

## ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD) on educational program "8D07304 - Land Management"

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on the topic: **"Assessment of Irrigated Land Degradation Processes in the Turkistan Region Using Remote Sensing Data"**

**Relevance of the dissertation work.** The dissertation research corresponds to the national priorities of the Republic of Kazakhstan and is aimed at solving the issues of efficient use of irrigated lands in order to ensure food security.

Global climate change and increased anthropogenic impact on soil cover contribute to the development of various types of degradation. The threat of degradation is increasing due to desertification of the region's climate and improper functioning of irrigation systems on irrigated lands.

In modern socio-economic conditions, sustainable development of agriculture in the republic is relevant to ensure food security. Turkestan region is one of the large agricultural regions of Kazakhstan, rich in agricultural land resources. The total area of agricultural land in the region is 10,042.4 thousand hectares (as of 2023), of which arable land is 931.0 thousand hectares, of which 459.8 thousand hectares or 49.3% are irrigated lands. Turkestan region accounts for 25.3% of all irrigated lands in the Republic of Kazakhstan. In 2022, irrigated land accounted for 45% or 820.5 billion tenge of income received from the use of arable land in the country.

Irrigated lands of the Turkestan region account for 100% of cotton production, 40.8% of horticultural and vegetable crops, and 25% of corn production in the Republic of Kazakhstan.

According to data for 2024, more than 30% of the region's irrigated lands have been subject to degradation, including salinization.

In this regard, the assessment of degradation processes on irrigated lands in the region and the development of proposals for their effective use are relevant for planning agricultural production and sustainable use of agricultural land in the context of climate change. Effective use of irrigated lands contributes not only to the development of agriculture in the region, but also to improving the quality of life of the rural population.

**The aim of the dissertation** is to assess degradation processes on irrigated lands of the Turkestan region using Earth remote sensing data.

To achieve this goal, the following **tasks have been defined** :

- to determine the theoretical and methodological basis for assessing degradation processes on irrigated lands, and to conduct an analysis of assessment methods;

- to analyze the current melioration state of irrigated lands in the Turkestan region, to determine the types of degradation processes on irrigated lands and the main factors causing degradation;
- identify and map degradation processes on irrigated lands based on remote sensing data (RSD);
- to verify the results obtained on the basis of remote sensing data using field research data and to compile maps of degradation processes on irrigated lands;
- to determine the economic damage caused by degradation in key areas of the study area and to develop proposals for preventing degradation processes and restoring irrigated lands.

**Object of study** – irrigated lands of the Turkestan region.

**Subject of research** – degradation processes on irrigated lands.

**Research methods:** to determine the main factors causing degradation processes on irrigated lands of the region - in particular, excessive rise in groundwater levels and salt content in their composition, field research methods were used in accordance with the "Rules for monitoring and assessing the meliorative state of irrigated lands of the Republic of Kazakhstan and analysis of the meliorative state of agricultural lands."

In addition, during the study, an analysis of irrigated lands in the Turkestan region was conducted using satellite images of remote sensing of the Earth (RSE).

In the dissertation, remote sensing methods were widely used as an important scientific tool for monitoring the state of irrigated lands and assessing degradation processes. Remote sensing data allows for fairly accurate assessment and mapping of areas with soil salinization and erosion.

Analysis of remote sensing data makes it possible to promptly identify degraded areas, establish patterns of their spatial distribution and scientifically substantiate agro-ameliorative measures. Unlike traditional field methods, such approaches allow saving resources and provide precise control over large areas.

To assess the degree of salinization and degradation, the following vegetation indices were used: NDVI, EVI, SAVI, MSAVI, OSAVI, GSAVI, IPVI; salinization indices : NDSI, SI1, SI2, SI3, S2, S3, S4, S5, S6; and water indices: NDWI and MNDWI. The results were verified using field studies and soil sample analysis.

In addition to the above methods, the work also used monitoring observations, laboratory analyses and statistical data processing methods.

The collection of initial information was carried out on the basis of: the remote sensing database, field research materials, official statistics of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan; the Ministry of Agriculture of the Republic of Kazakhstan and its Committee for Land Resources Management; the Department of Agriculture of the regional and district levels of the Turkestan region and other organizations.

**The scientific novelty of the research is determined** by the following provisions:

For the first time in the Turkestan region, a comprehensive assessment of degradation processes on irrigated lands was carried out based on Earth remote

sensing (ERS) data, which makes it possible to determine priority areas for the rational and sustainable use of irrigated agricultural lands.

- As a result of many years of field research, the main factors causing salinization processes in the study area were identified - the level of groundwater and its chemical composition. For the first time, maps of the Myrzashol and Kyzylkum irrigated areas were compiled at a scale of 1:100,000.

- Based on the processing of long-term archival and current remote sensing data and their verification with the results of field studies, applied maps were developed for assessing the degree of soil salinity in the Myrzashol and Kyzylkum irrigated areas.

- Using remote sensing data, an automated author's model for assessing degradation processes on irrigated lands in the Turkestan region was implemented for the first time. Vegetation indices (NDVI, EVI, SAVI, MSAVI, OSAVI, GSAVI, IPV) and salinization indices (NDSI, SI1, SI2, SI3, S2, S3, S4, S5, S6) were calculated, and an analysis of the spatial distribution and temporal dynamics of salinization processes was performed.

- For the first time, economic losses caused by salinization processes of varying degrees (medium, strong and very strong) on irrigated lands have been determined. On their basis, scientifically substantiated proposals for the rational use of irrigated areas in the region have been developed.

#### **Scientific and practical value of the research.**

The practical significance of the work is determined by the possibility of solving a number of problems associated with the reduction in the productivity of irrigated lands. This is achieved by providing management structures and agricultural enterprises with specialized information, cartographic materials and scientifically based recommendations.

The study proposes effective methods for using Earth remote sensing (ERS) data to assess and monitor degradation processes on irrigated lands in the Turkestan region. The developed criteria, monitoring data and author's maps provide a comprehensive spatio-temporal analysis of the ecological state. In addition, the results of the degradation assessment and recommendations for the restoration of degraded areas serve as a scientific basis for sustainable land use and effective management of irrigated lands.

The results of the study have practical significance for the preparation of program documents for the development of agriculture in the Turkestan region, as well as for planning melioration measures and the introduction of new technologies. Thus, the work represents an important scientific and practical basis for the socio-economic development of the region and sustainable land management.

Based on the results of the dissertation, author's certificates were obtained for maps of groundwater levels, their salinization and soil salinization in the Myrzashol irrigated area (No. 61184 dated 04.08.2025, No. 61183 dated 04.08.2025, No. 61185 dated 04.08.2025).

#### **The main provisions submitted for defense:**

1. Effective management of irrigated lands of the Turkestan region should be carried out taking into account their melioration status and natural resource potential.

This will ensure scientifically sound and sustainable use of agricultural land resources.

2. Intensive use of irrigated lands without taking into account their natural and ecological capabilities leads to degradation of the soil cover, secondary salinization and a decrease in crop yields. Monitoring and assessment of such processes is an important task in the land management system.

3. The use of Earth remote sensing (ERS) methods in land management research allows for the precise determination of degradation processes in space and time and their mapping. This contributes to improved land monitoring and land resource management.

4. Degradation maps developed on the basis of remote sensing data, field studies and verification allow to substantiate management decisions on restoration of the meliorative state and rational use of irrigated lands, and also contribute to the introduction of modern digital technologies into land management practices in the Turkestan region.

5. The implementation of scientifically based recommendations for the rational use and restoration of irrigated lands, developed on the basis of remote sensing data, field research and assessment of economic losses, will contribute to ensuring sustainable development of agriculture in the Turkestan region.

#### **Connection with the plan of main scientific works and international projects**

Field research within the framework of the dissertation work was carried out within the framework of the following projects:

1. Program-targeted financing for 2023–2024 on the topic: “Scientific and applied justification for the management of natural agricultural systems to prevent desertification processes in the southern regions of Kazakhstan in order to ensure sustainable development of rural areas” (IRN: BR18574227);

2. Grant funding for 2024–2026 on the topic: “Assessment of degradation processes of irrigated lands in the Turkestan region for the purposes of sustainable land use” (IRN: AP23490857).

**Testing the work.** The main results and provisions of this dissertation research were reported and discussed:

- at the first International Geographical Congress of the Turkic World, April 18-20, 2024, Turkestan, Republic of Kazakhstan;

- at the CARIN (Central Asian Regional Information Network) seminar held from 13 to 16 September 2023 in Bishkek, Kyrgyz Republic.

- at the International Scientific and Practical Conference "Current Issues of Soil Protection and Sustainable Use of Land Resources" dedicated to the 90th anniversary of the Kazakh National University named after Al-Farabi and the 90th anniversary of the birth of Doctor of Agricultural Sciences, Professor Esbol Usinbekovich Zhamalbekov, May 17-18, 2024, Almaty, Republic of Kazakhstan.

**Publication of research results.** Only 10 scientific papers have been published on the topic of the dissertation, including:

- 3 articles in top-ranked journals included in the Scopus and Web of Science databases;

- 4 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;
- 3 articles in the materials of international conferences.

The results of the dissertation research are confirmed by author's certificates.

**Structure of the dissertation .** The dissertation consists of 141 pages, includes 26 tables and 54 figures. The structure of the work includes an introduction, 4 chapters, a conclusion, a list of 173 references and 9 appendices.