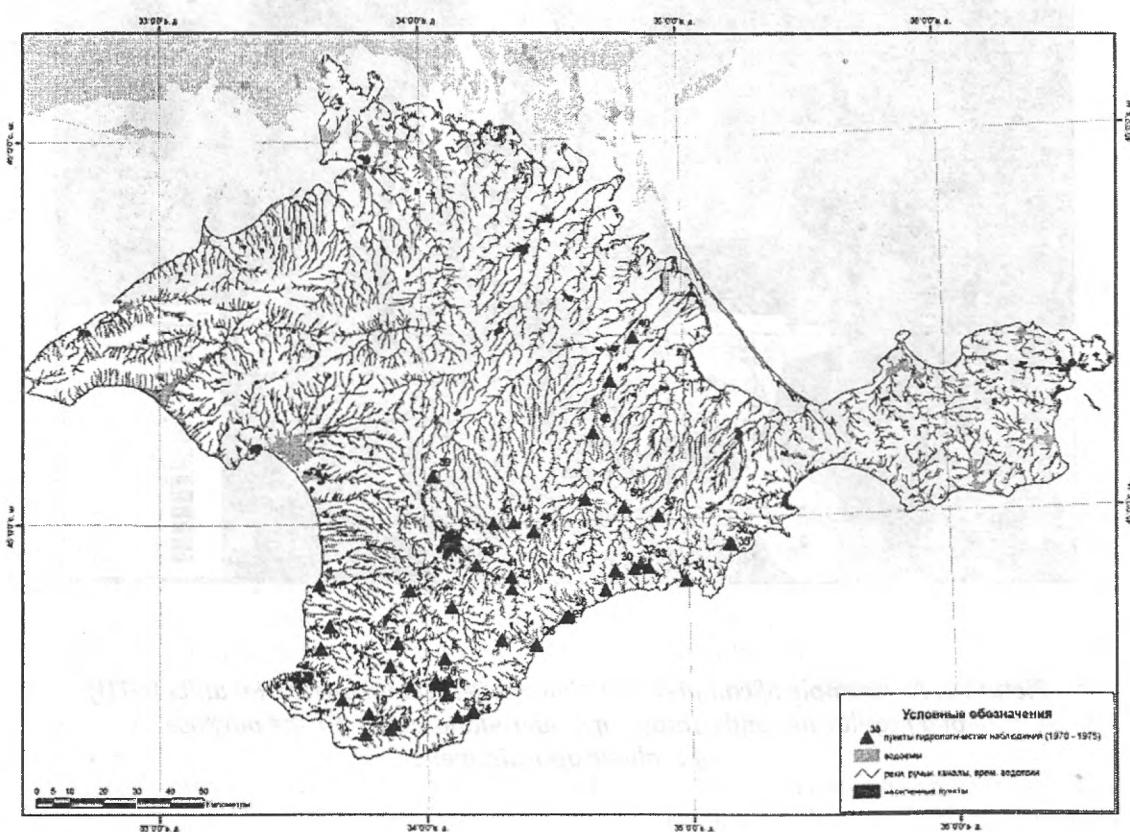
Visual representation function – cartographic representation of information about management objects. As a rule, survey maps and schemes of administrative-territorial division with elements of purposeful comparative appraisal of operating units are

used in such case. At the regional level administrative regions may be used as operating units, as well as village and city councils, forest quarters, agricultural organizations etc. GIS technologies development has led to an active use of computer maps (as a means of visualization) in the wide spectrum of applicable tasks: objectivation of placement of public service places, analysis of electoral preferences and objectivation of borders of electoral districts etc.

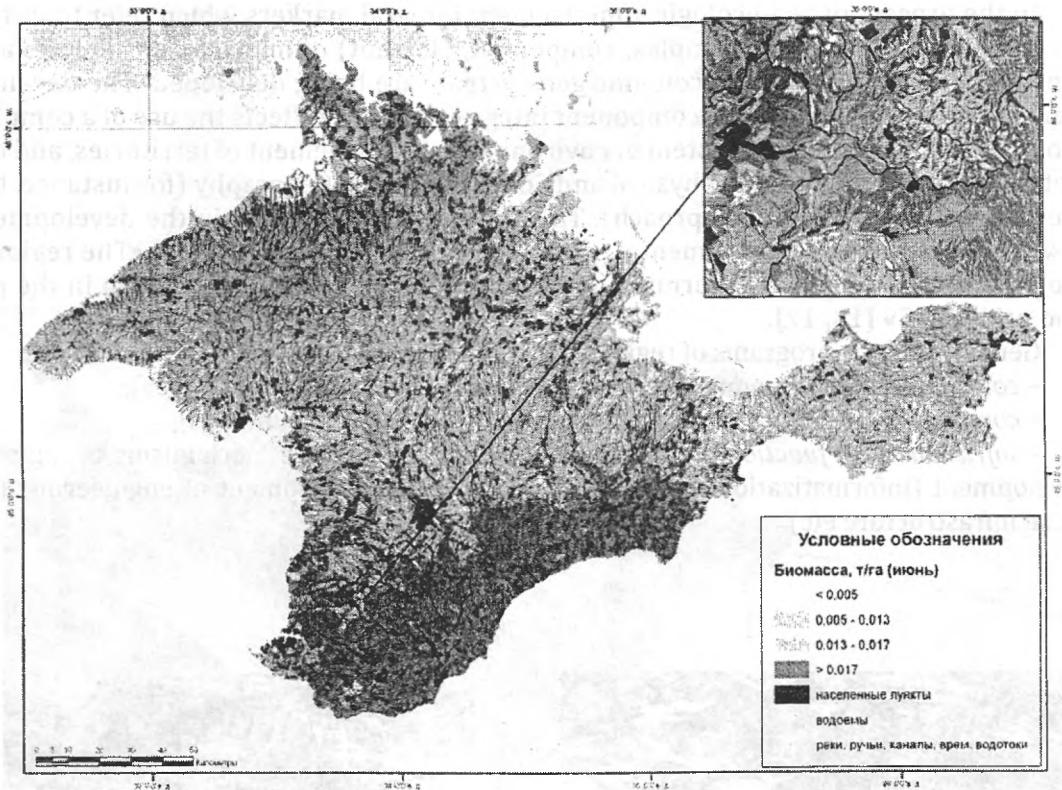
Complex system mapping which enables to form an integral picture of a managing territory in the form of series of maps and Atlases. Such surveys are quite effective for complex geographic maintenance of pre-plan documents and programs of regional development.

Transition to technological base of modern GIS enables to enhance effectiveness of complex mapping. «The Atlas of the Autonomous Republic of Crimea» [2] in polygraphic and electronic forms, in the from of geo-information database Arc-View composing of 16 information layers integrated into a united system of classifiers and cartographic approaches may serve as an example.

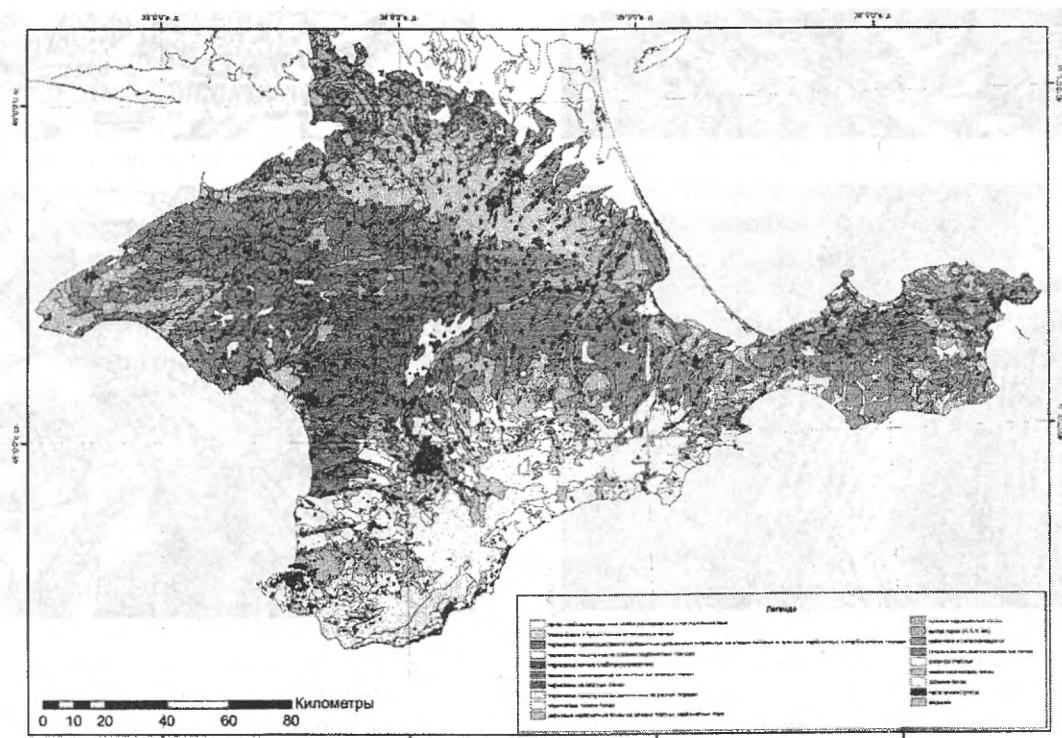
Complex geo-ecologic and geo-economic appraisement in the system of existing subject-object relations in the region. The types of appraisement and appraisals themselves are different and are determined by types of management objects involved within territorial systems and by the demands and variety of subjects of appraisal. In actual management practice types of environmental and economic appraisals of potential and rankings (investment, natural resources), results of socio-economic development of regions and environmental conditions of territories are mostly spread.



Picture 4. GIS-model of a hydrographic net and points for hydrologic monitoring [26]



Picture 5. Geo-information prognosticative SWAT-model of biomass increase in the territory of Crimea as a base for the preventative environmental management of territories [26]

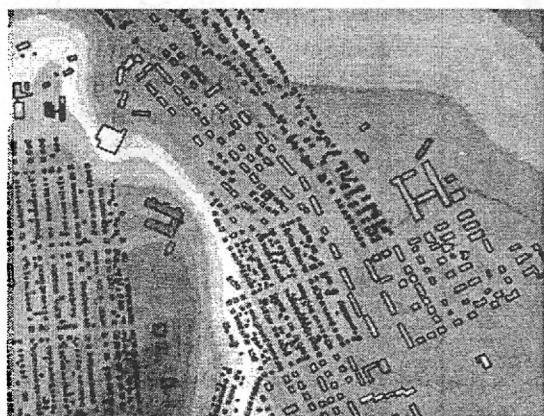
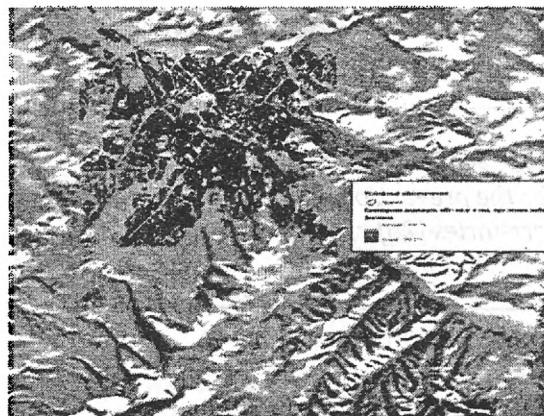


Picture 6. Geo-information model of the pedological cover [26]

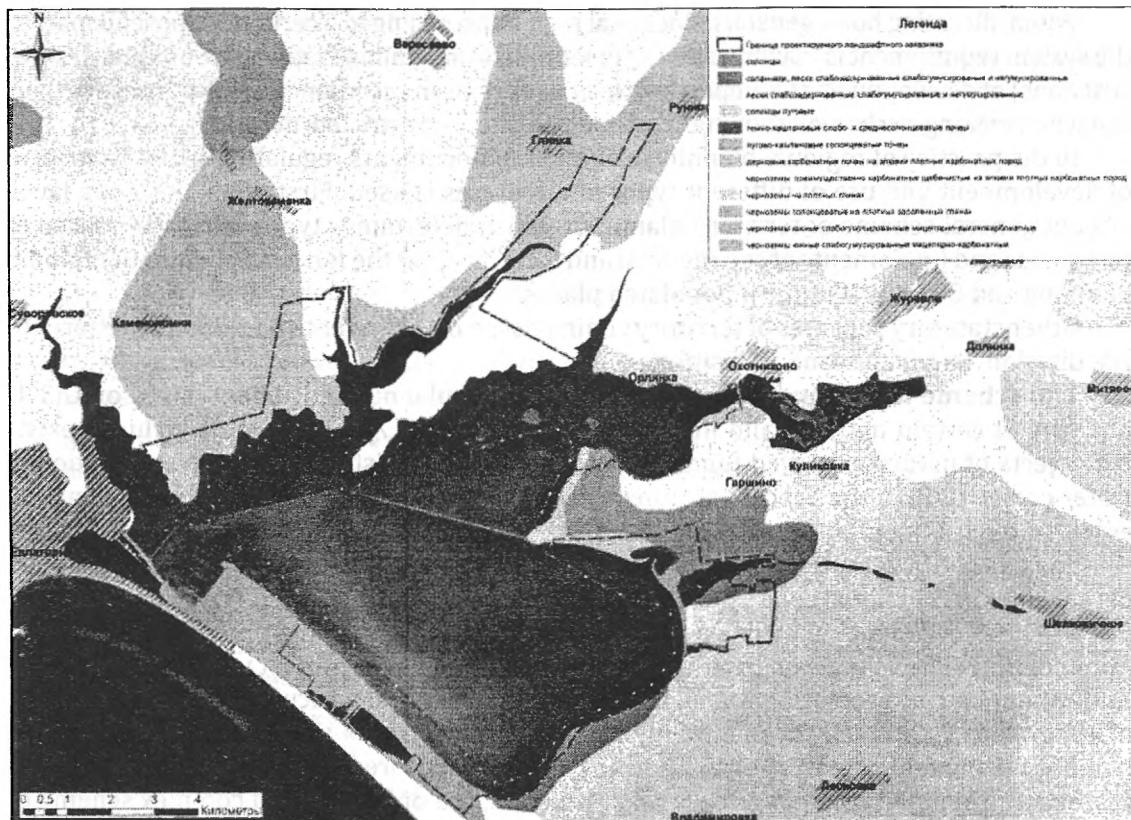
In the process of geo-ecologic appraisement integral markers which refer to different levels of organization (complex, component, element) of management objects and considered as natural social economic geo-systems are being developed. The development of intersectoral and intercomponent integral markers reflects the use of a complex geographic approach in the system of environmental management of territories, and the methodological apparatus of Physical and Social Economic Geography (for instance, the use of complex geographic approach). This approach was applied in the development of «The conception of environmental program of Crimea until 2010» and «The regional program of national eco-net forming in the Autonomous Republic of Crimea in the period until 2015» [13, 17].

Generally all the programs of regional development can be divided into:

- *complex* (social economic development of territories, regions of Crimea);
- *component* (according to types of activity and natural surroundings);
- *infrastructural functional* – provide system conditions and mechanisms of regional development (informatization programs, formation and development of engineering and social infrastructure etc).



Picture 7. GIS-modelling of solar energy provision of territories for the purpose of energetic management [27]



Picture 8. Geo-information model of Sasyk-Sivash lake for the purpose of environmental management of reserved territories

Environmental management of territories is being implemented by means of development of medium-term and strategic programs of regional development. Such GIS correspond to the specifics of programs and subprograms and may differ according to:

levels and subjects of administrative territorial division (administrative regions, large city councils, village councils with accepted information methodic base for subprograms of each level);

types of natural resources and nature components (protection, rational use and reproduction of air, water, forest, land and biological resources quality);

types of activity (industry, agricultural production, housing and public utilities, system of displacement of population, transport, forest, recreational, mineral and raw complex etc);

subjects of regional politics (in terms of population: sanitary hygienic security maintenance programs, educational programs: in terms of society: supplying of repatriates, crime precautions; in terms of effectiveness raise of systems of regional management: subprograms of information systems for making a cadastre of natural resources, environmental monitoring, prognosis of emergencies; in terms of business – development of small business, new forms of co-operation etc)

Feasibility of schemes of functioning zoning for purposes of territorial planning and development of social economic strategies of regional development are of great importance. Geo-informative technologies have become an inseparable part of development and feasibility of schemes of functional zoning and environmental substantiation of schemes of regional planning and of the general layouts of populated places. Functional zoning assumes allocation of homogeneous territories according to a certain marker and their combination. The use of modern geo-information technologies enables to solve such task of environmental management of territories effectively.

When allocating homogeneous functional regions according to a certain purposeful marker the system requirement is maximization of potential use and minimization of consequences (restrictions) of development. It is important to range regions in accordance to the purpose of their use when making a scheme of zoning (positive, positive but restricted, negative).

In the practice of regional planning a number of documents regulating spatial structure of development and use of different types of territories is used. First of all, these are laws: «About general scheme of territory planning» which determines types of prevailing use of territories and implements at the regional and local levels in the form of Schemes of regional planning and General layouts of populated places.

Other statutory schemes of territory zoning based on GIS refer to administrative territorial division, forest and land utilization.

The scheme of regional eco-net (REN) is a new planning document based on GIS. It is a part of certain national and international programs [17]. The scheme includes existing objects of natural reserved fund and other territories (historical cultural, recreational, water protection); in the process of transition to rational management of natural resources essential environment oriented restrictions appear within such territories.

The use of GIS in the system of environmental management of territories is able to supply schemes of functional zoning technologically and almost completely. The system of separate schemes of functional territory zoning of a region (with suitable pre-plan documents) must contain «The Scheme of general planning», schemes of land, forest utilization, schemes of development of recreational and mineral raw complexes, agricultural production and «The territorial complex scheme of environmental protection» which include all the system of environment oriented restrictions [5]. Thus, GIS of forest and land utilization, GIS of recreational complex, GIS of agricultural production, GIS of a territorial complex scheme of environmental protection etc can be developed. All of these GIS are effective tools for implementation of environmental management of territories.

Integration of the GIS schemes of territorial zoning (with possibilities for geo-information modeling and prognosis of scenarios of development) as listed enriched with the methodological apparatus of strategic territorial planning enables to reach scientifically feasible strategic spatial environmental management of a certain territory.

Transition to the next level of the information basis of the system of management in general is necessary for development of scientifically feasible approaches to strategic spatial environmental management of a region. It is quite difficult to overestimate the role of geographers in such question since except the geo-information technologies planning of configuration and regulation of monitoring nets, creation of systems of environmental monitoring and of information systems of natural resources cadastres and spatially distributed interdepartmental regional database also refer to the functions of information basis of the system of environmental management of regional development.

The quality and effectiveness of sustainable development planning greatly depend on content, nomenclature of original data, means of its previous preparation for assimilation in the regional management system. Generally the data and means of its organization (affixment of geographic coordinates or operation territorial units, subjects or management problems) can be named as the information basis of regional development.

The most effective means of information holding and processing are systems of databases management (SDM). If earlier the main reason for impossible operational information change, its integration and processing for the further use were disconnection of departmental systems of information holding and lack of technical means for its transfer (telecommunications), at the present time when telecommunication nets keep developing, unification of formats of data holding is involved, technical problems are easily solvable and are not obstacles for creation of a united system of information management. The core of such system which makes information holding and access to it possible may be departmental spatially distributed database [5, 8, 11, 12].

Thus, modern GIS technologies are a necessary part in the system of information feasibility of systems of environmental management of territories at the regional level. Geographic information systems specify technologies of strategic planning, territorial planning workings and planning and organization of environmental monitoring and audit.

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Аннотация. В представленной статье дается краткий обзор основных элементов системы геоинформационного обеспечения экологического менеджмента территорий. Кратко анализируется сущность системы экологического менеджмента, рассматривается связь таких понятий как экологический менеджмент территорий, стратегическое планирование, управление территориальным развитием. Отмечается специфика и принципы формирования и использования географических информационных систем в экологическом менеджменте территорий. Раскрываются основные черты структуре географических баз данных для целей экологического менеджмента. Представлен ряд картографических визуализаций геоинформационный баз данных.

Ключевые слова: экологический менеджмент, территориальный менеджмент, территориальное развитие, геоинформационные системы, геоинформационные банки данных, стратегическое управление.

Анотація. У статті даетсяться короткий огляд основних елементів системи геоінформаційного забезпечення екологічного менеджменту територій. Коротко аналізується сутність системи екологічного менеджменту, розглядається зв'язок таких понять як екологічний менеджмент територій, стратегічне планування, управління територіальним розвитком. Відзначається специфіка і принципи формування та використання географічних інформаційних систем в екологічному менеджменті територій. Розкриваються основні риси структури географічних баз даних для цілей екологічного менеджменту. Представлені ряд картографічних візуалізацій геоінформаційний баз даних.

Ключові слова: екологічний менеджмент, територіальний менеджмент, територіальний розвиток, геоінформаційні системи, геоінформаційні банки даних, стратегічне управління.

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