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USE OF GIS TECHNOLOGIES FOR GEODESIC ASSESSMENT OF LAND RESOURCES AND CADASTRAL ACTIVITIES

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Abstract. The article is devoted to the study of the implementation of geodetic innovations in the field of land management and cadastral activity. Modern technologies and their impact on the optimization and efficiency of work in the specified areas are considered. The main attention is paid to the methods of geographic information systems, their application for accurate mapping, data analysis and territorial development planning. The purpose of this article is to research and evaluate the use of the latest geodetic solutions in land and cadastral management, as well as to reveal the advantages and potential of their application to optimize the management of land resources. Used: analytical method, cartographic method, mathematical method, methods of digital automated processing of space images. Further research in the field of land management and cadastral activity can be directed to the development of new methods of processing and interpreting geodetic data using artificial intelligence and machine learning, adapting geoinformation systems to the needs of regional land management, in particular, to monitor climate changes, ensure food and water resources. The article can be useful for specialists in the field of land management, cadastre, as well as for everyone who is interested in innovative technologies in geodesy.

Keywords: land use, zoning of the territory, satellites and images, geoinformation, geographic information system, remote sensing of the Earth.

Actuality. The issue of regulation of land relations in the era of rapid technological development and digitalization acquires special significance not only for ensuring the convenience of citizens, but also for the formation of the socio-economic stability of the country. Currently, all spheres of the public and private sector of Ukraine are in dire need of an urgent transition to modern development conditions. The importance of solving the land issue, which affects the interests of every citizen of the country and every business entity in the field of land management and cadastral activity, requires scientifically based tools and a mechanism for the introduction and use of geodetic innovations.

The main way to improve the quality and efficiency of land management is innovation based on digital technologies. Modern technologies and appropriate software and hardware allow processing large volumes of information, increasing its accuracy, visibility and reliability, obtaining the most effective design solutions, and producing high-quality land management documentation [5, p. 43].

In Ukraine urban development, urban territories, soil, geobotanical and other surveys are of a local nature and cannot provide a picture of the entire land fund of the community. There is a need to reproduce the information base based on the use of new innovative technologies (telecommunications, information and satellite navigation systems for data collection and processing). The system of land management, land management and cadastral activity needs to be updated.

Analysis of recent research and publications. The application of the landscape approach in land use is based, first of all, on developments such researchers as : Viljanueva J., Blanco A. Ch., Rudenko L., Yamelynets T. Studies on the zoning (zoning) of territories, the use of cadastral systems were conducted by such scientists as: Vertegel S., Vyshnyakov V., Gurelya V., Slastin S., Piskun O., Kharchenko S., Moroz V., Shevchenko R., Chabanyuk V., Polivach K.

Issues of development and improvement of methods and technologies for the use of information systems for the purposes of cadastre, land management and monitoring of land resources are considered in the works of: Glotov V., Gunina A., Seyka Z. , Kosarev M. V., Yasenev S. O., Lazorenko- Hevel N. Yu.

The works of the named authors made a significant contribution to the formation and development of a system approach in land use, zoning of territories and the application of information systems for these purposes. However, these issues require further development and application of digital technologies in the field of land management and cadastral activity.

The aim of the study. The purpose of the article is study and analysis of the application of modern geodetic innovations in the field of land management and cadastral activity, as well as to determine the advantages and possibilities of their implementation to improve the efficiency of land resource management.

Objectives of the study:

–assess the current state of geodetic technologies used in the field of land management and cadastral activity;

–explore the latest surveying innovations and techniques currently entering the market;

–analyze the advantages and limitations of modern geodetic technologies in the context of their application for land management and cadastral activities;

–determine the main directions of implementation of geodetic innovations in practical activities in the field of land resource management.

Research methods. The research is based on the use of a number of methods and methodological approaches:

1. Analytical method. This method includes a systematic analysis of data to identify relationships, patterns, and cause-and-effect relationships. Determination of the main characteristics and parameters of land use, as well as identification of factors affecting the structure of land use.

2. Cartographic method. With the help of this method, maps are created and analyzed to visualize spatial data and understand the distribution and dynamics of phenomena on the territory, which allows to form structures in the land use of a certain territory.

3. Mathematical method. Application of mathematical models and formulas for data analysis and presentation. Modeling possible changes in the structure of land use in the future or changes in certain factors.

4. Methods of digital automated processing of space images. These methods include the processing and analysis of satellite and aerospace data using specialized software tools. Acquisition and interpretation of images of the Earth's surface, detection of changes in the structure of land use based on space images.

Research results. Land management and land cadastre are closely related to a new innovative field of research - geoinformatics. The tasks of geoinformation go beyond the boundaries of cartography, which makes the basis for the integration of various disciplines from different fields of knowledge for complex system studies. Cartographic materials, including land management schemes, are characterized by an extremely low degree of reliability, since they are usually used for the formation of land use statistics , which further complicates the task of obtaining real information about the state and use of land resources [1]. To solve the problems listed above, a source of up-to-date and reliable information, independent of possible abuses, is needed. Such a source of information is the data of remote sensing of the Earth (RDS), which allow to quickly obtain objective information about the use of land resources and their physical condition . To analyze the use and monitoring of land resources, it is necessary to use space images of various times, which allow to identify and trace in detail the sources of surface pollution, the nature of environmental disturbances and their dynamics [13].

For the analysis of long-term changes in certain natural conditions, objects and ecosystems, there are archival funds of materials from space photographs. One of these archival funds is the Office of the State Geological Survey of the United States, which stores declassified data from the Earth's space satellites in free access: Landsat-5, SPOT, IKONOS, WorldView-1, WorldView-2, QuickBird, GeoEye-1. Processing of digital images is the most important component of remote sensing of the Earth, the purpose of which is that digital images can be used in the field of land resources management, land management and cadastral activities [14].

One of the first tasks of processing satellite images is to combine image channels taken in different spectra of the same raster. Pictures from the WorldView-2 and SPOT 6 satellites are divided into several channels - each channel is a monochrome image. Combining different channels in different orders allows you to get a final raster picture with a different gamut. Currently, for each region of the Earth, there are freely available images from the WorldView-2 and SPOT 6 satellites, the detail of which captures on average is 0.98 meters per pixel, which means that the scale of the resulting image will be approximately 1:2000 [15]. On fig. 1 and 2 present satellite images in unnatural and natural colors, obtained by adding various channels, implemented in the ArcMap software complex.

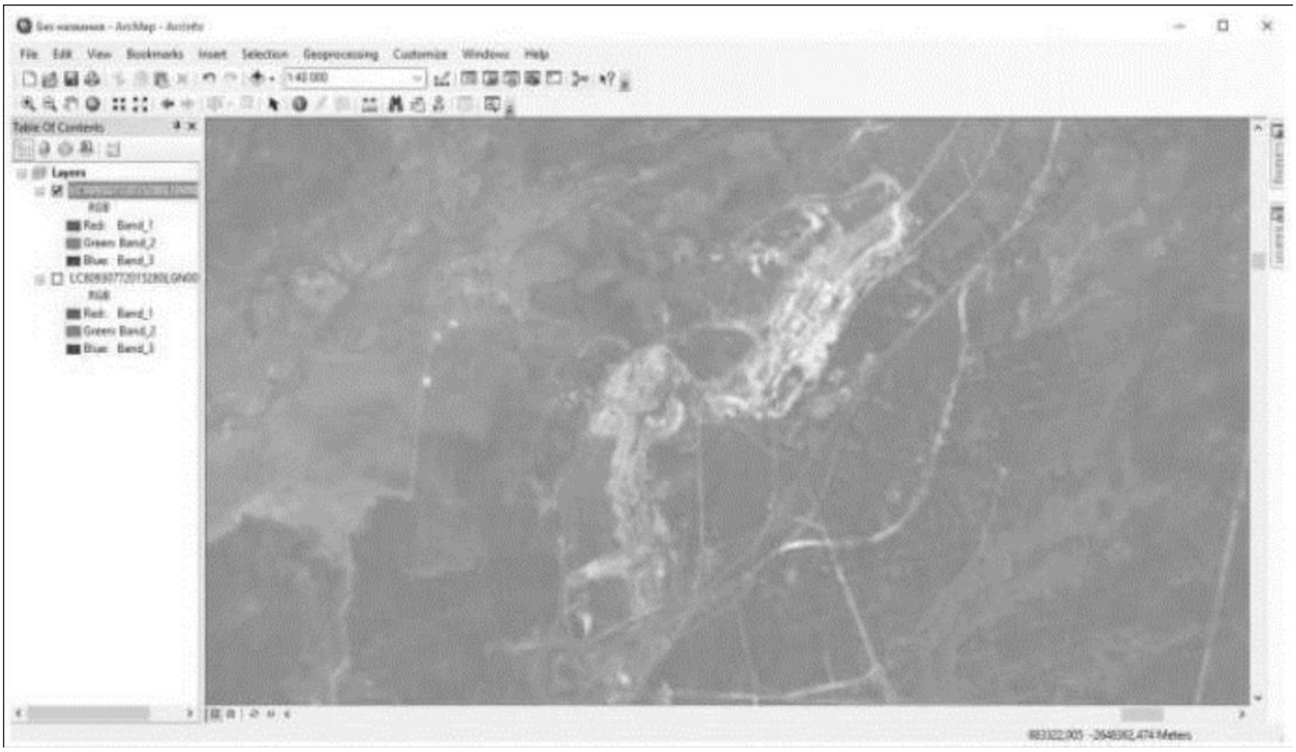

Fig. 1. Raster of land resources in "unnatural" colors [15]

Fig. 2. Raster of land resources in "natural" colors [15]

Thus, for the analysis of the state of land resources, even pictures of the optical-electronic satellite WorldView-2 can be used, since this space satellite allows you to receive pictures of ultra-high resolution and has nine spectral channels, and the spatial resolution is 0.46–1, 84 meters, compared to the SPOT 6 satellite, which provides high-resolution imagery and has 3 spectral channels and a spatial resolution of 1.5 - 8 meters, correspondingly lower spatial resolution than WorldView-2. The peculiarity of multi-zone images is that, knowing the peculiarities of the wave characteristics of the channels and their combinations, it is possible to obtain information of interest to us about the properties of various geographical and land resources . Vectorization is designed to convert an image from a raster format to a vector (set of primitives - points, lines, polygons), which is used for further map creation. Let's define the main spectral index used in the study of the state of land resources. The most popular and frequently used index is NDVI (The normalized difference vegetation index) [16].

Usually, the reflection spectrum in the red and infrared regions is combined, as the vegetation intensively absorbs the study in the red region of the spectrum (up to 90% caused by the pigment). At the same time, in the infrared region, green leaves are a strong reflector . A strong contrast of the reflection coefficient is observed only in green vegetation, while the soil devoid of vegetation presents the same reflection coefficient, both in the red and in the infrared region [10]. The index is calculated as the difference of the reflection values in the near-infrared and red regions of the spectrum, divided by their sum, the formula will look like this:

$$NDVI = \frac{\rho_{біч} - \rho_{ч}}{\rho_{біч} + \rho_{ч}} = \frac{RVI - 1}{RVI + 1} \quad (1)$$

As a result, the value of the index can vary from"-1.0 to 1.0" , but the value of the vegetation index usually varies from " 0.1 to 0.7 " (Fig. 3.).

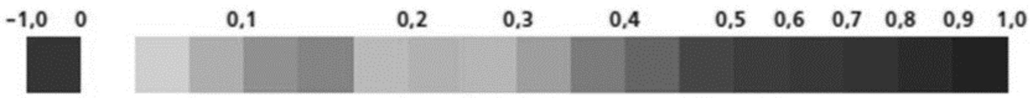

Fig. 3. The value of the NDVI index according to the scale of studies of the state of land resources [12]

Table 1 shows the NDVI values for different types of research objects.

1. NDVI values for different types of research objects [11].

Object type	The reflection coefficient in the red zone of the spectrum	The reflection coefficient in the near-infrared zone of the spectrum	NDVI value
Dense vegetation	0.1	0.5	0.7
Sparse vegetation	0.1	0.3	0.5
Open soil	0.25	0.25	0.025
Clouds	0.25	0.35	0
Snow	0.375	0.01	-0.05
Water	0.02	0.01	-0.25
Artificial covering (concrete, asphalt)	0.3	0.1	-0.5

Vegetation is characterized by less reflection in the red range compared to the near-infrared zone due to the absorption of light by chlorophyll. Therefore, NDVI indicators for vegetation always exceed 0 [7].

The NDVI index is a dimensionless indicator of the reflectivity of the studied object, which characterizes the state of land resources (Fig. 4.).

Fig . 4. An example of selecting the area with the largest plant biomass using the example of the NDVI index (right) and a space image from the Rapid Eye ISS (left) [12]

In fig. 4. it can be seen that with the help of the software it is possible to highlight the necessary areas in the "on-line" mode (red color) using GPS positioning. Data after processing are included in thematic GIS to conduct a detailed analysis and determine the trends of positive and negative processes (Fig. 5.).

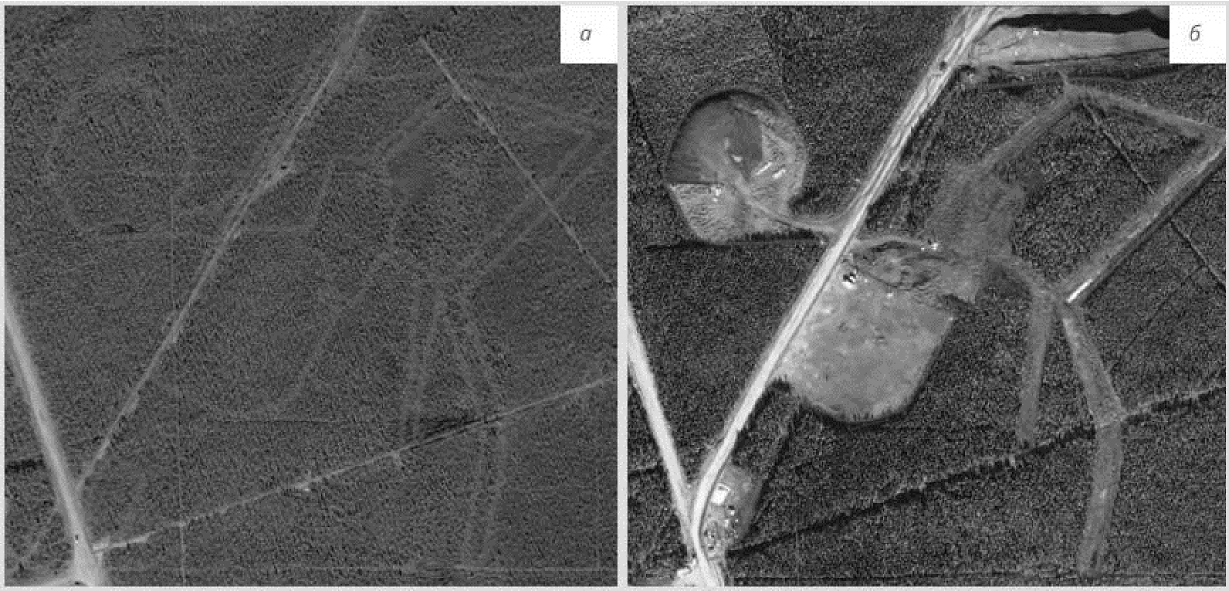

Fig. 5. Satellite images of assessment of the qualitative state of land resources: a) QuickBird snapshot; b) GeoEye image [3]

Existing satellite systems for land area monitoring provide [2, p. 91-92]:

–calculation based on multispectral observations of various indices characterizing the state of the land;

–the possibility of conducting fairly frequent observations, which are necessary to control the dynamics of the development of the components of the natural environment and its reaction to the influence of adverse factors.

Geographic information systems (GIS) are complex information solutions that allow collecting, archiving, processing and displaying spatial data, as well as performing analytics on their basis to obtain new information about objects and phenomena with a spatial location [1]. The peculiarity of GIS is their ability to process and interact with spatial information, which determines their difference from standard information systems.

We determine that the leading method of processing GIS data is a layer model, the essence of which is the distribution of objects into thematic layers. Layer objects are stored in a separate file, have their own identifier system, which can be accessed as a set. GIS involves working with the graphic part of the data in the form of electronic maps and the attributive part of the data, which contains a certain semantic load of the map and additional information that belongs to the spatial data, but cannot be directly plotted on the map. Graphical objects and attribute data are related to each other, in particular, graphic information is physically stored as one of the fields of the attribute table. The GIS toolkit makes it possible to conduct simulation modeling using attributive and spatial data requests [3].

In addition, built-in internal GIS programming languages allow you to create your own programs that contribute to solving specialized tasks. GIS technologies are used today in the preparation of land cadastres; thematic mapping; inventory and accounting of objects; marine cartography and navigation; terrain relief analysis; management of environmental protection measures and natural resources.

One of the possibilities of working in the GeoMedia Professional system, using various vectorizers, for example EasyTrace. The data can be stored in one of the exchangeable formats (for example, the Mid/Mif format of the Maplnfo Professional system), while it is possible to exchange data with global positioning systems and read directly from the formats of systems for which the appropriate drivers are available. For the GeoMedia Professional system it is: Arclnfo - ArcView Framme Maplnfo - MGE - CAD [6].

When choosing a GiS system, it is necessary to understand that the main exchange formats that are widely used do not convey topological relationships between objects. Such formats include DXF (AutoCAD), MIF (Maplnfo), GEN (Arclnfo), Shape (ArcView), F1-F20V, SXF, etc. As a rule, for the purposes of land management, this condition is not decisive, and the above-mentioned formats are effectively used for inventory. After the completion of the chamber stage, field work is carried out [9]. At this stage, new high-quality planning and cartographic material is selected, adjusted or created.

System modules include data processing of geodetic measurements, vectorization and archiving of maps, schemes, drawings, transformations of cartographic projections, combining spatial data. MapInfo allows you to get location information by address or name, find street intersections, borders, automatic and interactive geocoding, and place objects from the database on the map. The creation of a map of land resources begins with the formation of a digital model of the territory (CMT) [8]. The full-featured GIS MapInfo is used not only in land management, but also in the state real estate cadastre and monitoring of land resources [10].

In fig. 6. the "Landscape Subclasses" layer is shown with an open list and a map containing the signatures of the names of the landscape subclasses. Types of landscapes within subclasses were formed alternately in the layers "Field types of landscapes".

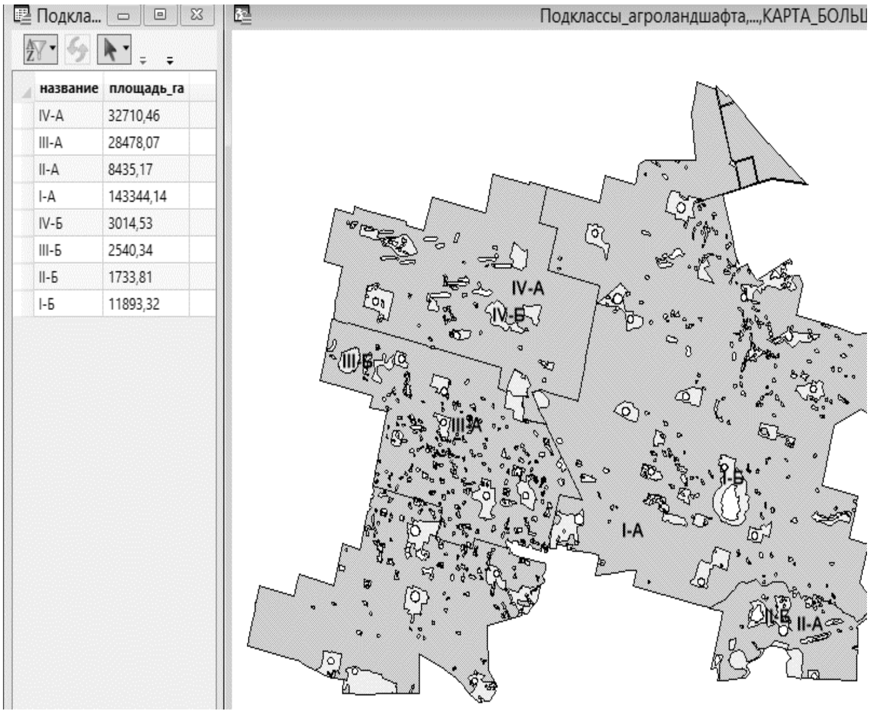

Fig. 6. "Landscape subclasses" layer [4]

The "Ecological and economic zones"layer is the final result of all the work done. The layers "Suitability groups" and "Landscape types" are workers, but they carry important information, so they are included in the map structure EKG Because of the war, the attributive database is replenished with information. In fig. 7. the "Landscape Types" layer is shown with an open list and map.

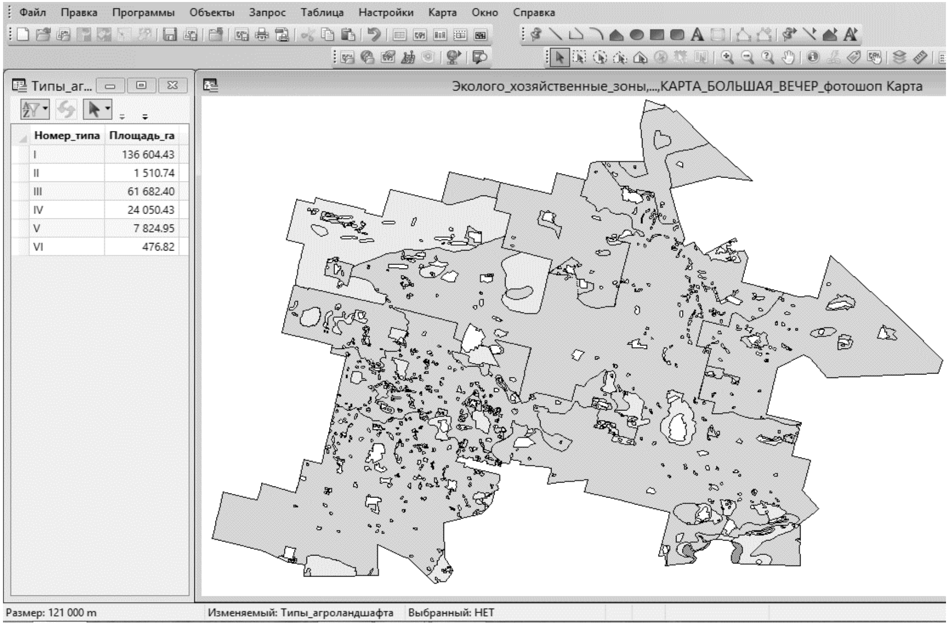

Fig. 7. "Landscape types" layer of the territory map [4]

In the MapInfo program, five zones are formed from six types of land in the landscape in the "Ecological-economic zones" layer with attribute information entered in the list of the "Ecological-economic zones" layer. Ecological and economic zones are shown with hatching for better visual perception. The "Ecological and Economic Zones" layer of the territory map is presented in Fig. 8.

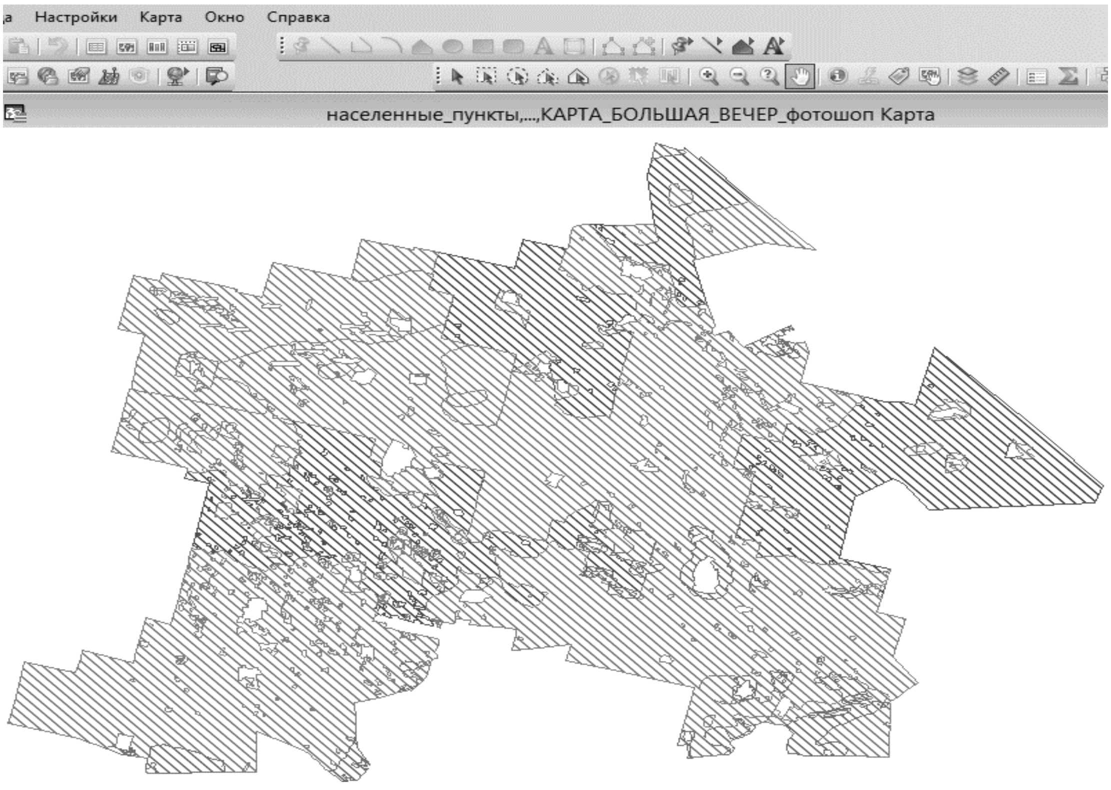

Fig. 8. "Ecological and economic zones" layer of the territory map [4]

The map as a visual result of the completed work on E and Z of the territory is presented in fig. 9.

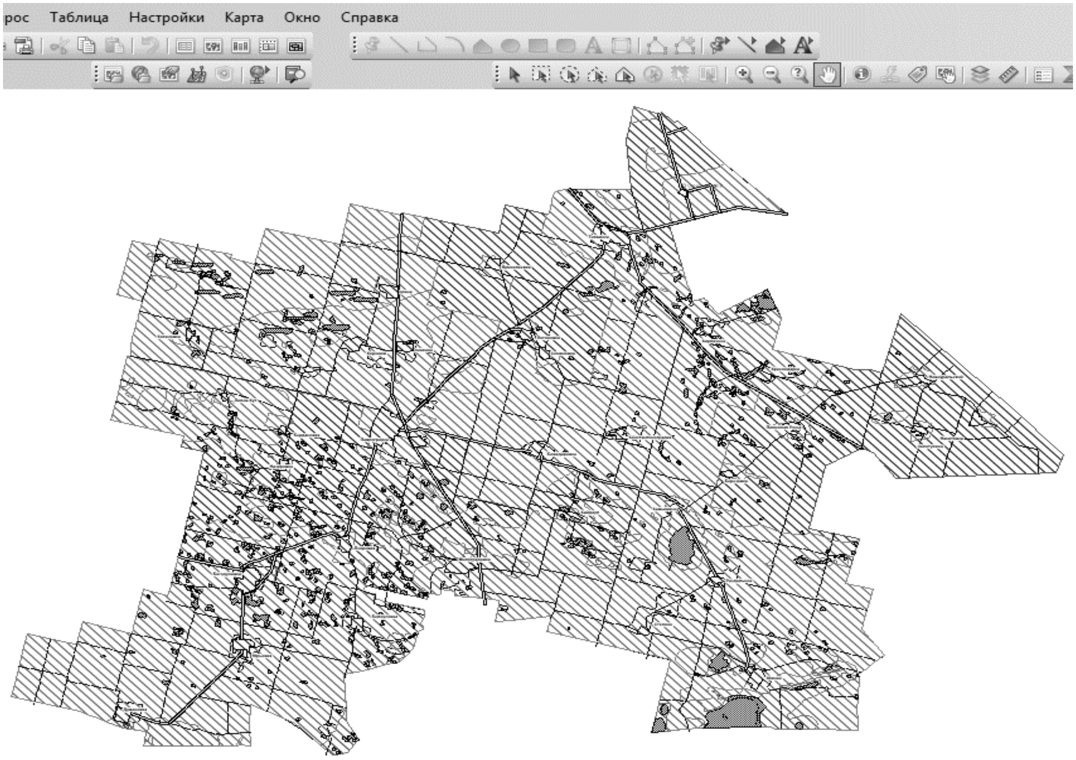

Fig. 9. Full map of the land area [4]

At the same time, numerous errors in determining coordinates, calculating areas, etc., are often revealed, which must be eliminated. Also, during this stage, a land management survey is carried out with the drawing up of deeds for each land plot or mass of territory that is settled on the land. The act of land management survey shows the following:

–land category: agricultural land.

–designation of land use according to cadastral documents.

–the nature of the use of land resources in the past and in the current period .

–cultural and technical condition of land resources .

–description of the boundaries of land resources .

–the presence of restrictions and burdens in the use of land resources .

–reasons for the removal of land from active circulation.

–special conditions under which land can be used .

Let's highlight the main areas of GIS use in land management and land cadastre:

1. Systematic monitoring of the state of land resources, assessment and forecast of changes in their state under the influence of anthropogenic and natural factors - land monitoring. The purpose of monitoring is to regulate the quality of the environment, prevent land pollution, and ensure their productivity.

2. Forecasting and planning of the development of territories based on the assessment of the resource potential of the land, organization of effective agriculture. Operational-objective cartographic display of the results of territory development forecasts using GIS allows for the adoption of appropriate management decisions regarding the development of territories.

3. Modeling rational use and protection of land resources. Rational use of land resources involves all kinds of improvement of land use with the growth of needs and material and technical capabilities of society. Land use modeling is based on GIS capabilities to automate calculations of quantitative indicators of land resources and their subsequent visualization.

It is noted that land assessment will be carried out in accordance with the division of land resources into categories, i.e. by purpose. We propose to establish the key areas of implementation of digital solutions in the field of land management and cadastre:

1. Constant monitoring of land plots, analysis and forecasting of changes caused by the influence of anthropogenic and natural factors. On the basis of monitoring data, reports, thematic maps, reports and scientific forecasts are formed, which are submitted to the relevant authorities.

2. Determination of development prospects of various territories, taking into account land resources, and further formation of effective land use strategies. Modern geoinformation systems contribute to the rapid analysis of statistical data, ensuring clarity and accessibility of information display.

3. Creating models of optimal land use and protection. Effective land use involves improving the use of land resources, taking into account the growing needs of society and technological capabilities.

4. In-depth study of land resources: their ecological, natural and economic potential, as well as analysis of the impact of human activities on the environment. The intensive use of geoinformation systems allows for a detailed analysis of land aimed at the balance between productivity and ecological stability.

5. Territorial planning is aimed at determining the destination of regions, taking into account a complex of sociological, economic, ecological and other aspects. This helps support sustainable development and modernization of engineering, transport and social infrastructure. The use of geoinformation technologies in this context provides an opportunity to optimize and improve the use of land resources.

Conclusions and perspectives. In this article, we identified directions for using innovative geoinformation technologies in land management and land cadastre. This topic is relevant in modern society and requires further improvement of geoinformation systems. Geoinformation technologies make it possible to open up new opportunities for increasing the practical productivity, environmental friendliness and profitability of the use of land resources. Improvement of the method of soil and agrochemical survey of agricultural and non-agricultural lands the appointment is most promising based on an in-depth analysis of earth remote sensing materials. The proposed method of soil survey involves, first of all, the analysis of the content of high-resolution space images with the selection of problem areas of the soil cover of land use, followed by their identification during selective mapping.

The content of the proposed approach consists in the organization of land use at different levels of landscape differentiation of the territory, taking into account both natural- ecological and economic factors. It was determined that the monitoring of land resources is carried out in four stages: classification of landscapes (the result is selected types of landscapes); assessment of types of landscapes (result – determination of the ecological state of types of landscapes, credit scores, productivity); selection of types of land resources in landscapes (result – selected types); selection of ecological and economic zones (result - selected zones). The directions of application of information systems in the field of land management have been established .

The scientific contribution of the article is as follows: modern technologies and methods used in geodesy and geoinformation systems are considered. This includes the use of modern tools, satellite systems and geodetic data processing methods. the use of modern geodetic technologies helps to optimize land use. This is important for ensuring sustainable development of territories and efficient use of land resources. The article examines how geodetic innovations affect the cadastral system and land management.

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Б.О. Нарадовий, І.Г. Рожі

ВИКОРИСТАННЯ ГІС-ТЕХНОЛОГІЙ ДЛЯ ГЕОДЕЗИЧНОЇ ОЦІНКИ ЗЕМЕЛЬНИХ РЕСУРСІВ ТА КАДАСТРОВОЇ ДІЯЛЬНОСТІ

Анотація. Стаття присвячена дослідженню впровадження геодезичних інновацій у сфері землеустрою та кадастрової діяльності. Розглянуті сучасні технології та їх вплив на оптимізацію та ефективність робіт у визначених сферах. Основна увага приділена методам геоінформаційних систем, їхньому застосуванню для точного картографування, аналізу даних та планування розвитку територій. Мета цієї статті полягає у дослідженні та оцінці використання новітніх геодезичних рішень у земельному та кадастровому управлінні, а також у розкритті переваг і потенціалу їх застосування для оптимізації управління земельними ресурсами. Використано: аналітичний метод, картографічний метод, математичний метод, методи цифрового автоматизованого оброблення космічних зображень. Подальші дослідження у сфері землеустрою та кадастрової діяльності можуть бути направлені на розробку нових методів обробки та інтерпретації геодезичних даних з використанням штучного інтелекту та машинного навчання, адаптацію геоінформаційних систем до потреб регіонального землеустрою, зокрема, для моніторингу змін клімату, забезпечення продовольства та водних ресурсів. Стаття може бути корисною для фахівців у галузі землеустрою, кадастру, а також для всіх, хто цікавиться інноваційними технологіями в геодезії.

Ключові слова: землекористування, зонування територій, супутникові знімки, геоінформація, географічна інформаційна система, дистанційне зондування Землі.