

ABSTRACT

for the research work of Gauhar Musaif on the topic “Post-classification analysis of Land use in an agroindustrial district” submitted for obtaining the degree of Doctor of Philosophy (PhD) under the educational program «8D07302 – Geodesy»

General Description of the work. The research is aimed at identifying driving mechanisms and assessing sustainable development trends in the districts of Akmola Region, which include an agro-industrial complex, an urban area, and a national natural park, through post-classification analysis of Land Use and Land Cover (LULC). The study is based on the integrated use of spatio-temporal data, as well as economic, environmental, and social indicators. The work is presented in the form of a series of articles published in journals indexed in the Scopus and Web of Science databases.

Relevance of the topic. In Kazakhstan, the majority of previous studies on agro-industrial districts have mainly been limited to evaluating changes in Land Use and Land Cover (LULC) classes through change detection, while inter-category transformations have remained insufficiently explored. In addition, no studies have been identified that assess sustainable development trends and determine the driving mechanisms in the districts of Akmola Region—covering an agro-industrial complex, an urban area, and a national natural park—through post-classification analysis of LULC based on the integrated use of spatio-temporal data and economic, environmental, and social indicators.

The results of current scientific research and applied work in the field of geoinformation technologies demonstrate that the integration of GIS tools and remote sensing data makes it possible to move beyond descriptive land assessment toward the development of multifactor suitability models. Such an approach enables the identification of key factors affecting productivity, as well as the scientifically grounded formation of options for spatial zoning of territories.

Objective of the research: The objective of the study is to identify the driving mechanisms in the districts of Akmola Region, which include an agro-industrial complex, an urban area, and a national natural park, and to assess the sustainability of their development trends through post-classification analysis of Land Use and Land Cover (LULC), based on the integrated use of spatio-temporal data and economic, environmental, and social indicators.

Research Tasks:

Based on the spatial characteristics of the agro-industrial complex, city, and national natural parks located within agro-industrial districts, the study includes the following objectives:

1. To determine the net changes in Land Use and Land Cover (LULC) classes through change detection by evaluating effective methods of remote sensing data classification, their accuracy, and the possibilities of integrating heterogeneous imagery.

2. To assess the intensity of exchanges and the stability between land categories in order to investigate long-term trends in LULC changes.
3. To determine whether changes in LULC classes are random or systematic.
4. To identify multiple linear correlations between LULC classes and statistical data (economic, social, and environmental indicators).
5. To identify the driving forces influencing territorial development using Principal Component Analysis (PCA).
6. To evaluate district development trends through an integrated four-stage analysis of economic, social, and environmental statistical information combined with spatio-temporal data.

Methods. A technical flowchart is presented for Land Use / Land Cover (LULC) mapping, analysis of driving mechanisms, and assessment of sustainable development in Burabay District. **LULC Classification Methods.** To successfully classify Land Use and Land Cover (LULC) on the Google Earth Engine platform, three algorithms were tested: Random Forest (RF), Classification and Regression Trees (CART), and Support Vector Machine (SVM).

The reliability of LULC classification based on Landsat 5 / Landsat 7 / Landsat 8 imagery using the RF method was verified through three data sources:

1. Comparison with WorldCover v2 (2021) data;
2. Classification of LULC using Sentinel-2 imagery (10 m spatial resolution) for the period 2016–2021, applying the same RF algorithm as for Landsat 5/7/8;
3. Comparison with actual Planet imagery data (6 m spatial resolution).

Overall, all three data sources confirmed the high reliability of LULC classification in Burabay District for the period 1999–2021.

Objects of the study: Burabay agro-industrial district of Akmola Region.

Main Provisions Submitted for Defense:

The main provisions submitted for defense arise from the research objectives:

1. Development of a methodological framework based on literature review and taking into account the specific features of the study areas.
2. Determination of the net changes in Land Use and Land Cover (LULC) classes through change detection by evaluating effective methods of remote sensing data classification, their accuracy, and the possibilities of integrating heterogeneous imagery.
3. Assessment of the intensity of exchanges and stability between land categories in the course of studying long-term LULC change trends.
4. Determination of whether changes in LULC classes are random or systematic.
5. Identification of multiple linear correlations between LULC classes and statistical data (economic, social, and environmental indicators).
6. Identification of the driving forces influencing territorial development using Principal Component Analysis (PCA).

Description of the Main Research Results. During the period 1999–2021, pasture lands experienced the greatest changes, decreasing by 16.69%, while croplands increased by 14.72%. Forest areas showed a slight increase (+1.81%),

built-up lands increased by 0.16%, and water bodies by 0.01%. Analysis of transition matrices showed that 17.5% of new croplands were systematically converted from pastures. Systematic transitions from pastures to forests (1.41%) were also identified, as well as random transitions from forest lands to built-up areas. According to the results of Principal Component Analysis (PCA), the first principal component (F1) explains 48.7% of the variance and reflects economic growth (output volume of farms, average monthly wages, and investments in fixed capital). The second component (F2), explaining 31.2% of the variance, is associated with vegetation indices (EVI, NDVI, NDWI) and climatic characteristics. Regression analysis confirmed that changes in the area of croplands, forests, and built-up lands are positively correlated with F1, whereas pasture lands are negatively correlated. The integrated sustainable development index demonstrated a positive trend, with growth in 2011, 2016, and 2020, followed by a sharp decline in 2021 due to the impact of the COVID-19 pandemic.

Justification of the Novelty, Significance, and Obtained Results.

Connection of the Scientific Research with State Programs The research was carried out under the supervision of Professor O.A. Alipbeki during 2021–2023, with the doctoral candidate participating as an исполнор of the project within the framework of the program-targeted funding of the Ministry of Agriculture of the Republic of Kazakhstan under project IRN BR10764919. A technical flowchart for assessing sustainable development was developed within the study. Its distinctive features include: comparison with WorldCover v2 (2021) data; LULC classification using Sentinel-2 imagery (10 m spatial resolution) for the period 2016–2021 with the same Random Forest (RF) algorithm applied to Landsat 5 / Landsat 7 / Landsat 8 data; and comparison with actual Planet imagery data (6 m spatial resolution). Overall, all three data sources confirmed the high reliability of LULC classification in Burabay District for the period 1999–2021. For the first time, the spatial and temporal changes in land use within agro-industrial regions during 1999–2021 were comprehensively analyzed, and their dynamics were identified. Using the Google Earth Engine platform, an automated land-use classification method based on long-term remote sensing data was proposed. Post-classification changes and trends in land use were determined, providing a scientific basis for current land resource management and planning.

Relationship of the Dissertation to State Programs.

The research results were published in 19 scientific works, including: 3 articles in Q1 journals indexed in Scopus (with contribution percentages of 87% and 90%); 1 article in a Q3 journal; 2 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan; 10 articles in international scientific-practical journals and conference proceedings; and 3 certificates of copyright registration were obtained.

In the article published in Sustainability (MDPI), Vol. 15(9), May 2023, pp. 1–36, entitled “*Untangling the Integral Impact of Land Use Change, Economic, Ecological and Social Factors on the Development of Burabay District (Kazakhstan) during the Period 1999–2021*”, the doctoral candidate is the first

author. All calculations, writing, and formatting of the article were carried out entirely with the personal participation of the doctoral candidate.

The scientific problem was independently identified, and the research objectives, tasks, and methods were developed by the doctoral candidate.

The doctoral candidate conducted a comprehensive literature review on the research topic and performed qualitative and quantitative assessments of spatio-temporal changes. In addition, the candidate prepared the initial drafts of the articles, including the introduction, methods, results, and conclusion sections, designed the graphical materials, and actively participated in editing the final versions of the publications.

Publications in Scopus and Web of Science Databases.

1. Alipbeki O., Mussaif G., Alipbekova C., Kapassova A., Grossul P., Aliyev M., Mineyev N.* Untangling the Integral Impact of Land Use Change, Economic, Ecological and Social Factors on the Development of Burabay District (Kazakhstan) during the Period 1999–2021. Sustainability (MDPI), 2023, 15, 7548. Q1. Impact Factor: 3.889. CiteScore: 5.0.

The doctoral candidate is the corresponding author. The scientific problem was independently identified, the research objectives and tasks were formulated, and the methods were developed.

2. Alipbeki O., Alipbekova C., Mussaif G., Grossul P., Zhenshan D., Muzyka O., Turekeldiyeva R., Yelubayev D., Rakhimov D., Kupidura P., Aliken E. Analysis and Prediction of Land Use/Land Cover Changes in Korgalzhyn District, Kazakhstan. Agronomy, 2024, 14, 268. Q1. CiteScore: 6.7. Contribution of the doctoral candidate: analysis of initial spatial data; processing of remote sensing materials; geoinformation analysis and thematic cartography in ArcGIS (land classification, indicator calculation); preparation and editing of the manuscript.

3. Alipbeki O., Grossul P., Rakhimov D., Kupidura P., Alipbekova C., Musaif G., Turekeldiyeva R., Augambaev K., Begaliyeva M. Ecosystem Health Assessment of the Zerendy District, Kazakhstan. Sustainability (MDPI), 2025, 17, 277. Q1. CiteScore: Contribution of the doctoral candidate: geoinformation analysis, thematic cartography, land classification, and post-classification analysis.

4. Alipbeki O., Ch. Alipbekova, G. Mussaif, N. Mineyev, M. Aliyev, B. Akhmetov, R. Turegeldiyeva. The Driving Forces of Changes in Land Use of a Peri-Urban Area: The Case of Tselinograd District, Kazakhstan. E3S Web of Conferences, Volume 386, 2023, Article 05013. Q3. Contribution of the doctoral candidate: participation in remote sensing methodology and post-classification analysis.

Publications Recommended by the Committee for Quality Assurance in Science and Higher Education of the Republic of Kazakhstan

1. Alipbeki O., Oryngozhin Ye., Musaif G., Abaeva K., Tajetdinov N., Baidauletova G., Mendybaeva G., Tuzelbai S.* Engineering-Geodesic Equipment of the Territory Used by Using Geoinformation Systems. Ізденістер, нәтижелер –

Исследования, результаты, 2024, No. 3 (103).Contribution of the doctoral candidate: geodetic analyses, manuscript preparation, and editing.

2. **Mussaif G., Toleubekova Zh.Z., Akhmadiya A.** Analysis of Land Use Changes in the Agro-Urban Area of Tselinograd District Based on Remote Sensing and Geodetic Data. Hydrometeorology and Ecology, No. 3 (118), 2025. 2025 <https://doi.org/10.54668/2789-6323-2025-118-3-127-140>

The doctoral candidate is the corresponding author. Contribution: development of the research concept, comprehensive literature review, data processing and analysis using GIS technologies, interpretation of results, and manuscript preparation.