

ABSTRACT

to the dissertation work of Marziya Daniyarova submitted for the degree of Doctor of Philosophy (PhD) under the educational program 8D07309 - “Cadastre” titled “Assessment of the qualitative state of agricultural land based on GIS technologies”

Relevance of the Research Topic. The current condition of Kazakhstan's land resources is characterized by a high level of degradation caused by the combined influence of natural and anthropogenic factors. According to the Committee for Land Resources Management of the Republic of Kazakhstan and international organizations such as the FAO, a significant portion of agricultural lands is exposed to erosion, salinization, desertification, and excessive grazing pressure. All these processes lead to a decline in soil fertility, reduction in crop productivity, and increased threats to food security.

The issue of effective land use is especially relevant in Northern Kazakhstan, where a high proportion of arable land has remained since the Virgin Lands campaign. Under modern conditions of intensive agricultural production, soil degradation and erosion processes have intensified, while in livestock-oriented regions, pastures are overloaded due to non-compliance with normative load limits. As noted in the Address of the President of the Republic of Kazakhstan, timely identification and redistribution of unused lands must be carried out using geoinformation technologies and artificial intelligence.

Understanding the value of land as a fundamental productive resource requires the development of comprehensive approaches to the rational allocation and use of agricultural lands. These processes increase the demand for integrated land quality assessment based on space monitoring and geoanalytics. Therefore, developing scientifically grounded methods for objectively evaluating land quality using modern monitoring techniques is of high importance.

Degree of Scientific Study of the Topic. The need for this study is driven by the lack of integrative approaches to land assessment that consider the spatiotemporal dynamics of both natural and anthropogenic factors. The use of remote monitoring and GIS technologies provides a transition from fragmentary research to systematic analysis and allows for the development of scientifically grounded recommendations for the rational use of land resources. The conducted analysis revealed the absence of similar comprehensive methodologies tailored to regional characteristics, which determines the novelty and patent purity of the work.

The metrological support of the research was ensured through the application of international algorithms for index calculation, standardized procedures for processing satellite information, and their verification with statistical and field data. The rationale for selecting the topic lies in the necessity to introduce GIS technologies and remote sensing methods into the analysis and monitoring of agricultural land conditions. In global practice, such tasks are widely solved within

the frameworks of the Copernicus Land Monitoring (EU) program and FAO initiatives, where vegetation indices and multicriteria evaluation methods are extensively used. However, in Kazakhstan, methodologies that integrate different indicators of the biophysical state of soils and vegetation and are adapted to the soil-climatic features of the steppe zone have not yet been developed.

Purpose and Objectives of the Study. The purpose of the dissertation is the development of a methodology for assessing the quality of agricultural lands through territorial zoning using the Weighted Overlay method based on multicriteria GIS analysis.

To achieve this purpose, the following objectives were addressed:

- to study international experience and approaches to land quality assessment and classification;
- to develop a land quality assessment model based on integration of vegetation, biophysical, and topographic indices;
- to conduct multicriteria analysis in GIS and evaluate the agricultural potential of territories;
- to produce a zoning map of land quality classes for commercial agricultural production;
- to determine the efficiency of agricultural land use;
- to develop recommendations for land management considering agroecological differentiation of the territory.

Object and Subject of the Study. The object of the study is the land resources of Zerendy and Yereymentau districts of the Akmola region, which demonstrate a clear contrast in land structure and levels of agricultural potential.

The subject of the study is the spatial patterns of land quality and its dynamic changes under the influence of natural and anthropogenic factors.

Theoretical and Methodological Basis of the Study. The theoretical basis of the dissertation consists of the works of foreign scholars in the fields of land management, GIS technologies, and sustainable land use, including Panagos P., Chen Y., Mugiyo H., Frankenberg C., Lal R., Abdellatif M.A., Wang Y., Wu W., Abdel Rahman M.A.E., Kumar A., Pravalie R., Zhang C., Thenkabail P.S., Ahmad H.R., Ziadat F., Abuzaid A.S., R. Binte Mostafiz, F. Qian, M. Bagheri Bodaghabadi, M.E. Fadl, as well as scholars from CIS countries and Kazakhstan – Dokuchaev V.V., Varlamov A.A., Volkov S.N., Gendelman M.A., Spektor M.D., Tkachuk S.A., Kurykbayev Zh.K., Alipbek O.A., Ozeranskaya N.V., Kurmanova G.K., Akimov V.V., Zhumanazarov K.B., Kabzhanova G.R., and others.

The methodological basis relies on the integration of two complementary approaches: GIS- and Remote-Sensing-Based Approach (using satellite data: Landsat 8/9 OLI/TIRS, SRTM), in which the following indices were calculated: NDVI, EVI, MSAVI, GNDVI, NDWI, VCI, BSI, SOCS, LST. Comprehensive assessment was implemented using the Weighted Overlay and Raster Calculator methods. Score-Based Evaluation Approach in which criteria

included soil (bonitet score), relief (elevation, slope), climate (precipitation, temperature), demographic and socio-economic indicators. A threshold scoring scale allowed for quantitative comparison of results.

Information Base of the Study. The information base consists of official statistical materials, cartographic data, land cadastre information, as well as Landsat 8-9 satellite imagery, SRTM digital elevation models, and vegetation-indicator datasets. Data were processed in the ArcGIS Pro environment, reclassified into a 5-point scale, and subjected to multicriteria analysis.

Scientific Novelty. The scientific novelty of the dissertation lies in the development of a new approach to assessing the quality of agricultural lands, based on an original model for evaluating the qualitative condition of agricultural lands and a threshold-based scaling assessment. Two methodological approaches are proposed: determination of the agricultural potential of territories using a threshold-based scaling method with aggregation by criteria, and application of multicriteria analysis using the weighted overlay method in a GIS environment. Each approach relies on specific groups of indicators that characterize the natural and socio-economic features of the study area.

Author's Personal Contribution. All stages of the research were carried out independently by the author. The author performed the collection, systematization, and spatial processing of the initial data, including Landsat, Sentinel, and SRTM satellite imagery, as well as statistical materials. A methodology for multicriteria assessment of the quality of agricultural lands was developed based on the integration of vegetation, biophysical, and topographic indices using the ArcGIS Pro software package.

The author adapted existing approaches to assessing the agro-economic potential of lands to the conditions of the Akmola Region and developed an original weighted overlay model of criteria, which made it possible to classify territories by levels of land quality and suitability for agricultural use.

Field surveys were conducted, and soil samples were collected to determine humus content in the laboratory of the Agroecological Testing Center at S. Seifullin Kazakh Agrotechnical Research University (Appendix A). In addition, a questionnaire survey of land users was carried out to identify existing problems and determine the socio-economic aspects of agricultural production. The author performed a spatio-temporal assessment of the dynamics of degradation processes and calculated indicators of the economic efficiency of land use for the study areas.

All cartographic materials, index calculations, diagrams, and tables were prepared personally by the author.

Main Provisions Submitted for Defense. The following provisions are submitted for the defense:

- scientific and methodological foundations of assessing the quality of agricultural lands;
- a threshold scoring system ranked by criteria;

- a GIS model based on the Weighted Overlay method;
- zoning of territory by quality classes;
- recommendations for applying remote-sensing-based classification in agricultural practice.

Theoretical and Practical Significance. The theoretical significance lies in scientifically substantiating a comprehensive methodology for assessing agricultural land quality by integrating GIS and multicriteria analysis. The practical significance lies in the applicability of the developed approaches in state land monitoring, the design of rational land use schemes, and assessment of agricultural productivity potential.

Approval and Implementation of the Research Results. Based on the conducted research, “Recommendations on the consolidation of small-scale farming entities (private subsidiary farms and peasant (farmer) farms) into agricultural cooperatives” were developed. These recommendations were granted a certificate of registration in the State Register of Rights to Copyright-Protected Objects (Appendix B).

The results were implemented:

- into the educational process in the study of the discipline “Land Resources Management” (Educational Program 6B07303 – Cadastre) at S. Seifullin Kazakh Agrotechnical Research University, with an official act of implementation in the educational process (Appendix B.1);
- into production practice at the branch of the Republican State Enterprise on the Right of Economic Management “State Institute for Land Survey and Assessment Works” under the Committee for Land Resources Management of the Ministry of Agriculture of the Republic of Kazakhstan, Akmola Region (Appendix B.2).

Publications. The research results were published in 14 research publications, including: 2 articles in Scopus-indexed journals (Q2, percentiles 58 and 72); 4 articles in journals recommended by the Committee for Quality Assurance in Science and Higher Education; 7 articles in international scientific-practical journals and conference proceedings, also a certificate of copyright registration was obtained.

The list of main publications:

1 Analysis of the use of land shares in Kazakhstan as a transitional form of joint land ownership // International Journal of Sustainable Development and Planning. – 2025. – №20(2). – P. 645-658.

2 Assessment of agricultural land potential in the Zerendy and Yereymentau districts of Northern Kazakhstan based on a comparative analysis // Sustainable Development of Mountain Territories. – 2025. – №17(2). – P. 886-899.

3 Качественное состояние сельскохозяйственных земель Республики Казахстан // Проблемы аграрынка. – 2020. – №4. – С. 183-190.

4 Повышение эффективности использования сельскохозяйственных угодий // Проблемы аграрынка. – 2021. – №4(4). – С. 169–177.

5 Пути объединения малых форм хозяйствования в сельскохозяйственные кооперативы // Вестник науки Казахского агротехнического университета имени С. Сейфуллина (Междисциплинарный). – 2022. – №1(112). – С. 73-82.

6 Роль информационного обеспечения при изъятии неиспользуемых земель // Проблемы агрорынка. – 2024. – №1. – С. 163-173.

Structure and Volume of the Dissertation. The dissertation consists of an introduction, 3 chapters, a conclusion, a list of references, and appendices. The dissertation consists of an introduction, three chapters, a conclusion, a list of references, and appendices. Chapter 1 presents the scientific and methodological foundations for assessing the qualitative condition of agricultural lands; Chapter 2 analyzes the agro-production potential of agricultural lands; Chapter 3 develops a methodology for assessing the qualitative condition of agricultural lands based on GIS technologies. The conclusion summarizes the main findings of the research. The volume of work is 148 pages, with appendices - 160 pages. The dissertation includes 17 tables, 66 figures, and 6 appendices. The list of references includes 299 sources.