

ABSTRACT

to the dissertation work of Timur Rafikov submitted for the degree of Doctor of Philosophy (PhD) under the educational program 8D07308 - “Land Management” titled “Improving the geoinformation database for the rational management of land resources on the example of the East Kazakhstan region”

Relevance of the Research Topic. Land resources constitute a fundamental basis for ensuring food security and the sustainable socio-economic development of regions. Under current conditions, effective management of the land fund requires the application of modern control methods to prevent the misuse of land, minimize adverse environmental consequences, and prevent soil degradation. The land resources database requires systematic updating and in-depth analysis to provide a more complete representation of land-use dynamics amid global climate challenges and demographic transformation.

Improving the geoinformation database (GDB) enables public authorities to make scientifically sound management decisions, optimize the structure of land allocation, minimize bureaucratic barriers, and reduce certain organizational and operating costs. The integration of modern information technologies, including geographic information systems (GIS), Earth remote sensing data, unmanned aerial vehicles (UAVs), and sensor networks, creates new opportunities for detailed data collection, multidimensional analysis, and visualization of spatial data, thereby increasing the reliability of information support.

East Kazakhstan Region, with its important geographical position and substantial natural-resource potential, is one of the country’s significant agro-industrial regions. The diversity of landscape zones—from the Altai mountain ranges to the steppe plains—determines the complexity of the land-use structure and necessitates the introduction of modern monitoring systems. The development of recommendations for improving the GDB in East Kazakhstan Region addresses the applied task of ensuring the rational use of agricultural land and improving the efficiency of regional land resources management.

Purpose and Objectives of the Study. The purpose of the study is to improve the geoinformation database for the rational management of land resources in East Kazakhstan Region, with a view to enhancing land-use sustainability and optimizing the region’s environmental and economic indicators.

To achieve this purpose, the following objectives were addressed:

1. To generalize and systematize the theoretical and methodological foundations for applying geoinformation technologies and Earth remote sensing data in land resources management.

2. To analyze the current state of land resources in East Kazakhstan Region, the existing system of their management, and the main problems of rational land use in the region.

3. To develop an integrated approach and a structural-functional model of a regional geoinformation database that provide for the integration of cadastral information, open spatial data sources, socio-economic indicators, and Earth remote

sensing materials.

4. To develop a software and analytical module and conduct a spatiotemporal analysis of vegetation cover based on long-term satellite data and the NDVI vegetation index, identifying periods of vegetation decline and recovery, as well as cadastral parcels with persistent negative dynamics.

5. To assess the technological and economic efficiency of the proposed geoinformation solutions and develop scientifically substantiated recommendations for rational land resources management and enhanced land-use sustainability in East Kazakhstan Region.

6. To design the architecture and implement a prototype regional geoportal that provides publication and visualization of thematic layers, access to spatial data, and information and analytical support for management decision-making.

Object and Subject of the Study. The object of the study is the land resources of East Kazakhstan Region and the processes of their information support, monitoring, and management under conditions of digital transformation.

The subject of the study is the organizational, economic, and methodological approaches to improving information support for land resources management through the integration of GIS, digital cadastre, and remote sensing technologies.

Research Methods. The dissertation employed methods of system analysis, comparative analysis, geoinformation mapping, spatial analysis, remote sensing data analysis, NDVI calculation, geoinformation database design, expert survey, SWOT analysis, economic and mathematical modelling, and forecasting. Spatial data were processed using ArcGIS, QGIS, and a software and analytical module developed for the automated assessment of land resources.

Theoretical and Methodological Basis of the Study. The methodological basis of the study rests on the principles of integrated analysis, which considers land resources as a complex dynamic system. The theoretical basis comprises the works of domestic and foreign scholars in land management, cadastre, geoinformatics, and sustainable natural resource use. The regulatory basis includes the Land Code of the Republic of Kazakhstan, the Law of the Republic of Kazakhstan “On Geodesy, Cartography and Spatial Data,” as well as the international ISO 19115 and OGC standards that ensure the standardization of spatial information.

Main Provisions Submitted for Defense.

1. An integrated approach to forming a regional geoinformation database of land resources through the integration of cadastral, spatial, and remote sensing data.

2. A structural-functional model of the geoinformation database of land resources of East Kazakhstan Region.

3. A software and analytical module for automated NDVI monitoring and identification of cadastral parcels with negative vegetation-cover dynamics.

4. Scientific and practical recommendations for improving land resources management in East Kazakhstan Region based on geoinformation analysis.

5. A regional geoportal for publishing, visualizing, and analyzing spatial data on land resources.

Description of the Main Research Results.

1. The theoretical and methodological foundations for applying geoinformation technologies and Earth remote sensing data in land resources management were generalized and systematized. The need to move from fragmented cadastral accounting to an integrated digital monitoring system that supports the joint use of spatial, cadastral, and socio-economic data was substantiated.

2. The current state of land resources and the existing land-use management system in East Kazakhstan Region were analyzed. The main problems identified include fragmented information resources, insufficiently rapid data updating, limited integration of cadastral and satellite information, and the need for early detection of land degradation processes.

3. An integrated approach and a structural-functional model of a regional geoinformation database of land resources were developed. A system of spatial and attribute data was created, including administrative boundaries, hydrography, agricultural land, transport infrastructure, and other thematic layers. The proposed model integrates cadastral information, open spatial data sources, socio-economic indicators, and Earth remote sensing materials and allows the database to be scaled to other regions of the Republic of Kazakhstan.

4. A software and analytical module was developed for automated spatial data processing and land-condition monitoring. Long-term Landsat imagery was used to analyze vegetation-cover dynamics in East Kazakhstan Region for 2000–2025 using NDVI. Periods of decline and recovery in green vegetation were identified, along with areas showing negative vegetation-cover dynamics. The cadastral parcels of Samar District were used to confirm the feasibility of automated identification of parcels with negative vegetation-cover dynamics.

5. The technological and economic efficiency of the proposed geoinformation solutions was assessed. The software and analytical module was found to reduce the duration of monitoring one district by a factor of 320—from 80 hours to 0.25 hours. The estimated potential avoided damage amounted to KZT 4,632,000. Based on the research results, scientifically substantiated recommendations were developed for introducing automated monitoring, improving the geoinformation database, and enhancing land-use sustainability in East Kazakhstan Region.

6. A regional geoportal for East Kazakhstan Region was designed and implemented. The geoportal provides publication and visualization of thematic layers, comparison of cadastral information with satellite-monitoring results, interactive analysis of spatial data, and information and analytical support for decision-making in land resources management.

Substantiation of the Novelty and Significance of the Results Obtained.

The scientific novelty of the study lies in the development and testing of methodological approaches to the use of geoinformation technologies for improving information support for land resources management in East Kazakhstan Region. An integrated approach to improving a regional geoinformation database of land resources was developed based on the integration of cadastral data, Earth remote sensing data, and open spatial data sources.

A structural-functional model of the geoinformation database and regional geoportal was proposed, ensuring scalability, integration of additional spatial datasets, and interactive visualization. A cadastral-oriented approach to geoinformation monitoring was developed, enabling land-parcel boundaries to be compared with multi-year NDVI series, vegetation-cover dynamics to be assessed automatically, and parcels requiring additional inspection and preventive measures to be identified.

The significance of the results obtained is determined by their practical orientation. The developed approaches improve the objectivity of land monitoring, reduce spatial-data processing time, enable early identification of problematic parcels, and provide a digital basis for scientifically sound management decisions.

Scientific and Practical Significance. The practical value of the study is confirmed by the testing and implementation of individual results in the practical and analytical activities of organizations engaged in land-resource monitoring and research. The geoportal for East Kazakhstan Region developed by the author can be used as a tool for integrating cadastral information and Earth remote sensing data, thereby contributing to greater transparency in land relations. The proposed methodology creates prerequisites for optimizing land use and reducing potential economic losses associated with soil degradation. The research results may be used in the educational process under the programs “Land Management,” “Cadastre,” and “Geodesy and Cartography.”

Compliance with the Directions of Scientific Development or State Programs. The dissertation topic corresponds to current directions in the development of land management, cadastre, geoinformation technologies, Earth remote sensing, and digital land resources management. The results are consistent with the objectives of digitizing the state land cadastre, developing the national spatial data infrastructure, improving the efficiency of land monitoring, and ensuring the rational use of land resources in the Republic of Kazakhstan.

The study is also related to the implementation of research projects aimed at developing decision-support systems, the natural and economic planning of territories, and the improvement of organizational and economic approaches to the rational use of agricultural land through GIS technologies.

The dissertation research was also conducted with due regard to the provisions of the State Program “Digital Kazakhstan,” approved by Resolution No. 827 of the Government of the Republic of Kazakhstan dated 12 December 2017, which provided for integrating fragmented cadastral information into a single information space and automating cadastral procedures.

Description of the Doctoral Candidate’s Contribution to Each Publication. The main results of the dissertation research are presented in the following publications:

1. “Evaluating Land Degradation in East Kazakhstan Using NDVI and Landsat Data” // International Journal of Design & Nature and Ecodynamics. – 2024. – Vol. 19, № 5. – P. 1677–1686. DOI: 10.18280/ij dne.190521. The journal is indexed in the international Scopus database.

2. “Применение данных дистанционного зондирования Земли и анализа NDVI в Восточно-Казахстанской области” // Изденістер, нәтижелер – Исследования, результаты. – 2024. – № 1 (101). – С. 183–191. DOI: 10.37884/1-2024/18.

3. “Повышение эколого-экономической эффективности использования земельных ресурсов” // Изденістер, нәтижелер – Исследования, результаты. – 2024. – № 2 (102). – С. 360–369. DOI: 10.37884/2-2024/35.

4. “Применение географических баз данных для развития геопорталов в Казахстане” // Изденістер, нәтижелер – Исследования, результаты. – 2025. – № 4 (108). – С. 470–480. DOI: 10.37884/4-2025/48.

5. “Use of Geospatial Databases in Rural Areas of Kazakhstan” // Problems of AgriMarket. – 2026. – № 1. – P. 50–60. DOI: 10.46666/2026-1.2708-9991.04.

6. “Remote Sensing-Based Evaluation of Land Degradation and Moisture Variability in Post-Nuclear Landscapes of Kazakhstan” // Journal of Geography and Environmental Management. – 2025. – Vol. 79, № 4. – P. 30–41. DOI: 10.26577/JGEM20257943.

In addition, the research results were published in scientific works devoted to the development of geoinformation databases, monitoring of vegetation and forest cover, improvement of agricultural maps, and the application of geoinformation technologies in land resources management. The results were presented and discussed at international scientific and practical conferences in Kazakhstan, Russia, Poland, and Ukraine.

The doctoral candidate’s contribution to the preparation of the publications included formulating the research objectives; collecting and systematizing the initial spatial and statistical data; designing geoinformation database structures; processing Landsat and Sentinel satellite imagery; calculating NDVI; conducting spatiotemporal and environmental-economic analyses; preparing digital maps, tables, and graphical materials; interpreting the results; formulating conclusions; and contributing to the preparation of the article manuscripts.

For the article “Evaluating Land Degradation in East Kazakhstan Using NDVI and Landsat Data,” the doctoral candidate selected and pre-processed Landsat satellite data, calculated NDVI, prepared cartographic materials, and interpreted vegetation-cover dynamics in East Kazakhstan Region.

In the publications devoted to geoinformation databases and geoportal development, the doctoral candidate contributed to designing the thematic-layer structure, systematizing spatial and attribute data, preparing cartographic content, and substantiating the potential application of geoportal technologies in land resources management.

In the environmental-economic studies, the doctoral candidate’s contribution comprised collecting and processing statistical data, calculating land-use efficiency indicators, preparing analytical materials, and developing practical recommendations.

In preparing materials for international scientific and practical conferences, the doctoral candidate participated in geoinformation analysis, the preparation of

reports and presentation materials, and the presentation and discussion of the research results.

The following intellectual property protection documents were obtained as a result of the research:

1. Copyright Certificate No. 48230 dated 9 July 2024, “Development of Kazakh Fonts for a Geospatial Database.”
2. Copyright Certificate No. 49508 dated 9 September 2024, “Development of a Geospatial Database for East Kazakhstan Region.”
3. Copyright Certificate No. 63222 dated 21 October 2025, “Software for Geoinformation Support of Cadastral Monitoring and Digital Zoning of Agricultural Land.”
4. Utility Model Patent No. 12020 dated 10 April 2026, “Method for Centralized Maintenance of a Geoinformation Database of Land Resources in a Geoportal.”

Approval and Implementation of the Research Results. Copyright certificates were obtained for the developed databases and software modules for monitoring agricultural entities using geoinformation technologies, and a utility model patent was obtained for the “Method for Centralized Maintenance of a Geoinformation Database of Land Resources in a Geoportal.”

During the study period, the author participated in Program-Targeted Funding Project BR24993222, “Building a Decision Support System for Natural and Economic Development of the North Kazakhstan Region in the Context of Sustainable Development” in which knowledge of database development and digital mapping of land resources was applied. The author also participated in initiative research project 0124RKI0214 titled “Improvement of Organizational and Economic Approaches to the Rational Use of Agricultural Land Based on GIS Technologies.”

Structure and Volume of the Dissertation. The dissertation consists of an introduction, three chapters, a conclusion, a list of references, and appendices. The main text comprises 131 pages, including 22 tables and 23 figures. The total volume of the dissertation, including appendices, is 144 pages. The bibliography contains 121 sources.