

Potential of the “Buxoro Agroecogis” Geoportal For Monitoring and Environmental Assessment of Irrigated Lands In Bukhoro District

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Abstract:

The article examines the potential application of geoinformation technologies for monitoring and environmental assessment of irrigated lands in Bukhoro District, Bukhara Region, Republic of Uzbekistan. The main objective of the study is to substantiate the functional capabilities of the specialized “Buxoro AgroEcoGIS” geoportal, designed for the spatial visualization, systematization, and analysis of data on the condition of agricultural lands. The main monitoring objects include soil cover, degree of salinity, agrochemical indicators, groundwater levels, the condition of the collector-drainage network, land use, and the condition of agricultural vegetation. The methodological framework of the study comprises geoinformation analysis, spatial modeling, cartographic methods, analysis of Earth observation data, and integrated environmental assessment. It is demonstrated that the use of the geoportal makes it possible to integrate heterogeneous spatial and attribute data within a unified digital environment. This is particularly relevant for Bukhoro District due to the long-term use of irrigated lands and the presence of soil salinization processes and changes in the soil water-salt regime. Based on an analysis of existing studies, a structure of thematic layers and functional modules for the geoportal is proposed. It is concluded that “Buxoro AgroEcoGIS” can be used as a tool for operational monitoring, identification of environmental risk zones, and decision support in the rational management of land and water resources.

Keywords: geoportal, GIS, Buxoro AgroEcoGIS, Bukhoro District, irrigated lands, environmental monitoring, soil salinization, groundwater, remote sensing, agricultural lands.

Introduction

Rational use of land resources is one of the most important conditions for the sustainable development of agriculture in arid regions. This issue is of particular importance for Bukhara Region, where a significant proportion of agricultural production is based on irrigated agriculture. Under such conditions, soil condition directly depends on irrigation regimes, water quality, groundwater depth, drainage efficiency, and patterns of land use.

Bukhoro District is one of the areas where long-term agricultural use of irrigated lands is accompanied by changes in the soil water-salt regime. Modern studies conducted directly in Bukhoro District indicate that, in irrigated meadow-alluvial soils, the content of total dissolved solids in the

investigated soil layers ranged from 0.330 to 1.495%, while pH values ranged from 7.8 to 8.5. In most of the investigated soil profiles, salt accumulation was observed in the lower layers under the influence of groundwater.

A separate study conducted in 2025 also focused directly on the irrigated soils of Bukhoro District and examined their texture, fertility, salinity, groundwater conditions, and reclamation characteristics.

The problem of salinization has a broader regional context. According to a study of the condition of irrigated lands in Bukhara Region in 2021, out of 275.03 thousand hectares of irrigated land, 237.113 thousand hectares were classified as saline to varying degrees. According to the table presented in that study, Bukhoro District had 30,280 hectares of irrigated land, of which 3,394 hectares were classified as non-saline and 26,915 hectares as saline; the proportions by salinity category were 2.0%, 22.3%, and 64.6%, respectively.

Consequently, environmental assessment of the lands of Bukhoro District should be carried out not only on the basis of individual field surveys but also through the use of modern digital technologies capable of analyzing the spatial structure and dynamics of environmental processes.

One promising solution is the development of a specialized “Buxoro AgroEcoGIS” geoportal focused specifically on the territory of Bukhoro District.

Materials and Methods. The study was conducted with reference to the territory of Bukhoro District, Bukhara Region, Republic of Uzbekistan.

The initial information base consisted of published materials on the condition of irrigated lands in Bukhoro District and Bukhara Region, soil research results, information on salinity, data on land-reclamation conditions, and modern approaches to the application of GIS technologies.

Of particular importance to the study are the results of recent soil investigations conducted directly in Bukhoro District. These studies examined irrigated soils and their agrophysical characteristics and proposed measures for preserving and improving soil fertility.

The proposed “Buxoro AgroEcoGIS” system is based on the principle of integrating spatial and attribute data.

Each land parcel may be assigned a unique identifier linked to a set of its characteristics.

For Bukhoro District, the following main GIS layers are proposed:

1. administrative boundaries of the district;
2. settlements;
3. agricultural lands;
4. irrigated lands;
5. soil cover;
6. degree of salinity;
7. groundwater;
8. collector-drainage network;
9. irrigation canals;
10. agricultural crops;
11. remote sensing data;
12. environmental risk zones.

The integration of these layers makes it possible to perform multifactor spatial analysis.

Satellite information can be used for monitoring agricultural lands.

One of the most widely used indicators is the Normalized Difference Vegetation Index (NDVI):

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED}),$$

where:

NIR — reflectance in the near-infrared band;

RED — reflectance in the red band.

The spatiotemporal dynamics of NDVI can be used to identify areas where vegetation condition is deteriorating.

However, the interpretation of satellite data should be performed in conjunction with ground observations, since a decrease in NDVI may be associated not only with salinity but also with insufficient moisture, changes in cropping patterns, plant diseases, and other factors.

For Bukhoro District, the following indicators are proposed as the most significant:

- ❖ degree of soil salinity;
- ❖ groundwater depth;
- ❖ groundwater mineralization;
- ❖ drainage condition;
- ❖ humus content;
- ❖ vegetation condition;
- ❖ irrigation efficiency.

Results. An analysis of published data indicates that salinization is one of the key factors that must be considered in the environmental assessment of the lands of Bukhoro District.

According to data from a study of irrigated lands in Bukhara Region, the area of irrigated lands in Bukhoro District amounted to 30,280 hectares, of which 26,915 hectares were classified as saline to varying degrees. The area classified as non-saline was reported as 3,394 hectares.

These data demonstrate that spatial monitoring of salinity in Bukhoro District is of considerable practical importance.

At the same time, recent soil studies conducted directly in the district confirm the presence of salt accumulation processes within the soil profile. For the investigated irrigated meadow-alluvial soils, total dissolved solids values of 0.330–1.495% and pH values of 7.8–8.5 were established, with salinity predominantly associated with sodium-sulfate composition and, in some deeper layers, with sulfate-chloride composition.

Based on the analysis conducted, the following structure of the geoportal is proposed.

One of the principal functions of the geoportal should be the creation of a digital soil salinity map.

For each land parcel, the following categories may be displayed on the map:

- ❖ non-saline;
- ❖ slightly saline;
- ❖ moderately saline;
- ❖ highly saline;
- ❖ extremely saline.

A corresponding color scheme can be developed according to these categories.

Such a representation makes it possible to visually identify the spatial distribution of problematic lands.

Groundwater depth is one of the key factors contributing to the development of secondary salinization.

It is therefore advisable to create a separate layer of observation wells within the geoportal.

For each observation point, the following information may be stored:

- ❖ coordinates;
- ❖ observation date;
- ❖ groundwater depth;
- ❖ mineralization;
- ❖ temperature;
- ❖ chemical composition;
- ❖ temporal dynamics.

In the future, groundwater-depth contour maps can be generated to identify areas with potential environmental risk.

The use of satellite data time series is particularly promising. If a persistent decline in vegetation indices is observed at a particular site over several growing seasons while deterioration of land-reclamation indicators is simultaneously recorded, the site may be classified as a high-risk area.

Studies of the Bukhara region indicate that the problem of irrigated lands is associated with a combination of an arid climate, high evaporation, groundwater rise, and soil salinization. Research covering the period from 2000 to 2013 identified problems related to water resources, rising groundwater levels, and widespread soil salinization in the region.

Therefore, for Bukhoro District it is particularly important not only to record the existing condition of soils but also to identify spatial patterns and predict the development of degradation processes.

The potential of GIS applications for irrigated land management is also supported by broader studies of the Bukhara region. Recent studies have applied GIS for hydromodule zoning of irrigated lands and optimization of water-saving technologies.

From a practical perspective, “Buxoro AgroEcoGIS” can be used by:

- ❖ land-resource specialists;
- ❖ water-management specialists;
- ❖ agronomists;
- ❖ soil scientists;
- ❖ environmental specialists;
- ❖ research organizations;
- ❖ territorial administrative authorities.

A separate interface can be developed for each category of users.

For example, an agronomist requires information on crop condition and soil moisture, a land-reclamation specialist requires information on groundwater, salinity, and the drainage network, while an environmental specialist requires information on the integrated environmental condition of the territory.

Conclusion. The study demonstrates that the development and application of the “Buxoro AgroEcoGIS” geoportal can become an effective tool for digital monitoring and environmental assessment of irrigated lands in Bukhoro District.

The relevance of the geoportal is particularly high due to the presence of soil salinization processes and changes in the soil water-salt regime in the district. Published studies conducted directly

in Bukhoro District confirm the accumulation of salts within the soil profile, an alkaline soil reaction, and the influence of groundwater on the lower soil horizons.

The main functional capabilities of the proposed system include:

1. creation of a digital land-use map of Bukhoro District;
2. development of a database on soil condition;
3. mapping of soil salinity levels;
4. groundwater monitoring;
5. analysis of the condition of the collector-drainage network;
6. integration of satellite data;
7. monitoring of agricultural crops;
8. calculation of an integrated environmental index;
9. identification of environmental risk zones;
10. generation of analytical maps and reports.

Of particular importance is the possibility of integrating remote sensing data, field observations, and laboratory analyses within a unified geoinformation environment.

In the future, it would be advisable to supplement “Buxoro AgroEcoGIS” with modules for automated satellite image processing, mobile field monitoring, salinity forecasting, groundwater dynamics analysis, and the generation of automated management recommendations.

Thus, the “Buxoro AgroEcoGIS” geoportal can serve as a foundation for the transition from traditional periodic land surveys to continuous digital monitoring of the environmental condition of irrigated lands in Bukhoro District.

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