MONITORING OF AGRICULTURAL AND PASTURE LANDS IN BUKHARA REGION USING INNOVATIVE TECHNOLOGIES

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INTRODUCTION

Agricultural and pasture lands in Uzbekistan, particularly in the Bukhara region, are increasingly affected by climate variability, soil degradation, salinity, and inefficient water management. These challenges require advanced and innovative monitoring technologies to ensure sustainable land use and maximize productivity. Modern tools such as Geographic Information Systems (GIS), satellite-based remote sensing, UAV (drone) surveying, and automated NDVI (Normalized Difference Vegetation Index) have become essential components of land monitoring worldwide.

Uzbek scholars such as X. Xudoyberdiyev, B. Jo'rayev, O. Yo'ldoshev, and S. Karimov have emphasized the importance of digital transformation in agriculture, land classification, and long-term monitoring. Their work demonstrates that high-resolution spatial data significantly improves decision-making and enables the detection of early-stage degradation.

This study focuses on the Bukhara region — one of Uzbekistan's key agricultural centers. The research evaluates land conditions during 2020–2024 through NDVI analysis, irrigation system assessment, and spatial identification of degraded territories. By integrating satellite imagery with local field inspections, this study demonstrates how innovative digital technologies can support sustainable agriculture, improve productivity, and prevent overuse of natural resources.

2. Methods

The methodological framework integrates several advanced monitoring technologies. First, Sentinel-2 satellite imagery (10–20 m resolution) was processed using QGIS to extract NDVI values for each growing season from 2020 to 2024. Cloud masking, radiometric correction, and supervised classification were applied to enhance accuracy. NDVI thresholds were used to classify areas into healthy vegetation, moderate vegetation, and degraded land.

Fieldwork was conducted across Vobkent, G'ijduvon, Kogon, and Bukhara districts to validate satellite-derived results. Soil samples and visual inspections helped identify salinity zones, poorly irrigated fields, and unused agricultural plots.

UAV (drone) surveys were applied to identify micro-level land degradation, canal breakages, irrigation inequality, and natural overgrazing on pasture lands. Spatial datasets were then integrated into GIS layers, creating detailed land category maps.

National research methodologies from Uzbek experts such as Yo'ldoshev O. and Karimov S. were adopted, particularly for land classification and vegetation assessment.

3. Results

NDVI-based vegetation trends reveal that the Bukhara region experienced a steady improvement in vegetation cover from 2020 to 2024, primarily due to improved irrigation practices and rehabilitation of canals.

Table 1: Average Annual NDVI in Bukhara Region (2020-2024)

Year	Average NDVI	Status (Assessment)
2020	0.32	Low (Degradation-prone)
2021	0.35	Low-Moderate
2022	0.38	Moderate
2023	0.41	Moderate-High
2024	0.44	Moderate-High

Graph 1: NDVI Change in Bukhara Region (2020–2024)

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NDVI Value
0.45 |              ●
0.44 |            ●
0.42 |          ●
0.40 |        ●
0.38 |       ●
0.36 |      ●
0.34 |     ●
0.32 |   ●
     +------------------------------
     2020 2021 2022 2023 2024
```
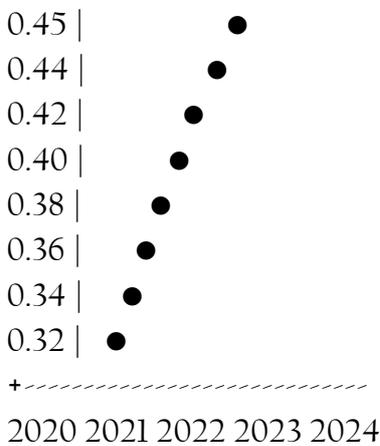
Spatial analysis revealed that most degraded zones occur in northern Bukhara, where salinity and water shortages remain problematic. Drone monitoring exposed micro-level issues:

● Hidden irrigation losses (leakage, seepage).
● Uneven watering across fields.
● Unused/abandoned agricultural plots.
● Localized overgrazing on pastures.

GIS-based mapping allowed for accurate classification of cropland, pasture, and degraded land, supporting optimized land allocation.

Diagram 1: Land Use Category Distribution (Sample Area, 2024)

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[Bukhara Region (Sample Area)]
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Category	Share
Healthy Cropland	55%
Moderately Used Land	20%
Pasture	15%
Degraded Land	10%

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4. Conclusion

The study demonstrates that innovative technologies significantly enhance the accuracy and efficiency of agricultural land monitoring in the Bukhara region. Satellite-based NDVI monitoring provides objective annual vegetation trends, while GIS systems ensure precise land categorization and degradation detection. Drone surveys fill the information gap by capturing micro-level issues in irrigation and land use that are invisible to satellites. This integrated approach provides a powerful toolkit for authorities and farmers, enabling proactive measures to combat degradation, optimize water use, and increase agricultural productivity. The successful application in Bukhara serves as a replicable model for other arid and semi-arid regions in Central Asia facing similar environmental challenges.

5. Recommendations

1. Introduce automated real-time irrigation monitoring systems based on soil moisture sensors and IoT.

2. Expand operational NDVI monitoring to all districts in the Bukhara region on a seasonal basis.

3. Implement a regular UAV monitoring program for seasonal pasture assessment and grazing management.

4. Establish a centralized, unified GIS-based land resource database for integrated management.

5. Train agricultural specialists and land management authorities in GIS, drone operation, and remote sensing analysis.

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