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GIS TECHNOLOGIES FOR CADASTRAL MONETARY VALUATION OF URBAN LANDS TO ACHIEVE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

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SUMMARY

Mass (cadastral) monetary valuation of land is one of the most relevant and crucial tasks in Russia and Commonwealth of Independent States (CIS) countries. This study aimed to analyze the feasibility and advantages of conducting cadastral monetary valuation of urban land using GIS technologies. The presented research, employing the content-analysis method and experts' survey, reviewed key theoretical concepts related to the use of GIS technologies in land valuation. Moreover, it proposed an algorithm for classifying cadastral monetary valuation of urban land with GIS application, identifying the key activities where GIS technologies significantly enhance the land valuation. The study found that strict adherence to requirements and standards by executors and using GIS technologies in land valuation ensures the following: a) comprehensive information about the state land cadaster; b) timely and high-quality service delivery; and c) optimization of the workforce involved in land management and valuation. In conclusion, in the monetary valuation of urban lands, GIS technologies offer significant advantages, including automation, reduced project timelines with improved quality documentation, unlimited reproducibility of valuation results, and standardization of project materials.

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Keywords: Urban land, urban land valuation, cadastral valuation, geographic information system (GIS), GIS technologies

Key findings: In the cadastral monetary valuation of urban lands, the integration of GIS technologies enhanced efficiency and accuracy. It automates data processing, reduces project completion times, and makes it more beneficial for optimizing land management and valuation processes.

INTRODUCTION

Mass (cadastral) monetary valuation of land serves as an integral characteristic that encompasses quantitative, qualitative, economic, legal, regional, and other indicators of land. In urban areas, it provides a foundation for systematization of data at the general accounting level and for specific land districts (Ivanov *et al.*, 2019). Additionally, it facilitates the factual determination of rental rates for individuals and legal entities and planning for current and future layouts (Epishina and Nikolaev, 2008). Cadastral monetary valuation establishes the regulatory framework for land and property relations and determines a tax base for property taxation (Nosov and Bondarev, 2013).

Currently, most land management and valuation documentation developers primarily utilize GIS technologies for graphical representation of existing data (Tyrova and Kutliyarov, 2017). Past studies enunciated that geographic information technologies in land valuation in Russia revealed most organizations still rely on traditional technologies, using computers only for technical documentation (Kudinova and Andreeva, 2012). The said situation stems from several factors, including a lack of necessary software and technical infrastructure within organizations responsible for land valuation projects in urban areas (Yarotskaya and Patov, 2016), insufficient funding for such projects (Zelman, 2017), and a low level of geoinformation literacy (Khodakovsky, 2016). Therefore, the regional and local land management bodies mainly receive customarily executed projects, consisting of paper maps of economic-planning zones and the zones affected by local environmental factors (Pylaeva, 2020). This considerably complicates the valuation of lands in medium and urban areas (Kotlyarov, 2012).

For data processing, the design of modern information technologies served to solve well-structured tasks with known input/output data and establish the algorithm procedures (Baranovich and Chichkalo, 2023). Such developments sought to automate routine, repetitive tasks in both professional and managerial workflows, applied at the operational level of personnel activities (Pylaeva and Emelyanova, 2016). Therefore, the implementation of current information technologies at this level significantly enhanced the work quality and personnel productivity, reducing the burden of routine tasks and optimizing qualified staff involved in preparing land management and valuation documentations (Kurakpayev and Mashanov, 2016).

This article aimed to analyze the feasibility and advantages of conducting cadastral monetary valuation of urban lands using GIS technologies. This article attempted to answer the two research questions: a) What is the algorithm for cadastral monetary valuation of urban land using GIS technologies? and b) What are the main activities involved in land valuation using GIS technologies?

Literature review

The systematic geographic information system (GIS) allows combining a model representation of a territory (electronic representation of maps, schemes, satellites, and aerial images of the Earth's surface) with statistical data and economic indicators (Raklov, 2011). It is a computer-based system that enables the storage, editing, analysis, and visualization of geographic data (Karpik, 2014; Sagandykova *et al.,* 2024).

Land valuation projects utilize the quantitative and qualitative characteristics, soil quality maps, cadastral zoning maps, master plans, and urban planning and development projects. The valuation projects also consider historical, cultural, functional, sanitary-ecological, and engineering-geological zoning (Ivanenko, 2009; Makhotlova *et al*., 2021). By performing a valuation of an individual land plot (as an ultimate goal of valuation), using GIS includes the available electronic map of the urban area (vector or raster) (Beshentsev, 2022), graphic data on zoning, local factors influencing zones, arable soil groups (Zhunisova, 2021), and data based on land registration systems (Yarotskaya and Patov, 2017; Mustafayeva *et al.,* 2024).

With available data, the system user can determine the value of land plots with different functional uses at any point on the urban area's electronic map, listing the local factors influencing the valuation (Akbasheva and Shafieva, 2018; Abbas *et al.,* 2023). Similarly, it can formulate the value of an unoccupied polygon, considering its location relative to influencing factors (Simakov *et al*., 2022), and determine the land plot value owned by a legal person. With a database, one can generate a valuation report (Karmanov *et al*., 2015; Chowhan *et al*., 2023).

End-to-end geoinformation development ensures information sharing among participants primarily involved in electronic form, using computer-based methods for recording the initial data and valuation results during execution (Makarova *et al*., 2018) and transmitting results to land resource management and tax administration authorities (Tyrova and Kutliyarov, 2017; Vasilyev *et al.*, 2023). This technology enables the efficient use of land valuation results for automated calculation of land payments based on its functional use and local influencing factors, as well as monitoring of monetary valuation and forecasting budget revenues in land payments (Nguyen *et al*., 2021).

The GIS advantage in land valuation lies in time savings, as well as in its ability to integrate with other urban planning tasks, such as master planning and urban land privatization schemes (Makhotlova *et al*., 2022). The GIS technology used in the urban land valuation highlights significant advantages, including the automation of these tasks and its application-related benefits (Akhmedova, 2019). These advantages manifested in a 2-to-3 times reduction in work completion time (Vasiliev, 2016), improved quality of project documentation (Kuryachaya and Romanova, 2016; Abadi *et al.,* 2024), virtually unlimited reproducibility of valuation results, and standardization of the project materials (Gavrilenko, 2019).

Thus, the relevance of this study and the formulation of the problems lie in improving the efficiency of cadastral monetary valuation of urban lands through GIS technologies. The novelty of the presented work lies in describing the possibilities of using GIS technologies to conduct cadastral monetary valuation of urban lands, which significantly improve the quality of valuation. As practice shows, the additional costs associated with GIS technologies for valuation are offset almost 2-3 times by the benefits achieved through the development of multipurpose geoinformation resources for the city as digital maps, digital orthophotos, and the database utilizing land data resources (Ershova, 2019; Lu *et al.,* 2024).

MATERIALS AND METHODS

Research approach

Following the described approach to using the GIS technologies in urban land valuation, a qualitative-quantitative research methodology was the option. The employment of in-depth interview methodology helped develop an effective mechanism for cadastral monetary valuation of urban land using GIS technologies and identify the main activities involved in land valuation with GIS. These interviews included specialists in cadastral land valuation and GIS technology application in several regions of the Russian Federation, such as the Vologda and Tyumen regions, Republic of Tatarstan.

However, it is pivotal to consider that this method has certain limitations. Hence, the authors clarified the primary objective of the study is to generate qualitatively new knowledge about the specific methodology of urban land valuation. However, the limited resources available to the researchers and the desire to conduct further studies on this issue have encouraged the publication of obtained results. Therefore, the said study aimed at engaging interested researchers and fostering discussion within the scientific community and professionals in land management.

Empirical context

In accordance with Federal Law No. 237 'On State Cadastral Valuation' dated July 03, 2016, the cadastral valuation of urban land proceeded (hereinafter referred to as the Law on SCV) and the Methodological Guidelines for State Cadastral Valuation No. 226 dated May 12, 2017. Before carrying out the study, a clarification ensured that cadastral valuation of land plots in the category of 'urban land' had already progressed multiple times in the regions under consideration.

For instance, in the Vologda Region, the conduct of cadastral valuation of urban lands transpired in 2019 and 2022, with the state cadastral valuation for all the categories of land carried out simultaneously. The 2022 state cadastral valuation results have been serving for tax purposes since January 01, 2023. In the Tyumen Region, the cadastral valuation of land plots within the urban land category took place in 2021, followed by the state cadastral valuation for all land categories in 2022. Similarly, in 2021, the state cadastral valuation occurred for urban land plots in the Republic of Tatarstan, and in 2022, for all land plots recorded in the Unified State Register of Real Estate.

In line with this study’s objectives, the random selection of web pages of state budgetary institutions (SBIs) ensued in the regions under consideration via Google.com. These institutions were responsible for cadastral valuation of lands:

- The Budgetary Institution in the field of State Cadastral Valuation of the Vologda Region—Bureau of Cadastral Valuation and Technical Inventory,
- The State Budgetary Institution of the Tyumen Region—Center for Cadastral Valuation and Storage of Registration and Technical Documentation, and
- The State Budgetary Institution—Center for State Cadastral Valuation, Republic of Tatarstan.

The sending of email communications also succeeded to the leadership of these SBIs, outlining the purpose and program of the study. The SBI leadership agreed to provide the necessary information for the study and confirmed their participation, pledging to share all the relevant data required for the presented research.

Data collection

Based on the study objectives, the selection of scientific sources using the Russian Science Citation Index (RSCI) was applicable, as well as international databases, such as Web of Science and Scopus. The selection relied on the keywords, viz., sustainable tourism, human capital, green technologies, and green human resources, both in English and Russian languages, with a publication date restriction of no more than 15 years. Data collection took place from November 10, 2023, to February 10, 2024, through field and desk research.

The field research focused on analyzing the prospects of using GIS technologies in urban land valuation and included nine in-depth interviews with directors of SBIs, heads of the various departments (subdivisions) for state cadastral valuation, and heads of departments (subdivisions) for cadastral work. All interviews helped gather information on the existing algorithm for cadastral monetary valuation of urban lands employed by the SBIs.

Interviewers introduced themselves at the beginning of each interview, explained the purpose of the study, and asked open-ended questions designed to explore perspectives, opinions, and existing practices within SBIs related to the research problem. Each interview lasted an average of 25–30 minutes. The data obtained from the interviews served to identify the problems associated with cadastral monetary valuation of urban lands.

These findings ultimately contributed to the development of an algorithm for such valuation using GIS technologies and understanding the key activities involved in land valuation via GIS technologies. The desk research involved analyzing reports and valuation methodologies provided by the organizations via email.

Data analysis

During the field study, interview recordings' transcription used the service zapisano.org. The collected data, as classified into homogeneous themes, further enhanced the comparability of the obtained information. After transcribing the recordings, a communication sent via email to the respondents requested them to rank the types of activities involved in urban land valuation using GIS technologies—identified during the study—on an ordinal scale by assigning points based on their level of significance. Then, each activity received a rank according to the points given by the respondents.

Ensuring an effective data analysis had the degree of agreement among the respondents' opinions measured through mathematical processing using Kendall's coefficient of concordance (W). The information's further processing determined the weights of the identified activities by constructing a rank transformation matrix and subsequently calculating the arithmetic mean of the individual weights for each activity. The final weight values defined the significance of each activity from the perspective of the SBI leadership.

In the data analysis process, the use of the triangulation method helped ensure the validity and reliability of the obtained empirical research results. Triangulation involved multiple researchers from different regions and countries, each participating in data processing. Following this, discussions occurred for each research question, with information agreed upon by all the research participants included in the report. This triangulation process enhanced the reliability of the interview data regarding their accurate reflection of the state of GIS technology application in cadastral land valuation and improved the quality of the information obtained. Documenting the results derived from the study succeeded in the research report.

RESULTS AND DISCUSSION

Based on the field study (in-depth interviews), the cadastral monetary valuation of urban lands using GIS technology led to developing an algorithm (Table 1). From field study results, the key activities defined where GIS technologies significantly enhanced the quality of land valuation were notable (Table 2). The experts identified five main stages based on the cadastral monetary valuation of urban lands using GIS technology (Table 1).

The first four stages encompass the work of design and research organizations that carry out urban land valuation projects. The fifth stage involves the use of results from the previous stages by regional and local land resource management authorities to assess the value of land plots for specific land users and to determine land payment amounts. During the development of digital cartographic databases for the city's territory, a digital map database' generation was successful, consisting of layers of a digital vector map at the scale of 1:10,000 or 1:5,000 and the raster plan at a scale of 1:2,000. Based on the city's master plan, the development of thematic layers for functional zones, major facilities, engineering network highways, and planning restriction zones succeeded.

The SBI leadership has outlined the key methodological requirements for the electronic map developed for urban land valuation:

- The electronic map requires development in a national/local coordinate system based on the vector model representing the urban area within its existing boundaries.
- During the raster model vectorization, the following informational layers need creation:
  - Existing urban boundary (polygonal and linear object),
  - Axial streets and highways (linear objects),

Table 1. Algorithm for cadastral monetary valuation of urban land using GIS technology.

Stages	Description
I	Development of digital cartographic data bases for the city's territory.
II	Collection and analysis of market information on valuation objects and justification for selecting a valuation model for cadastral value.
III	Functional zoning of the territory.
IV	Cadastral monetary valuation of land for various functional uses.
V	Determination of the land plot value using GIS technology.

Table 2. Key activities in urban land valuation using GIS technologies.

No.	Activities	Rank	Weight
1	Automated collection, processing, and systematization of source data (both cartographic and semantic)	1	0.37
2	Analysis of obtained information (application of spatial analysis methods for calculating areas, lengths, perimeters; use of overlay and buffer analysis to determine factor density; creation of cartograms and cartodiagrams for determining integrated quality indices of the territory; application of the isoline method for interpolation of results)	2	0.27
3	Searching, sorting, and extracting valuation results of individual land plots	3	0.22
4	Preparation and printing of valuation results using printers and plotters	4	0.14

Note: Compiled based on expert surveys; the Kendall coefficient of concordance W=0.70W = 0.70W=0.70 ($p < 0.01$), indicating strong agreement among expert opinions.

- Residential quarters, including multi-apartment, private, and mixed types (polygonal object),
- Quarters for dacha and garden communities (polygonal object),
- Quarters for public use (polygonal object),
- Recreational areas, including sanatoriums and resorts (polygonal object),
- Industrial zones (polygonal object),
- Utility and storage areas (polygonal object),
- Water surfaces (polygonal and linear objects),
- General and special-purpose green spaces (polygonal object),
- Railway rights-of-way (polygonal object),
- Railway tracks, including those in industrial and utility areas (linear object),
- Airport and airfield areas (polygonal object), and
- Special-purpose areas, such as military facilities, labor colonies, customs zones, and border strips (polygonal object).

The presence of these layers is a necessary condition for converting the developed digital electronic map.

A crucial aspect of GIS-based land valuation is the creation of a digital model of the planning framework of the target area, referred to as the base map and the city's topographical framework. The base map description was a set of the framework elements of the locality (Epishina and Nikolaev, 2008). These elements include:

- Urban boundary,
- Citywide and district-level highways,
- Street axes,
- Railway rights-of-way boundaries,
- Natural barriers (rivers, streams, canals, and ravines), and
- In some cases, boundaries of industrial enterprises, green spaces, and recreational zones.

However, during the execution of work, a diligent developer of documentation often faces the issue of the relevance of the planning and cartographic base. Several materials were outdated, and their updating requires considerable financial resources, depending on their complexity category (Karpik, 2014). In collecting and analyzing information on the market for valuation objects and justifying the choice of a cadastral valuation model, using GIS helped determine the metric characteristics of the structures and engineering communications to estimate the costs for development and improvement of the territory.

During functional zoning of the urban area, cadastral value differentiation was within the urban area based on functional zones, depending on the heterogeneity of the territory's functional and planning qualities. However, the land valuation structuring of the city's territory was the primary task. The digital model of valuation district boundaries reached development by applying GIS tools, employing the framework elements of the topographical base model, and the digital layers of the city's master plan (Makhotlova *et al*., 2021).

Performing qualimetric valuation of district areas used indicator groups that characterize their transport-functional convenience, level of engineering infrastructure, environmental quality, and socio-urban attractiveness. The GIS-based geographic analysis and spatial modeling methods were widely applicable for this purpose. For instance,

- Transport-functional convenience evaluation utilized gravitational modeling to determine district accessibility and account for travel time between districts via the city's transport network. A digital segment-node model of the city's road and transport network, as developed, automatically generated a graph-topological model for formulating the travel times between districts and assessing accessibility.
- Engineering infrastructure levels, determined through spatial analysis, evaluated the density of engineering networks and conditions for connecting new consumers within valuation districts.
- Environmental quality assessment engaged overlay analysis, and overlapping district territories with environmentally polluted zones.

The GIS use for evaluating intermediate and final results through thematic maps of valuation districts by baseline indicators significantly enhanced the quality of outcomes. The errors become evident due to an obvious spatial representation of the results (Raklov, 2011). The outcome determined the price zones and justification and valuation indicators based on the analysis of qualitative gauges of adjacent valuation districts and merging similar-quality districts into zones. The GIS automatically generates price zone boundaries by merging adjacent valuation districts with similar consumer qualities, using predefined programmatic and dialog-based inputs.

For different functional uses, the land's evaluation within functional zones of the urban area continued through cadastral monetary valuation. Using GIS, digital maps of influence zones for territorial-planning, engineering-geological, historical-cultural, natural-landscape, sanitary-hygienic, and engineering-infrastructure local factors succeeded production, along with a database of corresponding coefficients for distinguishing the land plot valuations within functional zones.

The GIS functions as a computer-aided design system used for designing influence zone boundaries for local factors. Buffer zone methods' application was successful, such as the creation of pedestrian accessibility, sanitary protection, conservation zones, and using terrain modeling to automate the identification of areas with slopes exceeding 20% (Makarova *et al*., 2018). The GIS's quality and efficiency surpassed the traditional methods by several orders of magnitude. Most importantly, the GIS develops a geoinformation resource on digital media, essential for automating the final stage—the practical application of preliminary results for monetary valuation of thousands of individual land plots in medium and large cities (Kurakpayev and Mashanov, 2016; Ahmad *et al.,* 2023).

In the final stage, the value of a land plot with a specific functional use reached establishment based on spatial analysis of the land plot's location within the functional zone relative to the influence zones of local factors. The GIS application is particularly effective because it involves the valuation of thousands of land plots in each urban area. A critical aspect of this stage was the development of a specialized geoinformation resource—a geocoded city address registry in the form of a database containing street names, house numbers (land allotments), and centroid coordinates for spatial address identification. Given the labor-intensive nature of conducting a comprehensive inventory of land plots and developing a database of their boundary coordinates, the geocoded address registry allows for sufficiently accurate monetary valuation of land plots using GIS tools.

In cadastral monetary valuation, the resulting maps must include the following mandatory thematic layers:

- Functional zones (polygonal objects with attributes: zone number, area in km², and standard monetary valuation per m² in rubles),
- Zones of influence of local valuation factors—a separate layer for each factor (polygonal object with attributes: factor name, influence zone radius in meters, and local factor coefficient value), and
- All cadastral valuation maps must also display:
  - The projected boundary of the urban area, if included in approved urban planning documentation (polygonal and/or linear object),
  - Functional zone boundaries (polygonal object), and
  - Functional zone numbers.

Each informational layer must include semantic information. For example, for linear objects (highways, roads, and streets), this information requires the street name and its width, and for planar objects (industrial and utility-storage facilities), they also include the name, address, and dimensions of the sanitary protection zone. For urban land valuation, the geoinformation technology principles laid out in the presented research implementation can be in a software-methodological complex comprising the following components:

- A software suite for functional zoning of the territory and mass monetary valuation of urban lands,
- A terrain modeling software processor,
- An information-analytical system for developing and maintaining the urban land cadastre, and
- A subsystem for land plot valuation based on spatial analysis of local factor influence and monitoring of monetary land valuation in urban areas.

The complex integrates with widely used GIS tools, such as the MapInfo Professional 5.0 GIS package, thanks to its ease of use and functional capabilities, which help address issues related to thematic map development. Key advantages of MapInfo 5.0 include:

- An integrated SQL query language,
- Support for various raster formats (GIF, JPEG, TIFF, PCX, BMP, TGA, and BIL),
- A universal translator for importing maps developed in other GIS and CAD formats,
- The ability to work with data in multiple formats (Excel, Access, xBase, Lotus, and text files), and
- Access to remote databases.

An open system with the MapBasic programming language allows users to develop custom GIS solutions within MapInfo for addressing the specific applied tasks.

CONCLUSIONS

Systematic use and processing of various sources of information on the current state of urban land, along with the development of electronic vector maps using GIS technologies, enable practitioners to eliminate issues related to incorrect use of initial information by determining the cadastral value of urban lands. The GIS technology application in the monetary valuation of urban lands highlights the considerable advantages, including reduced project completion times, improved quality of project documentation, virtually unlimited reproducibility of valuation results, and standardization of project materials. Despite its theoretical and practical contributions, the promising study has partial limitations due to the size and localization of the expert pool (SBI leadership), which prevents broader generalizations. The specific features of cadastral monetary valuation of urban lands using GIS technologies require further investigation, with a potentially expanded expert pool that includes practitioners and broader geographic coverage. Authors also authenticate the need for parallel research on this issue. A promising direction for future research could involve the development and testing of a software-methodological complex for urban land valuation.

REFERENCES

Abadi HH, Mohamadi-Nejad A, Gilanpour O (2024). Investigating factors affecting the development of contract farming. Case study: Tomatoes in Kermanshah Province. *Braz. J. Biol.* 84. https://doi.org/10.1590/1519-6984.281760.

Abbas M, Aleem M, Altaf A, Akram MW, Butter NA, Raza HA (2023). Delineation of water quality aspects through water quality index using GIS and statistical approach in Faisalabad. *J. Glob. Innov. Agri. Sci*. 11(3): 38-39. https://doi.org/10.29214/GIJAS/11.1010.

Ahmad TM, Haider MS, Randhir TO, Randhir R, Ahmad SR (2023). Spatial analysis of factors influencing bacterial leaf blight in rice production. *Braz J Biol.* Mar 17, 2023; 83:e264249. doi: 10.1590/1519-6984.264249. PMID: 36946787.

Akbasheva AS, Shafieva ET (2018). GIS and land cadastre. *Ekonomika i Sotsium* 11(54): 82-86.

Akhmedova DM (2019). GIS information basis for solving the tasks of the land cadastral. In: Computer technologies and modeling in science, engineering, economics, education, and management: Trends and development. Materials of the International Scientific and Technical Conference. Dagestan State Technical University, Makhachkala, pp. 213-215.

Baranovich AY, Chichkalo LS (2023). Use of GIS technologies in the management of land and property complexes. *Molodoy ucheny* 50(497): 8-10.

Beshentsev AN (2022). Geographic Information Technologies in Land Resource Management: Textbook. IPR Media, Moscow, pp. 104.

Chowhan S, Ghosh SR, Akter S, Hossain MAE, Chakraborty T, Rahman MM, Akter N, Roy S (2023). Agro-product transportation systems and its subsequent development. *Int. J. Agri. Biosci*. 12(4): 245-251. https://doi.org/10.47278/journal.ijab/2023.071.

Epishina ED, Nikolaev BA (2008). Building a model for determining the value of land plots based on location. *Imushchestvennye Otnosheniya v RF* 7: 68-80.

Ershova MS (2019). Use of GIS technologies for solving urban cadastre management tasks. *Sovremennye Naukoemkie Tekhnologii* 10-2: 195-195.

Gavrilenko DY (2019). Features of GIS technologies in land cadastre management. In: Innovative prospects of Donbass. Materials of the 5th International Scientific and Practical Conference. Donetsk National Technical University, Donetsk, pp. 123-129.

Ivanenko DE (2009). Cadastral value of a land plot: Mass and individual valuation. In: Financial education throughout life - a foundation for innovative development of Russia. Materials of the 1stInternational Internet Conference. Rostov State University of Economics, Rostov-on-Don, pp. 35-36.

Ivanov NI, Pylaeva AV, Sevostyanov AV (2019). Systemic contradictions and problems of cadastral real estate valuation. *Zemleustroystvo, Kadastr i Monitoring Zemel* 3:42-47.

Karmanov AG, Knyshev AI, Eliseeva VV (2015). Geographic Information Systems for Territorial Management: Textbook. ITMO University, St. Petersburg, pp. 121.

Karpik AP (2014). Methodological and technological foundations of geoinformation support of territories: Monograph. SGGA, Novosibirsk, pp. 260.

Khodakovsky EM (2016). Geographic information system as a knowledge base for managerial decision-making. *Metody Menedzhmenta Kachestva* 8: 36-39.

Kotlyarov MA (2012). Cadastral valuation of urban land as an indicator of territorial attractiveness (example of Sverdlovsk region). *Vestnik UrFU. Seriya Ekonomika i Upravlenie* 1: 115-125.

Kudinova AV, Andreeva AY (2012). Use of sectoral municipal GIS for solving spatial and analytical territorial management tasks. *Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i Aerofotos'emka* 6: 97-99.

Kurakpayev OT, Mashanov AA (2016). The possibility of using GIS technology in land management and land cadastre. *Vestnik Kyrgyzsko-Rossiyskogo Slavyanskogo Universiteta* 16(5): 154-156.

Kuryachaya EA, Romanova MA (2016). Application of geographic information systems in land management and cadastre. In: Current problems of land reclamation, cadastre, and land use. Materials of the International Scientific and Practical Conference dedicated to the 95th anniversary of the Faculty of Land Reclamation and Cadastre at VSAU. Voronezh State Agrarian University named after Emperor Peter I. Voronezh, pp. 152-155.

Lu S, Kong L, Liu Y, Zhang Q, Zhang D, Wang MJ (2024). Refined assessment of thermodynamic effects of urban green spaces based on GIS technology and optimization of their layout strategy. *Int. J. Heat Technol*. 42(6): 2008-2018. https://doi.org/10.18280/ijht.420618.

Makarova KP, Levina YB, Zarubin OA (2018). Use of GIS technologies for modeling the spatiotemporal structure of urban development. In: Spatial organization of society: Theory, methodology, practice. Proceedings of the International Scientific and Practical Conference. Perm State National Research University, Perm, pp. 67-71.

Makhotlova MSh, Balkizov AB, Bekanova RR, Beppaeva DI, Nyrova RN, Tkhashokova SV (2022). Application of GIS technologies in the field of cadastre on the territory of urban lands. *Moskovskiy Ekonomicheskiy J.* 9: 46-56. https://doi.org/10.55186/2413046X_2022_7_9_528.

Makhotlova MSh, Chechenova AA, Miziev ZI, Khabylova AZ (2021). Land management and territorial development management using GIS. *Agrarnoe i Zemel'noe Pravo* 1(193): 88-91. https://doi.org/10.47643/1815-1329_2021_1_88.

Mustafayeva F, Elnural H, Jeyhuna H, Afsana A, Abbasova FG, Gasmova T, Izabella T, Musa BA, Tarana SB (2024). Geospatial inventory of the Galakand forestry area utilizing GIS database and remote sensing techniques. *J. Glob. Innov. Agri. Sci.* 12(1): 61-66. https://doi.org/10.29214/GIJAS/12.126.

Nguyen CT, Phan TQ, Alekseev AS, Chernikhovsky DM, Lyubimov AV, Sergeeva VL (2021). Analysis of land use dynamics in urbanized area using remote sensing materials, GIS-technologies and mathematical modeling. *Trudy SPbNIILKh* 2: 39-53. https://doi.org/10.21178/2079-6080.2021.2.39.

Nosov SI, Bondarev BE (2013). Cadastral land valuation: Methodology of calculations and expertise of results. *Imushchestvennye Otnosheniya v RF* 7(142):6-17.

Pylaeva AV (2020). Cadastral land valuation in the system of organizational and economic measures regulating land and property relations. *IOP Conf. Ser.: Earth Environ. Sci.* 579: 012133. http://dx.doi.org/10.1088/1755-1315/579/1/012133.

Pylaeva AV, Emelyanova MA (2016). Selection of valuation companies for cadastral valuation of real estate objects in the Russian Federation. *Vestnik Tomskogo gosudarstvennogo universiteta. Ekonomika* 4(36): 95-109. https://doi.org/10.17223/19988648/36/9.

Raklov VP (2011). Cartography and GIS: A textbook. Konstanta, Moscow; Kirov, pp. 214.

Sagandykova D, Ussipbayev G, Khassamdinova E, Omarbekova A, Jangarasheva N (2024). Scientific foundations of application of new effective technologies in land surveying studies (On the example of Talgar District, Almaty Region). *Instrum. Mesure Métrol*. 23(3): 183-191. https://doi.org/10.18280/i2m.230301.

Simakov AV, Simakova TV, Evtushkova EP, Ratsen SS, Starovoitova ES, Konoplin MA, Soloshenko AI (2022). GIS technologies in land management and cadastre. State Agrarian University of the Northern Trans-Ural, Tyumen, pp. 254.

Tyrova AS, Kutliyarov AN (2017). Use of GIS-technologies in land management and a land cadastre. In: V.A. Tarbaev (editor). Upravlenie ob'ektami nedvizhimosti i razvitiem territorii. OOO - Tsentr sotsial'nykh agroinnovatsiy SGAU, Saratov, pp. 352-355.

Vasiliev VN (2016). Review of existing GIS. *Molodoy Ucheny* 14(118): 62-66.

Vasilyev GS, Kuzichkin OR, Surzhik DI, Koskin AV (2023). Control and stabilization of the spatiotemporal distribution of climatic parameters at agricultural facilities using thermoelectric systems. *Int. J. Agri. Biosci*. 12(4): 228-233.

Yarotskaya EV, Patov AM (2016). Problems of GIS application in municipal land resource management. In: Information technologies in economics, business, and management. Materials of the 3rd International Scientific and Practical Conference. Derzhavin Tambov State University, Tambov, pp. 255-261.

Yarotskaya EV, Patov AM (2017). The use of geographic information systems in land use planning and cadastre for land resource management at the municipal level in the Karachay-Cherkess Republic. *Natsional'nye interesy: Prioritety i Bezopasnost* 4: 660-670.

Zelman OS (2017). Analysis of GIS applications in real estate cadastre. *Novaya Nauka: Problemy i Perspektivy* 1(2): 137-140.

Zhunisova KE (2021). Application of GIS technologies in land cadastre management. In: Research by young scientists. Materials of the 20th International Scientific Conference. Molodoy ucheny, Kazan, pp. 20-22.