
ASSESSING THE EFFECTIVENESS OF IRRIGATED LAND USE IN THE AMUDARYA DISTRICT THROUGH DIGITAL TECHNOLOGIES

Kurvantayev Raxmon

Doctor of Agricultural Sciences, Professor [0000-0001-8731-4376]

Institute of Soil Science and Agrochemical Research

Djumabekova Nilufar Masharipova

Senior Lecturer [0009-0002-3494-1899]

Tashkent State Agrarian University

Abstract

This article highlights the importance and prospects of applying Geographic Information System (GIS) technologies in the rational and efficient use of land resources in the Amudarya district. The study analyzes the capabilities of GIS for the digitalization of land plots, monitoring processes, optimizing the placement of agricultural crops, and early detection of environmental problems.

Keywords: GIS technologies, land resources, digital mapping, cadastre, monitoring, satellite imagery, crop productivity, water resource management, environmental monitoring, soil salinization, digital agriculture, agrotechnics, soil fertility.

Introduction

Effective use of irrigated land resources is one of the most pressing issues in the agricultural sector today. Global climate change, water scarcity, and soil degradation require rational land resource management in the regions [1; 2018; 2; 2022]. Irrigated lands in the Amudarya district are an important part of the district's economy, and their effectiveness is closely related to national food security and the stability of agricultural production [3; 2019).

The use of modern digital technologies - geographic information systems (GIS), remote sensing (DM), drone monitoring, and analysis models based on artificial intelligence - makes it possible to determine the state of irrigated lands, manage water resources, and predict yields [4; 2022]. Therefore, the assessment and improvement of the efficiency of land resources in the region through digital monitoring is relevant from a scientific and practical point of view [5; 2020]. The system, created for monitoring irrigated lands in the Amudarya district, will function as an interactive and digital management platform. The main goal of this geoportal is to effectively manage agricultural resources in the region, optimize water supply and productivity, as well as determine environmental indicators such as heat stress and soil moisture. The system was formed as a database in the ArcGIS Pro program, and the final visualization was carried out through the ArcGIS Online Dashboard (Fig. 1).



Figure 1. Data visualization main window

The internal components of the system are:

1. District boundary and contour base: This layer represents the district territory in a polygon form and ensures coordination with all other layers. The contour database serves not only as a regional referent but also as the primary database for linking data with attributes and conducting statistical analysis.
2. Satellite indices (NDVI, NDMI, LST): allow for the assessment of such indicators as vegetation status, soil moisture, and surface temperature using digital indicators. This data is calculated on the Google Earth Engine platform and then integrated into ArcGIS Pro.
3. The layer of irrigated and non-irrigated lands is determined by the intersection of the NDVI and NDMI indices. This layer is converted from a raster into a vector, and irrigated areas are depicted in green and non-irrigated areas in red (Fig. 2).



Figure 2. Base of irrigated and non-irrigated contours



1. Layer of land types: Rice, gardens, lakes and other lands are distinguished by special colors. This layer allows for the analysis of the area, distribution of crop species, and land resources in the territory of the district (Fig. 3).



Figure 3. Land type base (Other lands are lands without allocation of crop types)

1. Dynamics of NDVI: allows tracking the state of vegetation and crop potential in the period 2020-2024. This section is important for analyzing annual trends, yield diagnostics, and irrigation efficiency (Fig. 4).



Figure 4. Diagram window showing NDVI dynamics

1. LST dynamics: analyzes indicators of surface temperature and allows determining areas of thermal stress and water scarcity. These values are the main source for planning irrigation strategies (Fig. 5).

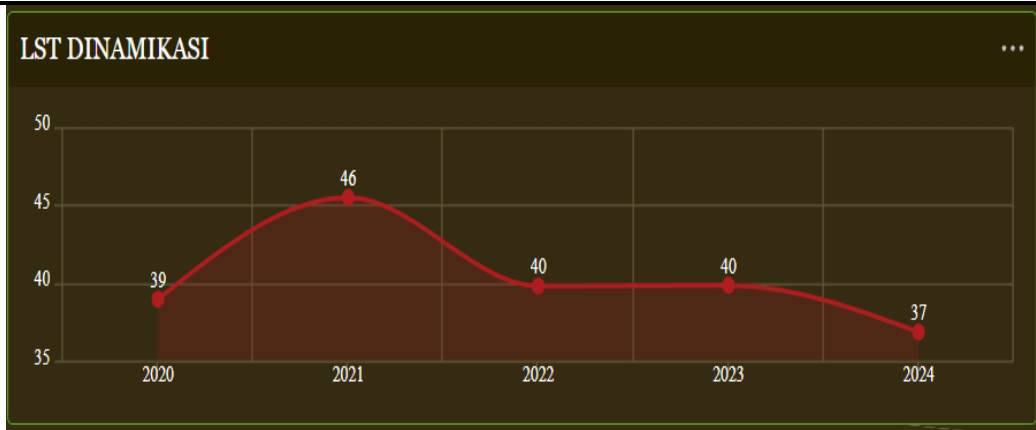


Figure 5. LST dynamics graph window

1. Geodigital database and attributes: Each contour contains attributes such as NDVI, NDMI, LST, land type, and irrigated areas. This data is used to generate analysis, reports, and trend graphs.
2. Dashboard Visual Interface: Works interactively through the ArcGIS Online platform. The user can view the district boundary and all layers, obtain statistical data on land types, monitor the NDVI and LST graphs, and prepare reports. This interface provides real-time monitoring and quick decision-making (Fig.6).



Figure 6. Interface of the irrigated land monitoring system

Future prospects and directions of system functional expansion.

The created geoportal for monitoring irrigated lands allows for dynamic monitoring of the vegetation state, water dependence, and thermal stress of sown areas based on satellite indices. However, the main goal of the system is not only observation, but also automation of decision-making processes based on digital analysis and increasing production efficiency. Therefore, in the future, the system will be functionally expanded and enriched with scientific models. Below are the main promising directions proposed based on the existing concept.

The first important direction is the development of a crop diagnostics module. This module allows for the assessment of the physiological state of plants through the reflective properties of vegetative biomass in the red ranges using the NDRI (Normalized Difference Redness Index) indicator. NDRI, being more sensitive to detecting changes in pigmentation and photoactive areas compared to NDVI, helps to identify stressed areas early. The diagnostic model is linked to historical yield data, agrotechnical measures, soil fertility, and water supply monitoring. The final result is the approximate value of profitability at the end of the season for each contour, which will help the farmer make a decision.

The second direction is the classification of crop types and the integration of the water consumption model. Although the current system tracks the state of vegetation by indices, the exact type of crop is not automatically identified. A solution to this problem is proposed by applying machine learning algorithms (Random Forest, SVM, LSTM) based on the spectral series Sentinel-2, PlanetScope, and MODIS. Depending on the agro-climatic conditions and water requirements of each crop type, a balance model of annual water consumption is constructed. Through this model, it is determined how much water was supplied to each area, how much reached the field, how much was lost, and which areas are consuming excess water. As a result, the possibility of rational use of resources in planning irrigation policy increases.

The third direction is the module for determining the degree of salinity. Based on the indices obtained from LST, NDMI, specific electrical conductivity, soil temperature, and the SWIR spectra of Landsat 8/9, a cartogram of saline areas is compiled. Timely monitoring of salinity is important for assessing the effectiveness of land reclamation measures and identifying the consequences of improper water resource management. With the help of this module, it will be possible to develop recommendations for drainage, flushing, irrigation, or crop rotation to high risk zones.

The fourth and most relevant area is the creation of a decision support system that recommends the most suitable crop type based on the contour state. The system develops a point index based on factors such as agroclimatic boundaries, soil granulometric composition, average NDVI, water supply, balance, salt content, average temperature, and agricultural history. With the help of this index, crops corresponding to the region are presented on a rating basis. For example, alfalfa and peas can be recommended for water-scarce areas; sorghum and rice for saline areas; and grain and cotton for high-yielding areas.

At the final stage, the entire system works automatically based on the principle of servers-free models in integration with ArcGIS Online. Data is updated in real time, and users access it through the web interface. In the future, the system will also be implemented in the format of a mobile application and will provide online consultations in field conditions.

In conclusion, it can be said that GIS technologies are not only a convenient management tool for the Amudarya district, but also a strategic tool for combating such problems as water scarcity, salinization, and climate change in its difficult

environmental conditions. The development and implementation of these technologies will not only increase the efficiency of local agriculture, but will also create valuable scientific and practical experience and a model for the entire Aral Sea region.

References

1. Abdullaev A. Sustainable development of agricultural lands and their monitoring. - Тошкент, "Фан," 2018. - 150 p.
2. Abdullaev A. Efficiency of Irrigated Land Resource Use: A Digital Technology Approach. Science and Technology. -Tashkent, 2022.- 128 p.
3. Karimov S. Water Resources Management and Monitoring in Agriculture. - Тошкент, 2020. - 120 p.
4. Yusupov A. Assessment of land efficiency based on geographic information systems and NDVI. - Тошкент: ЎЗМУ, 2022. - 105 p.
5. Shomurodov H. Monitoring and optimization of land resources in the Amudarya district. - Тошкент: "Fan," 2020. - 120 p.