AGRICULTURAL LAND MONITORING USING GEOINFORMATION SYSTEMS

Abdiraxmatov Nuriddin Abdiraxmatovich
Karshi State Technical University
Email: nabdiraxmatov@bk.ru

Sharipova Zamira Ahad qizi
Student of Karshi State Technical University
Email: axadovnazamira9@gmail.com

Abstract: This article examines the theoretical and practical aspects of agricultural land monitoring using geoinformation systems and remote sensing technologies. The study analyzes the role of GIS-based tools in assessing the current condition, structure, and efficiency of agricultural land use, with particular emphasis on the integration of cartographic, spatial, digital, and visual data. Real-time monitoring methods based on satellite imagery and unmanned aerial vehicle technologies are considered as effective instruments for the operational collection and processing of large-scale geospatial information. The research evaluates the effectiveness of GIS applications in resource management, including the vectorization of land plots, identification of cultivated areas, detection of overgrown and degraded lands, and assessment of land cover dynamics. Special attention is given to the development of recommendations for rational land use, transition to precision and organic agriculture systems, and improvement of decision-making processes in agro-industrial management. The results demonstrate that the implementation of geoinformation technologies significantly enhances the accuracy, efficiency, and sustainability of agricultural land monitoring and management.

Keywords: Geoinformation systems (GIS), agricultural land monitoring, remote sensing, satellite imagery, unmanned aerial vehicles (UAV), precision agriculture, land resource management.

Introduction

Rational use of agricultural land plays a decisive role in ensuring regional food security and sustainable development of the agrarian sector. The Kashkadarya region is one of the major agricultural territories of Uzbekistan, characterized by irrigated farming systems, rainfed lands, and extensive pasture areas. The sharply continental climate, limited water resources, risks of soil salinization, erosion, and land degradation necessitate scientifically grounded approaches to the management and monitoring of agricultural lands. Under these conditions, the implementation of geoinformation systems and remote sensing technologies becomes an essential tool for effective land resource management.

In the context of ongoing economic reforms and transformation of land relations, a number of challenges have emerged in the use of agricultural lands. These include inefficient utilization of arable areas, expansion of abandoned and fallow lands, overgrowth of agricultural plots with shrubs and natural vegetation, and incomplete or outdated cadastral records. In certain areas of Kashkadarya region, insufficient compliance with scientifically justified crop rotation systems and excessive application of agrochemicals have contributed to soil fertility decline and ecological imbalance. The absence of comprehensive and up-to-date spatial analysis complicates the identification of degraded lands and the assessment of their current condition.

Traditional methods of land inventory and control are no longer sufficient to provide timely and accurate information about the dynamics of agricultural land use. Modern GIS technologies enable the integration of cartographic, textual, numerical, and visual data into unified spatial databases, allowing for comprehensive analysis and monitoring at different levels of spatial hierarchy — from regional to local scales. The main advantage of GIS lies in its ability to collect, store, process, analyze, and visualize geospatial information, supporting both analytical and monitoring tasks.

The application of remote sensing data, including satellite imagery and unmanned aerial vehicle technologies, provides opportunities for real-time monitoring of land cover changes, identification of unused and inefficiently used lands, and assessment of degradation processes. The vectorization of land plots, classification of land cover types, and spatial analysis of agricultural territories make it possible to determine the structure of cultivated areas, detect overgrown or abandoned plots, and evaluate the effectiveness of land use in different districts of Kashkadarya region.

Thus, the integration of geoinformation systems into agricultural land management forms the basis for scientifically justified decision-making, optimization of land use structure, and transition toward precision and resource-efficient agriculture. The present study aims to assess the effectiveness of agricultural land monitoring in Kashkadarya region based on remote sensing data and GIS technologies, as well as to develop recommendations for improving land resource management and ensuring sustainable agricultural development.

Materials and Methods

Modern agricultural production in Kashkadarya region requires a comprehensive inventory and assessment of natural, agricultural, organizational, technological, economic, and labor resources, particularly in relation to land use and crop production. The heterogeneity of ecological and biotic conditions, significant differences in field size and configuration, variability of soil cover and fertility, and instability of production indicators determine the necessity of advanced spatial analysis tools for effective land management.

Agricultural producers frequently encounter informational and analytical challenges, including the need for detailed and up-to-date data on field conditions and crop status; rapid response to unfavorable processes in different parts of farms; time-sensitive field operations; and limited technical and labor resources. These factors often lead to organizational inefficiencies and suboptimal decision-making,

resulting in reduced yields, soil degradation, and negative environmental impacts. Therefore, the rapid collection, processing, and analysis of spatial data on agricultural lands form the methodological basis for the transition toward precision and resource-efficient farming systems in the region.

The present study is based on the application of geoinformation systems and remote sensing technologies for monitoring and assessment of agricultural lands in Kashkadarya region. The research integrates satellite imagery, unmanned aerial vehicle data where available, digital cartographic materials, and official statistical data. Spatial datasets were processed within a GIS environment to create digital terrain maps integrated with spatial databases, enabling interactive visualization and analysis of agricultural land use.

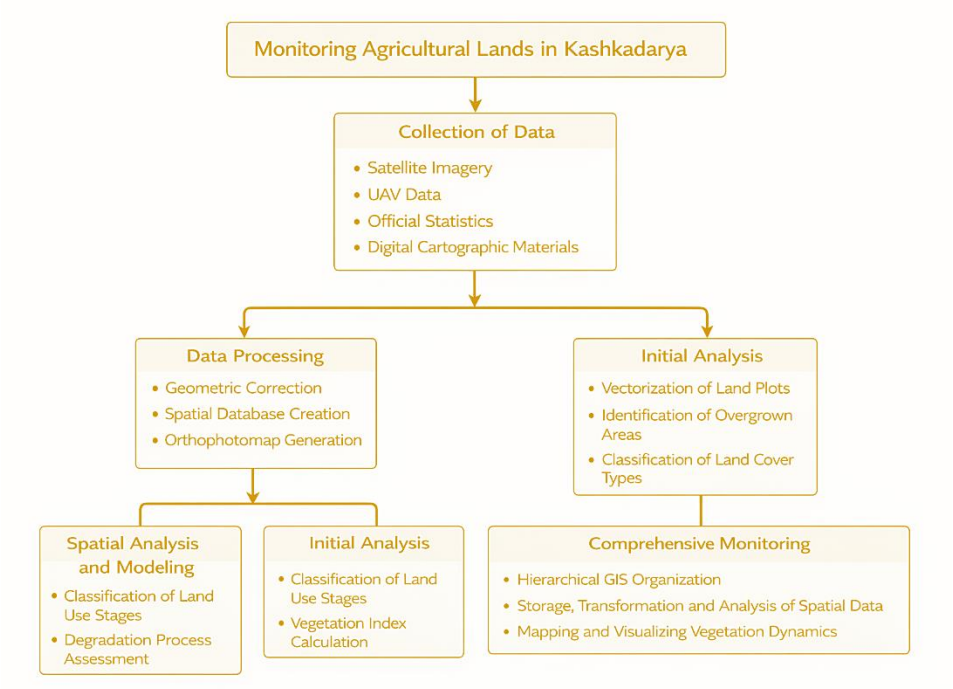

Figure 1. Block diagram of the GIS-based methodology for monitoring agricultural lands in Kashkadarya region.

The GIS framework applied in this research was designed to address two principal tasks in near real-time: the creation and updating of digital land-use maps with integrated spatial databases, and the visualization and analytical interpretation of these maps for decision-making purposes. The system performed a range of

general and specialized functions, including processing of remote sensing data; application of photogrammetric and cartographic methods; spatial data analysis; development and maintenance of thematic spatial databases; and construction of vector and raster maps of agricultural lands.

Special attention was given to the identification and classification of land cover types, vectorization of agricultural plots, detection of overgrown and fallow lands, and analysis of degradation processes. Digital orthophotomaps were generated where applicable, and spatial terrain models were used to evaluate topographic influences on land use patterns. Agricultural lands were analyzed on the basis of GIS maps combined with the results of statistical and analytical assessments.

Structurally, the applied GIS represents a hierarchically organized electronic cartographic system integrating cartographic, textual, numerical, and visual information. The system operates with vector, raster, and matrix data formats, allowing for flexible transformation, editing, and visualization of spatial information. Digital data were converted and processed in different formats to ensure compatibility and analytical efficiency.

The methodological approach included statistical analysis, spatial modeling, and photogrammetric interpretation of remote sensing data. The stages of land overgrowth, land use inefficiency, and spatial distribution of agricultural resources within Kashkadarya region were determined through integrated GIS-based analysis. This комплекс methodological framework ensured comprehensive monitoring and objective assessment of the current state and dynamics of agricultural lands in the study area.

Results

Remote sensing data proved to be one of the most efficient and reliable sources of obtaining up-to-date semantic information on agricultural land parcels in Kashkadarya region. The use of high-resolution satellite imagery ensured operational data acquisition characterized by speed, objectivity, and spatial accuracy

throughout the vegetation period. Multi-temporal satellite data enabled continuous monitoring of arable lands and assessment of their current qualitative condition.

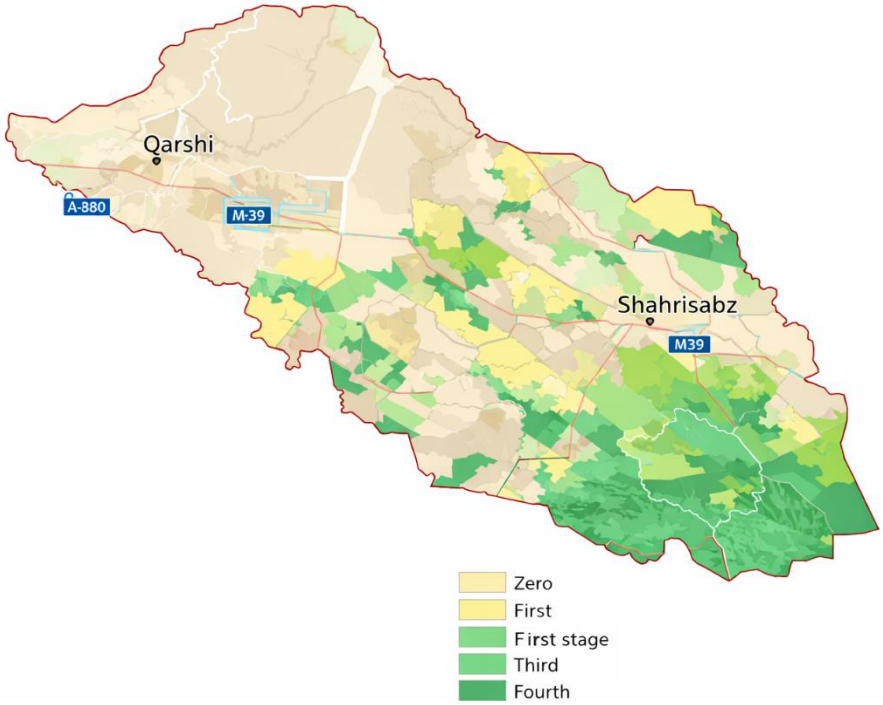

Figure 2. The map of agricultural land overgrowth stages in Kashkadarya region.

At the initial stage of the study, orthophotographic materials and satellite images of the selected agricultural territories were processed within a GIS environment. Spatial data were geometrically corrected using reference coordinate systems and ground control points, ensuring accurate spatial alignment. The transformation of images included distortion control and affine correction where necessary. Subsequent vectorization of agricultural land parcels was carried out through visual interpretation and automated classification procedures in the GIS platform.

Table 1. Classification of Agricultural Land Overgrowth Stages in Kashkadarya Region

Stage	Vegetation Characteristics	Spectral / GIS Indicators	Land Use Status

Zero Stage	No visible overgrowth; active agricultural cultivation.	High NDVI uniformity; regular field boundaries; absence of woody vegetation in false color composites.	Fully utilized for crop production.
First Stage	Initial shrub and young tree growth; projective cover up to 10%.	Slight NDVI variability; light red tones in false color imagery; minor texture heterogeneity.	Partially utilized; early signs of underuse.
Second Stage	Formation of small woody clusters and shrub thickets; density up to 20%.	Moderate NDVI increase in patches; visible textural fragmentation; mixed spectral response.	Inefficient use; temporary abandonment likely.
Third Stage	Significant increase in shrubs and trees; formation of layered vegetation structure.	High NDVI values; darker red tones in false color composites; strong spatial heterogeneity.	Long-term underutilization; productivity decline.
Fourth Stage	Dense woody vegetation approaching closed canopy conditions.	Very high NDVI; uniform dark red signature in NIR composites; absence of cultivated patterns.	Land withdrawn from active agricultural turnover.

The latest state of agricultural lands was assessed using multi-temporal satellite datasets, including freely available Earth observation resources. The interpretation of fallow and degraded lands was based on spectral response analysis and textural characteristics of vegetation cover. Since fallow lands often demonstrate heterogeneous vegetation patterns, their identification required comparison of

images from different dates and analysis of vegetation indices. Spectral vegetation indices, including NDVI, were applied to evaluate biomass density, plant vigor, and spatial variability of crop conditions.

False color composite analysis was used to detect degradation processes associated with overgrowth of arable lands by herbaceous and woody vegetation. The near-infrared spectral band combined with red and green channels allowed clear differentiation between cultivated lands, dense vegetation, bare soil, and built-up areas. Areas with dense vegetation appeared in darker red tones, while open soil and anthropogenic surfaces were represented in grey or brown shades. This method significantly improved the reliability of visual interpretation.

Based on the integrated GIS analysis, stages of agricultural land overgrowth were identified and mapped within Kashkadarya region. The following classification was established:

- Zero stage: no visible signs of overgrowth; land actively used for its intended agricultural purpose.
- First stage: initial appearance of shrubs and young tree growth with projective cover not exceeding approximately 10%; herbaceous vegetation remains dominant.
- Second stage: formation of small clusters of woody undergrowth and shrub thickets with vegetation density up to about 20%.
- Third stage: significant increase in tree and shrub density, formation of a multi-layer vegetation structure, and active competition between species.
- Fourth stage: development of dense woody vegetation close to closed canopy conditions, indicating long-term abandonment.

A thematic digital map of overgrowth stages was developed, allowing quantitative assessment of the spatial distribution of degraded and fallow lands. The GIS calculation modules enabled the determination of the area of cultivated lands, actively used fields, and fallow territories at different degradation stages.

The results demonstrate that a considerable portion of agricultural land in certain districts of Kashkadarya region is affected by varying degrees of underutilization and overgrowth. The spatial analysis revealed that early stages of degradation are predominantly associated with insufficient land management and temporary abandonment, whereas advanced stages correspond to prolonged non-use.

The integration of GIS technologies with remote sensing data provided comprehensive analytical capabilities, including:

- accurate delineation of cultivated fields and land-use structure;
- monitoring of crop development from sowing to harvesting; assessment of vegetation condition and biomass using spectral indices;
- identification of environmental risks such as drought impact and soil degradation;
- estimation of potential productivity and support for decision-making in land resource management.

Conclusion

The conducted research confirms that the integration of geoinformation systems and remote sensing technologies significantly enhances the efficiency, objectivity, and analytical depth of agricultural land monitoring in Kashkadarya region. The use of multi-temporal satellite imagery, vegetation indices, orthophotomaps, and spatial databases enabled accurate identification of cultivated, underutilized, and overgrown lands. The developed GIS-based classification of overgrowth stages provided a structured assessment of land degradation processes and allowed the spatial differentiation of agricultural territories according to their qualitative condition. The obtained results demonstrate that GIS technologies form a reliable scientific basis for improving land resource management, optimizing land-use structure, and supporting decision-making at regional and local levels. The implementation of digital monitoring tools contributes to the restoration of unused

lands into agricultural turnover, increases transparency of land control mechanisms, and facilitates the transition toward precision and resource-efficient agriculture. Overall, the proposed methodological approach ensures sustainable agricultural development and rational utilization of land resources in Kashkadarya region.

References

1. Burrough P.A., McDonnell R.A., Lloyd C.D. Geographical Information Systems and Science. Harlow, Pearson Education, 2015, 610 p.
2. Longley P.A., Goodchild M.F., Maguire D.J., Rhind D.W. Geographic Information Science and Systems. Hoboken, John Wiley and Sons, 2015, 540 p.
3. Lillesand T.M., Kiefer R.W., Chipman J.W. Remote Sensing and Image Interpretation. New York, John Wiley and Sons, 2015, 736 p.
4. Campbell J.B., Wynne R.H. Introduction to Remote Sensing. New York, Guilford Press, 2011, 667 p.
5. Jensen J.R. Introductory Digital Image Processing: A Remote Sensing Perspective. Upper Saddle River, Prentice Hall, 2016, 544 p.
6. Weng Q. Remote Sensing and GIS Integration: Theories, Methods, and Applications. New York, McGraw-Hill, 2010, 397 p.
7. Mulla D.J. Twenty five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps // Biosystems Engineering, 2013, Vol. 114, No. 4, pp. 358–371.
8. Zhang C., Kovacs J.M. The application of small unmanned aerial systems for precision agriculture: A review // Precision Agriculture, 2012, Vol. 13, No. 6, pp. 693–712.
9. Tucker C.J. Red and photographic infrared linear combinations for monitoring vegetation // Remote Sensing of Environment, 1979, Vol. 8, No. 2, pp. 127–150.
10. Foody G.M. Status of land cover classification accuracy assessment // Remote Sensing of Environment, 2002, Vol. 80, No. 1, pp. 185–201.

11. Eastman J.R. IDRISI and GIS modeling for land-use change analysis // Clark Labs Technical Report, Worcester, 2016, 45 p.
12. FAO. The State of the World's Land and Water Resources for Food and Agriculture. Rome, Food and Agriculture Organization of the United Nations, 2011, 285 p.
13. FAO. Guidelines for Land Use Planning. Rome, Food and Agriculture Organization of the United Nations, 1993, 96 p.
14. Congalton R.G., Green K. Assessing the Accuracy of Remotely Sensed Data: Principles and Practices. Boca Raton, CRC Press, 2019, 328 p.
15. United Nations. Sustainable Development Goals Report 2023. New York, United Nations Publications, 2023, 64 p.