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PROSPECTS OF APPLYING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE LAND CADASTRE SYSTEM

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Abstract: This article examines the current state, challenges, and future prospects of applying artificial intelligence technologies in the land cadastre system. The role of artificial intelligence in land resource management, improving cadastral data accuracy, processing remote sensing data, automating land control, and integrating with geographic information systems is highlighted. The study also identifies major challenges related to data quality, insufficient digitalization, workforce competencies, and technological infrastructure, while proposing practical solutions for improving the efficiency of land cadastre systems.

Keywords: artificial intelligence, land cadastre, land resource management, geographic information systems, remote sensing, digital cadastre, land control, automation, land monitoring.

Аннотация: В данной статье рассмотрены современные направления применения технологий искусственного интеллекта в системе земельного кадастра, существующие проблемы и перспективы развития. Освещается роль искусственного интеллекта в управлении земельными ресурсами, повышении точности кадастровых данных, обработке данных дистанционного зондирования, автоматизации земельного контроля и интеграции с геоинформационными системами. Также анализируются проблемы качества данных, недостаточного уровня цифровизации, подготовки кадров и технологической инфраструктуры, а также предлагаются пути их решения.

Ключевые слова: искусственный интеллект, земельный кадастр, управление земельными ресурсами, геоинформационная система, дистанционное зондирование, цифровой кадастр, земельный контроль, автоматизация, мониторинг земель.

Annotatsiya: Mazkur maqolada yer kadastri tizimida sun’iy intellekt texnologiyalarini qo‘llashning bugungi holati, mavjud muammolar hamda istiqbolli yo‘nalishlari tahlil qilingan. Yer resurslarini samarali boshqarish, kadastr ma’lumotlarining aniqligini oshirish, masofadan zondlash ma’lumotlarini qayta ishlash, yer nazoratini avtomatlashtirish va geoaxborot tizimlari bilan integratsiyalash jarayonlarida sun’iy intellektning o‘rni yoritilgan. Shuningdek, yer kadastri tizimida uchrayotgan ma’lumotlar sifati, raqamlashtirish darajasining yetarli emasligi, kadrlar malakasi va texnologik infratuzilma bilan bog‘liq muammolar ko‘rib chiqilib, ularni bartaraf etish bo‘yicha amaliy takliflar ishlab chiqilgan.

Kalit so‘zlar: sun’iy intellekt, yer kadastri, yer resurslarini boshqarish, geoaxborot tizimi, masofadan zondlash, raqamli kadastr, davlat yer nazorati, avtomatlashtirish, yer monitoringi

INTRODUCTION

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Today, the acceleration of digital transformation processes worldwide is driving the broad implementation of modern information and communication technologies across all sectors. In particular, artificial intelligence, Big Data, geographic information systems (GIS), remote sensing, cloud technologies, and digital platforms are being effectively applied in public administration and key sectors of the economy. Among these technologies, artificial intelligence holds particular importance due to its ability to rapidly analyze data, automate complex processes, and improve the efficiency of management decision-making.

Land resources represent a vital strategic asset for the economic, environmental, and social development of any country. Rational use of the land fund, preservation of its qualitative condition, regulation of land relations, and effective management of land plots are among the priority directions of state policy. Therefore, forming an accurate, reliable, and continuously updated database on land resources is one of the core tasks of the land cadastre system.

The land cadastre system ensures the collection, processing, storage, and provision of information on the legal, economic, and natural condition of land plots to users. However, traditional cadastre systems face problems such as labor-intensive data collection and updating, a high degree of human-factor influence, the obsolescence of certain data, and insufficiently automated control mechanisms. These issues lead to reduced efficiency in land resource use and, in some cases, cause illegal land seizure, incorrect classification of land categories, and errors in cadastral data.

In recent years, the sharp increase in the volume of data obtained from satellite imagery, unmanned aerial vehicles (drones), laser scanning technologies, and geographic information systems has demanded new approaches within the land cadastre system. Processing such large volumes of data using traditional methods is a complex and time-consuming process. From this perspective, the application of artificial intelligence technologies is emerging as an important tool for automatically detecting land plot boundaries, classifying land cover types, identifying illegal construction, conducting land monitoring, and regularly updating cadastral data.

The experience of developed countries shows that integrating artificial intelligence technologies into land cadastre and land resource management systems significantly improves data accuracy, reduces costs, and enhances management efficiency. As a result, land monitoring processes are being automated, instances of illegal land use are detected promptly, and transparency in the land market is ensured.

In the Republic of Uzbekistan as well, large-scale reforms are being implemented to digitalize the land cadastre sector, introduce geoinformation technologies, and convert public services into electronic form. At the same time, improving the completeness and accuracy of cadastral data, enhancing land monitoring, integrating databases, and applying modern artificial intelligence technologies in practice remain among today's pressing tasks.

The purpose of this article is to analyze the theoretical and practical foundations of using artificial intelligence technologies in the land cadastre system, to identify existing problems in this field, and to develop scientifically grounded proposals and recommendations for addressing them. The article also covers the prospects of artificial intelligence technologies in land resource management, state land control, geoinformation systems, and the development of digital cadastre.

Artificial intelligence technologies integrated with geoinformation systems are creatin g new opportunities in land resource management. Based on data stored in GIS platforms, the development prospects of territories, the efficiency of land use, and ecological conditions are analyzed. Artificial intelligence, in turn, deeply studies this data and generates recommendations for management decision-making, thereby improving the quality of strategic planning.

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In agricultural lands, artificial intelligence technologies are widely used to forecast crop yields, assess crop conditions, and optimize irrigation systems. Based on images obtained via drones, crop diseases, moisture levels, and fertilizer needs are identified, enabling more efficient use of land resources.

Today, many developed countries around the world are working to create "smart cadastre" systems. In these systems, artificial intelligence, GIS, cloud technologies, and remote sensing data are unified within a single platform. As a result, cadastral data is updated in real time, and users are provided with prompt service.

In the context of Uzbekistan, the broad introduction of artificial intelligence technologies into the land cadastre system could elevate the quality of land resource management to a new level. In particular, artificial intelligence has great practical significance for conducting a complete inventory of the land fund, reducing instances of illegal land use, improving land monitoring, and digitalizing public services.

Thus, artificial intelligence technologies are among the most promising innovative solutions serving to ensure the efficiency, accuracy, and transparency of the land cadastre system. Their broad implementation creates a solid foundation for the rational use of land resources, the regulation of land relations, and the further improvement of state land control.

CURRENT CHALLENGES IN IMPLEMENTING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE LAND CADASTRE SYSTEM

Digitalizing the land cadastre system and applying artificial intelligence technologies in practice is one of the priority tasks for many countries today. However, despite the great potential of these technologies, a number of organizational, technical, economic, and legal problems arise during their full integration into the land cadastre system. A thorough analysis of these problems and the development of mechanisms to address them are essential conditions for the effective use of artificial intelligence.

Problems related to the quality and completeness of cadastral data

The effective operation of artificial intelligence systems depends directly on data quality. In the land cadastre system, problems arise in certain areas due to insufficiently updated data, incompletely formed information on some land plots, and the use of outdated maps.

In many cases, information on the area, boundaries, type of use, or legal status of land plots is stored separately in different databases. This leads to discrepancies between datasets. When artificial intelligence operates on incorrect or insufficient data, it may produce erroneous results. Therefore, data accuracy and reliability are among the most important issues in implementing artificial intelligence.

In addition, since land inventory work has not been fully completed in certain areas, the database on the land fund has not been adequately formed. This negatively affects the quality of land monitoring and analysis processes.

Insufficient level of digitalization

The use of artificial intelligence technologies requires that all data be in digital form. However, in some areas, a portion of land cadastre documents is still kept on paper. The lack of digitization of archival documents, old land-use planning materials, and historical maps hinders the full formation of the database.

The sl ow pace of digitization makes it difficult to form the large volumes of data required for artificial intelligence systems. As a result, the level of automation decreases, and dependence on the human factor persists.

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Moreover, the shortage of modern software and technical resources in certain organizations also negatively affects the pace of digitization.

Lack of integration between geoinformation systems and databases

The land cadastre system is closely linked to the activities of many government bodies. Data related to land resources, construction, architecture, agriculture, ecology, taxation, and other sectors is stored in various information systems. The fact that data-exchange mechanisms between these databases have not been fully established reduces the effectiveness of artificial intelligence systems.

For example, information about a land plot may exist in one database, while related construction or tax data may be stored in another system. This complicates the collection of information needed for comprehensive analysis.

The absence of a unified, integrated geoinformation platform is also one of the factors limiting the efficiency of land resource management.

Difficulties in processing satellite and drone data

Modern satellites and drones generate extremely large volumes of data. Storing, processing, and analyzing this data requires high-capacity servers and modern software tools.

In some cases, low image quality, high levels of cloud cover, or technical errors complicate data processing. In addition, training artificial intelligence algorithms requires a large volume of reference (labeled) data.

These problems can negatively affect the accuracy of land monitoring results and the decision-making process.

Shortage of qualified specialists

Demand for highly qualified specialists in artificial intelligence, GIS technologies, remote sensing, and data analysis is growing year by year. However, in practice, the number of such specialists remains insufficient.

Some employees working in the land cadastre field lack sufficient knowledge and skills to work with modern digital technologies. As a result, the implementation of new technologies slows down.

Furthermore, the scarcity of specialized educational programs in higher education institutions dedicated to the integration of artificial intelligence and land cadastre also affects the quality of personnel training.

Problems related to technical infrastructure

The effective application of artificial intelligence technologies requires modern computer equipment, servers, data storage centers, and high-speed internet networks.

In some areas, outdated technical equipment, insufficient server capacity, and poor internet quality make it difficult to work with large volumes of data. This, in turn, hinders the organization of real-time monitoring and analysis work.

Information security and data protection problems

The land cadastre system stores large volumes of important data. The loss, corruption, or unauthorized use of this data can negatively affect state interests.

Since artificial intelligence systems are integrated with internet networks and cloud technologies, cybersecurity issues are of particular relevance. Insufficiently developed data protection mechanisms can give rise to various risks.

Underdeveloped legal and regulatory framework

Certain legal issues related to the use of artificial intelligence technologies have not yet been fully regulated. In particular, clear norms need to be developed regarding the legal force of automatically detected data, liability for decisions made by artificial intelligence, and the procedures for using such data.

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Improving the regulatory and legal framework is essential for the future broad implementation of artificial intelligence technologies in the land cadastre system.

CONCLUSION

Land resources play an important role in any country's economic development, food security, ecological stability, and social development. Therefore, the role of the land cadastre system in accounting for land resources, organizing their rational use, and exercising control over them is invaluable. In the current era of rapidly developing digital technologies, improving the land cadastre system and increasing its efficiency is becoming one of the priority directions of state policy.

The research results show that artificial intelligence technologies have significant potential to improve the processes of collecting, processing, storing, analyzing, and updating data within the land cadastre system. In particular, the high effectiveness of artificial intelligence is evident in processing remote sensing data, automating land monitoring, detecting illegal land seizure, defining land plot boundaries, and evaluating land value.

At the same time, the study identified problems hindering the implementation of artificial intelligence technologies in the land cadastre system, including insufficiently formed databases, a low level of digitalization, underdeveloped technical infrastructure, a shortage of qualified specialists, and the need to improve the regulatory and legal framework. These problems prevent the full use of the opportunities offered by artificial intelligence technologies.

In the future, by integrating artificial intelligence, geoinformation systems, remote sensing technologies, and big data analysis, it will be possible to form a "Smart Cadastre" system. This would increase the efficiency of land resource management, strengthen state land control, ensure transparency in land relations, and expand opportunities for the rational use of the land fund.

In conclusion, the broad implementation of artificial intelligence technologies in the land cadastre system will not only improve the accuracy and reliability of cadastral data but will also contribute to forming a modern, efficient, and digital model of land resource management. This, in turn, is one of the important factors for the country's sustainable economic development and the efficient use of land resources.

SUGGESTIONS AND RECOMMENDATIONS

Based on the research results, the following proposals and recommendations were developed to ensure the effective use of artificial intelligence technologies in the land cadastre system:

1. Create a unified digital land cadastre platform. Consolidate data on all land plots across the republic into a single electronic database and integrate it with artificial intelligence technologies.

2.Introduce an AI-based land monitoring system. Develop a monitoring system that automatically analyzes data obtained from satellite imagery and drones.

3.Integrate GIS and AI technologies. Combining geoinformation systems, remote sensing data, and artificial intelligence algorithms within a single platform increases the efficiency of land resource management.

4.Automatically detect illegal land use. Implement a system using artificial intelligence to monitor changes in land plots and detect violations of the law in real time.

5.Develop an intelligent land valuation system. Using artificial intelligence algorithms to determine the market value of land ensures accuracy and transparency in the valuation process.

6.Regularly update cadastral data. Establish mechanisms for continuously updating data based on remote sensing technologies.

7.Enhance personnel capacity. Introduce courses such as "Artificial Intelligence and Land Cadastre" and "Machine Learning in Geoinformation Systems" in higher education institutions.

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8.Strengthen information security.Implement modern cybersecurity mechanisms to protect land cadastre data.

9.Study international experience.Examine the smart cadastre systems of developed countries and adapt them to national practice.

10.Improve the legal framework.Develop and refine regulatory and legal documents related to the use of artificial intelligence technologies.

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