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IMPROVING GEOINFORMATION TECHNOLOGIES FOR IRRIGATED LAND MONITORING

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Abstract. This article examines modern approaches to improving geoinformation technologies in irrigated land monitoring. The role and significance of Geographic Information Systems (GIS), remote sensing data, satellite imagery, unmanned aerial vehicles, and artificial intelligence technologies in irrigated land monitoring are analyzed. The advantages of geoinformation technologies for the rapid assessment of land reclamation conditions, soil salinity levels, soil moisture, and vegetation indicators are substantiated. Furthermore, the study addresses the development of a unified digital geospatial database, the automation of monitoring processes, and the improvement of decision-making efficiency in land resource management. The research findings contribute to the effective management of irrigated land resources, prevention of land degradation processes, and promotion of sustainable agricultural development.

Keywords: irrigated lands, land monitoring, Geographic Information Systems (GIS), remote sensing, satellite imagery, geospatial database, digital monitoring, soil salinity, artificial intelligence, drone technologies.

Introduction. In today's world, digital transformation processes are encompassing all sectors of the economy, including education, healthcare, and agriculture. In particular, the introduction of digital technologies in agriculture plays a crucial role in increasing production efficiency, rational use of land and water resources, and scientifically substantiating management decisions.

Modern agro-economic and agrotechnological systems are developing based on geoinformation technologies, remote sensing data, satellite observations, and specialized software platforms. These technologies enable regular monitoring of agricultural land conditions, assessment of the composition and dynamics of cultivated areas, control of soil fertility, and improvement of water resource utilization efficiency.

In global practice, land resources are regarded as limited and strategically important natural assets. Extensive scientific research is being conducted on the digitization of cartographic data related to agricultural lands, the creation of land information systems, and the development of geospatial databases. In this context, Geographic Information Systems (GIS), remote sensing technologies, and digital land monitoring tools are recognized as modern instruments for land resource management. These approaches serve to rapidly assess the condition of the land fund, identify degradation processes, forecast the efficiency of land use, and ensure the sustainable management of land resources [5].

In the modern agro-industrial system, digital technologies and software solutions play a decisive role in effectively organizing agricultural production, conserving resources, making data-driven decisions, and improving product quality. Every country is implementing smart solutions and innovative software platforms for agricultural development in accordance with its natural, economic, climatic, and social conditions [5, 6]. This process manifests itself in the following main directions:

1. Efficient management of land resources
2. Automation of irrigation and agrotechnical processes
3. Digitization and analysis of data
4. Monitoring and control systems
5. Economic and social impact

During the research, Professor S. Avezbayev, who has conducted studies on the automation and digitization of data, emphasized that “In the field of land management, automatic data processing (recording, analysis, and decision-making) is essential because traditional manual methods have low efficiency and a high probability of errors.” Additionally, Professor R.A. Turayev has placed special emphasis on improving the methodology of land monitoring based on modern digital technologies [1, 2, 3, 4].

Our research has shown that the difference in economic efficiency between irrigated and rainfed lands is manifested not only in productivity levels but also in investment requirements, the efficiency of water resource use, and long-term sustainability indicators. This situation further strengthens the relevance of the research topic and necessitates the search for ways to increase the efficiency of irrigated land use.

1-table

DYNAMICS OF CHANGES IN CULTIVATED AREAS IN THE REPUBLIC OF UZBEKISTAN FOR 1996–2026 (THOUSAND HA)

Land Type	1996 yil	2006 yil	2016 yil	2026 yil	Relative to 2026	
					1996	2006
Total Cultivated	4 476	4 450	4 040,8	4 046,7	-429,3	-403,3
AreasOf which Irrigated	4 223	4 198	3 284,5	3 278,4	-944,6	-919,6

***Note**: * – Source: Cadastre Agency under the National Committee for Urbanization and Sustainable Development of the Housing Market of the Republic of Uzbekistan, 2026.*

Table Analysis. The table analysis shows that in recent decades, particularly during 2016–2026, the area of irrigated croplands has demonstrated a steady declining trend. From 1996 to 2026, the total reduction in irrigated land amounted to 129.0 thousand hectares, while over the last 20 years (approximately 2006–2026), about 45.1 thousand hectares of irrigated cropland have been withdrawn from agricultural circulation across the Republic. This is equivalent to an average annual loss of 2.25–2.5 thousand hectares of irrigated land.

The main reasons are as follows:

- ✓ Reduction of water resources due to natural and anthropogenic factors;
- ✓ Physical wear and deterioration of the technical condition of irrigation networks and hydro-technical structures;
- ✓ Decline in the meliorative condition of lands (salinization, waterlogging, erosion);
- ✓ Insufficient water supply and disruption of irrigation regimes.

This process significantly limits the possibilities for efficient use of land resources in the agricultural sector and negatively affects the sustainability of agricultural production. Given the high economic efficiency of irrigated lands (the value of products obtained from 1 hectare of irrigated land is equivalent to that from 10–12 hectares of

rainfed land), their reduction poses a serious threat to the country's food security, export potential, and income sources for the rural population.

Conclusion. The results of the conducted research indicate that digital transformation processes are one of the important factors in increasing the efficiency of land resource use in the agricultural sector. Geographic Information Systems (GIS), remote sensing data, satellite observations, and modern software platforms provide opportunities for rapid assessment and monitoring of land resources, as well as scientifically based management decisions.

The analysis revealed a declining trend in both total cultivated areas and irrigated land areas in the Republic of Uzbekistan. In particular, the area of irrigated land has significantly decreased during 1996–2026, a situation explained by water scarcity, deterioration of irrigation systems, worsening meliorative condition of lands, and anthropogenic factors. The reduction of irrigated land can negatively impact the volume of agricultural production, food security, and the economic sustainability of the agrarian sector.

The study substantiates that the digitization and automation of irrigated land monitoring is one of the most promising directions for improving the efficiency of land resource management. Monitoring systems built on modern information technologies enable the assessment of the meliorative condition of lands, identification of salinization and degradation processes, optimization of water resource use, and forecasting of changes in the land fund.

Proposals

1. It is advisable to introduce a unified digital monitoring system based on GIS, remote sensing, and satellite data for monitoring irrigated lands.
2. It is necessary to expand monitoring mechanisms based on Sentinel and Landsat data for regular control of the meliorative condition of lands, salinization levels, and soil moisture.
3. Existing data on irrigated lands should be consolidated in a unified geospatial database and integrated with the information systems of the Cadastre, Water Management, and Melioration organizations.
4. It is recommended to develop forecasting models using artificial intelligence and machine learning technologies to identify the factors causing the reduction of irrigated lands and to eliminate them.

5. To increase the efficiency of water resource use, it is necessary to expand the implementation of water-saving technologies such as drip irrigation, sprinkler irrigation, and others.

6. Modernization of irrigation networks and collector-drainage systems is required to improve the meliorative condition of lands and reduce the area of lands being withdrawn from agricultural circulation.

7. Integrating the results of land monitoring into management decision-making processes at regional and republican levels can enhance the economic efficiency of land resource use.

8. It is advisable to strengthen the training of specialists in geoinformation technologies, digital land monitoring, and remote sensing in higher education and research institutions.

Thus, improving the monitoring of irrigated lands based on digital technologies is an important scientific and practical direction for ensuring rational use of land and water resources, improving meliorative conditions, and achieving sustainable development of agricultural production.

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