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IMPROVING THE METHOD OF ACCOUNTING FOR AGRICULTURAL LAND BASED ON GEOINFORMATION TECHNOLOGIES

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Annotation. Management of land resources and improvement of computer technology in land management are among the most important tasks of the state, the efficient implementation of which is inextricably related to widespread introduction of the latest achievements of the information technologies. Obviously, increasing the reliability and manageability of the infrastructure, reaching the maximum transparency of processes are vital in the area of geoinformation resources and spatial data resources. With the powerful tools of visualization, analysis and modeling, which allow bringing together the knowledge about the environment, measurements and calculations, geoinformation technologies have become widespread in various fields, and are the informational basis for decision-making. Their application to agricultural land accounting enables the systematic collection, processing, updating, and comparison of spatial and attribute data. The proposed approach improves the accuracy of land records, supports continuous monitoring of land use, identifies inefficiently used areas, and facilitates informed decisions concerning sustainable agricultural development and planning.

Keywords: land relations, geoinformation resources, spatial data, land management, agricultural land accounting, geoinformation technologies.

Introduction. Land resources form the foundation of any state's socio-economic well-being; they define and constitute the very basis of the nation. Consequently, there is currently significant interest in land as a primary source of wealth and value among all natural resources. Access to comprehensive, timely, accurate, and up-to-date information regarding land, landowners, and land users serves as a benchmark of a state's maturity and an indicator of its level of economic development. Such information enables the formulation and implementation of land policy and the monitoring of land reform processes. Furthermore, it establishes the necessary prerequisites for participating in the global system of industrial raw material production and the service sectors.

Research materials and methods. The methodological basis of the research includes works of the leading Kazakhstani, Russian and foreign authors in the area of geoinformation resources and spatial data, as well as case studies in special literature. The information-empirical and regulatory base of the research consists of Laws, Presidential Decrees, Decrees of the Government of the Republic of Kazakhstan, and normative legislative acts. To achieve the objectives, the research used general scientific methods for analytical, structural and comparative analysis, as well as statistical research methods.

Results and discussion. Currently, information systems are used in various fields of human activity. However, users quite often need to determine the spatial position of studied objects. Any spatial information system is based on the principles inherent in all information systems. Such systems are presented as automated information systems intended for displaying and analyzing natural and artificial objects located on the surface of the Earth. The spatial reference of the studied objects was used as the basis for introducing term “Geographic Information Systems”. Broadly speaking, geographic information systems are perceived as models of the real world, while in the narrow sense they are systems of accumulating and storing data hooked to the earth's surface. With that, the most promising direction in development of geoinformation systems is the ability to support the decision-making processes [1, 2].

Presently, automation in the area of geoinformation resources has reached the level that allows solving the tasks of spatial analysis, implementing keeping the graphic and attribute databases, and correcting information and printing. Thus, the main difference between geographic information resources and computer graphics is that geographic information systems, in addition to the graphical display, contain information about objects and their elements. In addition, they also ensure assessment of the area and land distribution by categories, acreage, land ownership, economic use, etc. Information about each object included into a geographic information system is stored in digital format[3, 4].

Such information may be generated, for example, with the materials of automated survey, scanning, and remote probing. Thus, the result of the operator's work depends largely on the accuracy of previously populated information. Therefore, the area and other derived parameters will be calculated by the information contained in the databases. The more accurate this information is, the more reliable result will be obtained.

The current stage of information technologies development is characterized by transition to integration of all kinds of geographic information resources. Therefore, along with the semantic information technologies, geoinformation technologies also develop rapidly, which ensure communication between users of different digital spatial data, which are usually provided together with their attribute data. Spatial data are understood as digital data about geographic objects, including information about their location, shape and properties shown in the coordinate-time system, and attribute data are properties, qualitative and quantitative characteristics of spatial objects represented in digital form [5].

Entering data into a geographic information system is an operation of reading the information from various media. Before entering into a geographic information system, the data are to be converted into digital format. This process is called "digitizing", and may be automated in modern geographical information systems through the use of scanning technology. In modern geographic information systems, relational models of data are used, which store information as tables [6].

The data about the spatial position (geographical data) and the appropriate tabular (attribute) information are generated directly by the user, or obtained from suppliers commercially or elsewise. In the geographical information systems, these data are integrated with other types and sources of information. With that, various organizations may use external, more powerful database management systems for organizing and using the available information. In order to improve the geoinformation resources based on the spatial data, analysis of lands distribution by category in the Karmakshy district of the Kyzylorda region was made in the research. Table 1 shows the data for years 2021 through 2025.

Table 1 – Land distribution in the Karmakshy district of the Kyzylorda region by category

Categories	2021		2022		2023		2024		2025	
	thousand ha	%	thousand ha	%	thousand ha	%	thousand ha	%	thousand ha	%
Agricultural land	483.5	18	486.5	18	361.5	14	362.4	14	364.0	14
Land of settlements	44.1	2	44.1	2	44.1	2	44.1	2	44.1	2
Industrial lands	2.2	-	2.4	-	4.1	-	4.0	-	4.0	-
Specifically protected territories	-	-	-	-	-	-	-	-	-	-
The lands of the Forest Fund	429.0	16	429.0	16	429.0	16	429.0	16	429.0	16
Water resource lands	10.7	-	10.7	-	10.7	-	10.7	-	10.7	-
Reserve lands	1,706.1	64	1,702.9	64	1,826.2	68	1,825.4	68	1,823.8	68
Total area	2,675.6	100	2,675.6	100	2,675.6	100	2,675.6	100	2,675.6	100

Over time, many categories have changed. Over the past five years, agricultural land decreased by 4%, the land state reserve, in turn, increased by 4%. The forest fund land has remained the same, which is particularly important in the context of Kazakhstan. Analysis of the diagram showed that the largest area in the Karmakshy district of the Kyzylorda region constituted reserve land (68%), forest fund land (16%), and agricultural land (14%) (Figure 1).

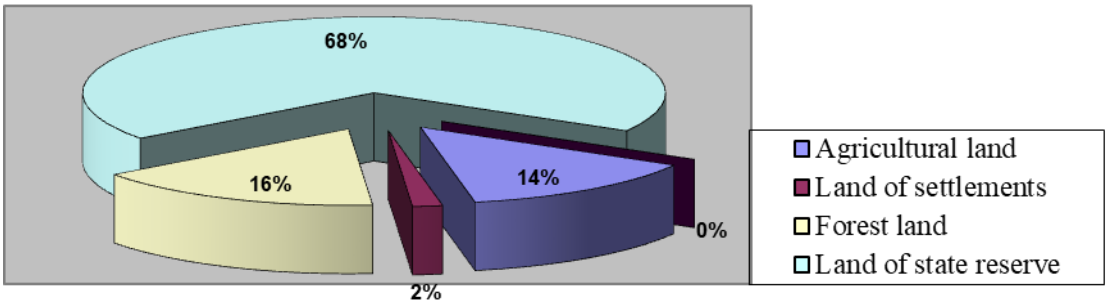

Figure 1 – Land distribution in the Karmakshy district by category (01.11.2025)

Insignificant area is occupied by settlements land, industrial land and water fund land. For generating spatial data, the Limited Liability Company “Zhanazhol” in the Karmakshy district was analyzed within the framework of this research (hereinafter referred to as "the farm").

Table 2 – Land distribution at farm “Zhanazhol” in the Karmakshy area by the type of land

Type of land	2021		2022		2023		2024		2025	
	ha	%	ha	%	ha	%	ha	%	ha	%
Arable land	3,852	30	3,910	31	3,885	30	3,885	30	3,950	31
Haylands	658	5	658	5	658	5	658	5	658	5
Lealands	5,923	46	5,865	45	5,890	46	5,890	46	5,825	45
Other lands	2,396	19	2,396	19	2,396	19	2,396	19	2,396	19
Total	12,829	100	12,829	100	12,829	100	12,829	100	12,829	100

The total area of the farm is 12,829 hectares, agricultural lands take 10,432.6 hectares, or 81%, while other land (saline soils, sands, takyrs) takes 2,396.4 hectares, or 19%. The planted acreage of the farm is 3,950 ha (Table 2). Table 2 shows that the farm has reserves for increasing arable land at the expense of lealands.

The study has shown that a considerable area of the farm is taken by rice, alfalfa of past years and alfalfa of this year. An insignificant area is taken by alfalfa for seeds, spring wheat and potato (Figure 2).

Improvement of the geographic information system based on the spatial data should include a comprehensive analysis of land use with regard to the balance of graphical and attribute data. Based on these requirements, the authors have developed a flow chart of improving the geographic information system (Figure 3).

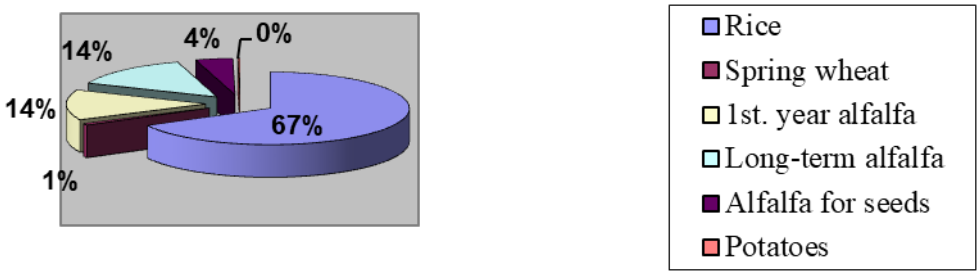

Figure 2 – Dynamics of cultivated area at the "Zhanazhol" farm in the Karmakshy district

Graphical data are used to derive the spatial data, which are considered as the decision-making process that has significant impact on the geographic information system. In order to improve geographic information system, the attribute data should be made for determining the area and distribution of land by categories, ownership, type of economic use, and for cases of qualitative and quantitative characteristics of the spatial objects.

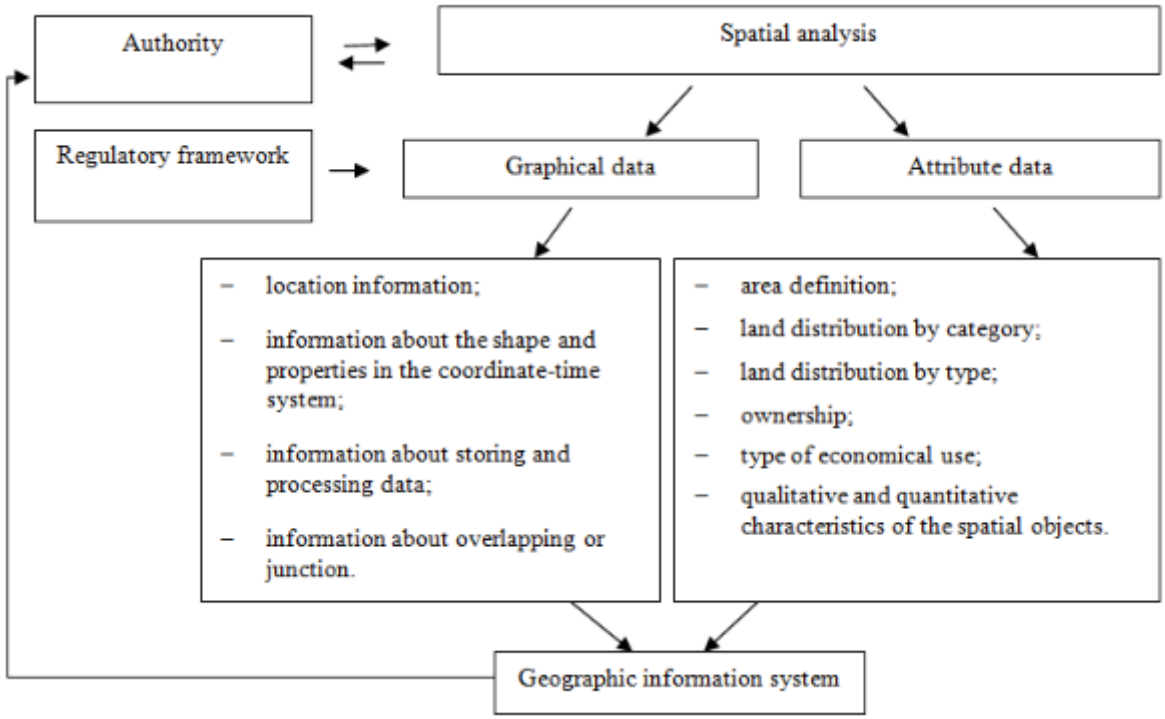

Figure 3 – Flow-chart of improving the geographic information system

A way of organizing data in a geographic information system is a layered model, the essence of which is in dividing objects into thematic layers. Objects in the layer are saved to a separate file, they have their own system of identifiers that can be referred to as a certain set. The geographic information system envisages operation of the graphical part of the data in the form of electronic maps and the attribute part of the data that contains some meaning of the map and additional information related to the spatial data, but cannot be directly plotted on the map (description of areas or the information describing the quality characteristics of object – attributes). Graphical objects and attribute data are interrelated; in particular, the graphical information is physically stored as one of the fields of the table of attributes. By manipulating the information layers and objects, by using arrays of digital maps, the user can generate the required

set of objects in the form of map coverage. The toolkit of the geoinformation system provides a possibility to use the query attribute and graphic data, and to perform simulation modeling. In addition, the built-in internal programming languages of the geographic information system allow creating native apps that contribute to solving specialized tasks [7, 8].

Geoinformation technologies may be used in land management, land registries; design, engineering, surveying and planning in urban construction; thematic cartography; facilities inventory and accounting; marine cartography and navigation; analysis of the terrain features; navigation of ground transportation; air traffic control; geology; environmental monitoring; management of environmental protection measures and natural resources [9, 10].

Forming a geographic information system based on the spatial data consists in establishing new regularities that characterize land use in relation to the needs of the society, availability of other resources, population growth, achievements of the scientific and technical progress; improvement of methods of land use analyzing, predicting and planning; determining efficiency of land use from the economic, social and environmental point of view; formulation of new tasks, problems and issues in accordance with development of the society, its production force, needs and requests for using research results in preparing forecast and planning documents.

The rational use of land resources requires full-scale improvement of land use with the growth of needs and the material-and-technical capabilities of the society. Improvement of land use is based on the ability to automate calculation of quantitative indicators of land resources, followed by their visualization, for example, automated calculation of yield and gross output from the crop rotation fields with regard to the soil and terrain conditions. Field arrangement and crop rotation work plots are planned on this basis. First, a digital model of land use is built, which includes thematic layers (topography, soils, hydrography, map of land utilization, etc.). Fields are placed upon overlaying digital maps (topographic, terrain, existing map of land use and soil map). With that, the map of the land use shows the main directions of treatment proposed on-farm roads from the fields to the production centers, and shelterbelts. The overlaying of maps in designing land use ensures the best accounting for the directions of land drainage, accounting for location of topographical features (ravines, gullies, etc.) [11, 12].

Efficient use of digital data involves availability of software tools that provide functions of data storage, description, update, etc. Depending on the types and formats of presentation, the level of software tools for a geographic information system and some characteristics of the environment and conditions of use, various options may be offered for storage and for access to the spatial data; methods of organization are different for graphical and attribute parts.

In simple software tools for a geographic information system, there are no specific tools for organizing storage, data access and handling, or these functions are implemented by means of the operating system in its file organization.

Data are stored in the geographic information systems in the form of a set of thematic layers, which are combined based on their geographical location. This flexible approach and the possibilities of geographic information systems are effective in solving any problems related to spatial information.

Components of geographic information systems are the following:

- hardware;
- software. Geographic information system software contains functions and tools required for storing, analyzing and visualizing spatial information; and
- the data are represented either in the form of ready-made maps with the required thematic layers, or in the form space and aerial images [13, 14].

Geographic information systems and spatial research are directly related to absolute and relative localization of terrain features, as well as to properties and symptoms of these features. Usually, not only localization of important geographical objects such as rivers and currents is recorded, but their size, flow velocity, water quality as well. Indeed, these characteristics often

depend on the spatial location of the terrain features. Geographic information systems help analyze and display these spatial dependencies.

Maps and plans created with the use of the geoinformation technology are products of the new generation. Digital maps and plans may be used for qualitative analysis, for example, in order to determine what lands are located on a specific land plot, or location of the most dangerous enterprises for human health. Besides, maps and plans created with the use of geoinformation technologies allow solving problems that are more complex in a quite simple way. For example, coordinates of the rotation angles of a land plot may be used for obtaining several quantitative characteristics: the area occupied by the project, the lengths of the sides, and the values of the directional angles.

The minimum set of criteria that identify each specific geographic information system forms a "system of coordinates" for the three-dimensional space, the axes of which are the territorial coverage and associated functional scale (or spatial resolution), subject area of information modeling, and problem orientation.

With all the variety of operations, goals, areas of information modeling, problem orientation, and other attributes that are typical for newly created and the existing geographic information systems, several building blocks may be separated logically and organizationally in them, which are also called modules or subsystems that perform more or less clearly defined roles. In turn, the functions of geoinformation systems are derived from four types of solved problems:

1. Collection;
2. Processing; and
3. Modeling and analysis.

Digital and electronic maps serve as the basis for creating, operating and developing geoinformation systems of various levels and topics. Modern computer technology allows fast processing and interpreting large amounts of mapping data of various purpose, content and scale. However, in order to efficiently use the maps and the information contained therein, one has to choose and apply such methods of analysis, synthesis and forecasting that will result in solving the problems [15].

The latest geoinformation technologies allow the use of computerized programs for mathematical and cartographic modeling and traditional methods of mapping implemented with the use of displays and displayed electronic maps.

Geoinformation technology is developed and refined through technical progress, and increasing spatial data. Geographic information systems are being implemented, and disclose new opportunities in the field of spatial planning and forecasting. Specialists in the field of land relations extend the use of geographic information systems to solving their specific problems, and thereby contribute to development of geoinformation technology.

Development of geographic information technologies consists in free creation of any tables to be used for generating databases. To achieve progress in the geoinformation technology, one has to widely use:

- practical implementation of e-government;
- software;
- integration of spatial data;
- development of information resources;
- improving efficiency of local government and planning;
- system accounting and inventory; and
- visibility, accessibility and accuracy of the information.

Refining a geographic information system with account to the graphical and attribute data is of great importance:

- for public authorities: obtaining visual information about land price, the status of quarters and plots; the possibility of analyzing data based on the information about the

percentage ratio of land by kind of ownership, by category; information for preparing analytical reports about efficiency of land use.

- land services: checking correspondence of the cadastral and market value; providing information services to the population and businesses.

- for businesses: obtaining information about the allowed use of land plots; forming output documentation according to standard templates, including a map of site boundaries; performing spatial analysis of the chosen land plot; creating a database about the land plot; providing information services to the population and businesses.

Conclusion. Improving geoinformation technology implies implementation and use of modern software products of the nationwide geographic information system for repeatedly tried and progressive criteria and technologies available in the world community at the moment; it will also, based on spatial information, allow for a more widespread use of land resources, based on the digital geographical and attribute data.

Based on the analysis of spatial data in case of timely and qualitative collection primary data about land resources (quality, area and land distribution), the results of land use, it is necessary to develop interrelated activities that would allow for accumulation of information and its generalization in relevant geoinformation resources at each level of the system.

Formation of geoinformation resources not only allows improving the spatial system, but also raises their informative value, which increases the interest of agricultural enterprises in them. Thus, further improvement of the spatial data by switching to automated technology will, in the end, create all favorable conditions for landowners and land users.

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ГЕОАҚПАРАТТЫҚ ТЕХНОЛОГИЯЛАР НЕГІЗІНДЕ АУЫЛ ШАРУАШЫЛЫҒЫ ЖЕРЛЕРІН ЕСЕПКЕ АЛУ ӘДІСТЕМЕСІН ЖЕТІЛДІРУ

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Аңдатпа. Жер ресурстарын басқару және жер қатынастары саласында компьютерлік технологияларды жетілдіру мемлекеттің аса маңызды міндеттерінің бірі болып табылады. Бұл міндеттерді тиімді жүзеге асыру ақпараттық технологиялардың заманауи жетістіктерін кеңінен енгізумен тікелей байланысты. Инфрақұрылымның сенімділігі мен басқарылуын арттыру, сондай-ақ үдерістердің барынша ашықтығын қамтамасыз ету геоақпараттық ресурстар мен кеңістіктік деректерді басқару саласында ерекше маңызға ие. Геоақпараттық технологиялар визуализациялау, талдау және модельдеудің қуатты құралдарын ұсынады. Олар қоршаған орта туралы мәліметтерді, өлшеу нәтижелері мен есептеулерді бірыңғай ақпараттық ортада біріктіруге мүмкіндік береді. Сондықтан бұл технологиялар әртүрлі салаларда кеңінен қолданылып, негізделген басқарушылық шешімдер қабылдаудың маңызды ақпараттық базасы ретінде қызмет етеді. Геоақпараттық технологияларды ауыл шаруашылығы жерлерін есепке алуда қолдану жер туралы ақпараттың дәлдігін, тиімділігін, қолжетімділігі мен ашықтығын арттыруға, сондай-ақ жер ресурстарын орнықты басқаруды қамтамасыз етуге мүмкіндік береді. Оларды ауыл шаруашылығы жерлерін есепке алу саласында қолдану кеңістіктік және атрибутивтік деректерді жүйелі түрде жинауға, өңдеуге, жаңартуға және салыстыруға мүмкіндік береді. Ұсынылған тәсіл жер-есептік мәліметтердің дәлдігін арттырады, жердің пайдаланылуына үздіксіз мониторинг жүргізуді қамтамасыз етеді, тиімсіз пайдаланылатын аумақтарды анықтауға мүмкіндік береді және ауыл шаруашылығын тұрақты дамыту мен жоспарлау саласында негізделген шешімдер қабылдауға ықпал етеді.

Тірек сөздер: ауыл шаруашылығы жерлері, жерді есепке алу, жер қатынастары, геоақпараттық технологиялар, геоақпараттық ресурстар, кеңістіктік деректер, жер ресурстарын басқару, ауыл шаруашылығы жерлерін есепке алу, геоақпараттық технологиялар.

СОВЕРШЕНСТВОВАНИЕ МЕТОДИКИ УЧЁТА ЗЕМЕЛЬ СЕЛЬСКОХОЗЯЙСТВЕННОГО НАЗНАЧЕНИЯ НА ОСНОВЕ ГЕОИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ

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Аннотация. Управление земельными ресурсами и совершенствование компьютерных технологий в сфере земельных отношений относятся к числу важнейших задач государства. Эффективное решение данных задач непосредственно связано с широким внедрением современных достижений информационных технологий. Повышение надёжности и управляемости инфраструктуры, а также обеспечение максимальной прозрачности процессов имеют особое значение в области управления геоинформационными ресурсами и пространственными данными. Геоинформационные технологии предоставляют широкие возможности для визуализации, анализа и моделирования. Они позволяют объединять сведения об окружающей среде, результаты измерений и расчётов в единой информационной среде. Поэтому данные технологии широко применяются в различных сферах и служат важной информационной основой для принятия обоснованных управленческих решений. Использование геоинформационных технологий при учёте земель сельскохозяйственного назначения позволяет повысить точность, эффективность, доступность и прозрачность земельной информации, а также обеспечить устойчивое управление земельными ресурсами. Их применение для учета земель сельскохозяйственного назначения обеспечивает систематический сбор, обработку, обновление и сопоставление пространственных и

атрибутивных данных. Предлагаемый подход повышает точность земельно-учетных данных, обеспечивает непрерывный мониторинг использования земель, позволяет выявлять неэффективно используемые территории и способствует принятию обоснованных решений в области устойчивого развития и планирования сельского хозяйства.

Ключевые слова: земли сельскохозяйственного назначения, учёт земель, земельные отношения, геоинформационные технологии, геоинформационные ресурсы, пространственные данные, управление земельными ресурсами, учет земель сельскохозяйственного назначения, геоинформационные технологии.