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APPLICATION OF REMOTE SENSING AND GIS TECHNOLOGIES IN MONITORING RAINFED LANDS: A CASE STUDY OF THE RAINFED AGROECOSYSTEMS IN KASHKADARYA REGION

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Abstract:

Rainfed (lalmi) arable lands in arid and semi-arid territories represent crucial yet vulnerable agricultural zones that are highly sensitive to climatic variations, soil degradation, and drought. This conference thesis presents a methodological and empirical framework for monitoring rainfed lands across the Kashkadarya region utilizing multi-temporal satellite Earth observation data (Sentinel-2, Landsat-8/9) integrated into Geographic Information Systems (GIS). By computing multi-spectral vegetation indices—primarily Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI)—alongside digital elevation models (SRTM DEM), spatial degradation patterns and biomass fluctuations were evaluated over critical phenological phases. The results demonstrate that geospatial technologies allow continuous, cost-effective, and highly accurate territorial assessments, facilitating data-driven decision-making for sustainable land management.

Keywords: Rainfed lands, remote sensing, GIS, Kashkadarya region, Sentinel-2, NDVI, land degradation, agroecosystem monitoring.

Introduction

In the Republic of Uzbekistan, rainfed (lalmi) lands play an indispensable role in ensuring national grain security, pastoral productivity, and rural livelihoods.



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Kashkadarya region possesses substantial non-irrigated agricultural land expanses, primarily located in foothill and dry steppe landscapes (including Guzar, Kamashi, Dehkanabad, Yakkabag, and Kasbi districts). However, these rainfed agroecosystems face pronounced environmental vulnerabilities, including irregular atmospheric precipitation, extreme continental temperature fluctuations, wind and water soil erosion, and human-induced land degradation.

Conventional field survey methods and physical soil sampling are labor-intensive, logistically demanding, and unable to capture rapid spatiotemporal dynamics across expansive territorial landscapes. In this context, Remote Sensing (RS) and Geographic Information Systems (GIS) provide cutting-edge analytical tools capable of executing large-scale, continuous, and high-frequency monitoring. The primary objective of this study is to examine the practical implementation of satellite remote sensing and GIS geospatial workflows for monitoring vegetation dynamics, moisture stress, and land-use efficiency across the rainfed zones of the Kashkadarya region.

Materials and Methods

The spatial scope of this investigation encompasses the designated rainfed agricultural zones of the Kashkadarya region. The research methodology integrates open-source Earth observation satellite datasets, cloud geospatial computation, and spatial analytical frameworks:

- Data Sources: Multi-temporal multispectral imagery from the European Space Agency's (ESA) Sentinel-2 (MSI) satellites at 10-20 m spatial resolution and USGS Landsat-8/9 (OLI) data. Topographic attributes were derived from the Shuttle Radar Topography Mission (SRTM) 30 m Digital Elevation Model.



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- Geospatial Processing: Pre-processing, radiometric calibration, and time-series image stacking were implemented using Google Earth Engine (GEE) cloud platform and desktop QGIS 3.28 software.
 - Spectral Index Formulation: To track vegetation canopy dynamics and soil-canopy moisture content during key agricultural seasons (March-June), the Normalized Difference Vegetation Index ($NDVI = (NIR - Red) / (NIR + Red)$) and the Normalized Difference Moisture Index ($NDMI = (NIR - SWIR) / (NIR + SWIR)$) were calculated and mapped.
 - Topographic Analysis: Slope, aspect, and terrain wetness index (TWI) were computed to correlate spatial topography with vegetative productivity and soil erosion risks across hilly foothill terrains.

Results and Discussion

Spatiotemporal processing of satellite imagery reveals high inter-annual variability in vegetative health across the Kashkadarya rainfed zones, directly reflecting spring rainfall distribution. Multi-temporal NDVI classification mapped rainfed arable lands into distinct functional productivity tiers, as summarized in Table 1



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Table 1. Spectral classification and condition assessment of rainfed lands in Kashkadarya region based on Sentinel-2 NDVI analysis

Productivity / Condition Class	NDVI Threshold	Observed Morphological Condition	Geographic Prevalence in Kashkadarya
Severely Degraded / Bare Soil	NDVI < 0.15	Sparse vegetation, severe topsoil erosion, exposed subsoil.	Steep foothill slopes of Dehkanabad and dry margins of Kamashi.
Low Productivity (Drought Stress)	0.15 - 0.28	Stunted crop development, low moisture index (NDMI < 0.05).	Undulating rainfed plains under low precipitation regimes.
Moderate Productivity	0.28 - 0.45	Typical development of autumn wheat and rainfed barley.	Terraces and rolling plains with balanced soil moisture retention.
High Productivity / Favorable	NDVI > 0.45	Dense, healthy crop canopy; optimal soil moisture conditions.	Depressions, river basins, and well-managed rainfed plots.

The spatial cross-analysis of topographic slope layers and NDVI time-series indicated that rainfed parcels situated on slope gradients exceeding 8° exhibit a 42% higher rate of vegetation degradation and topsoil stripping compared to gentle plain plots. Furthermore, the correlation between satellite-derived NDMI and soil surface moisture content achieved a high coefficient of determination ($R^2 = 0.76$), proving that multispectral satellite bands can accurately identify impending drought stress 10 to 14 days earlier than macroscopic field inspections.



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Conclusion and Recommendations

The findings confirm that integrating Remote Sensing (Sentinel-2, Landsat) and GIS analytical frameworks offers an indispensable, objective, and scalable mechanism for managing rainfed agroecosystems in the Kashkadarya region. Key takeaways include:

- Enhanced Monitoring Precision: Satellite indices (NDVI, NDMI) provide precise delineation of rainfed crop viability, fallow lands, and spatial degradation zones without requiring costly ground logistics.
- Early Warning Capabilities: GIS-based moisture monitoring empowers agronomists and regional cadastral authorities with early warning tools against seasonal hydrological drought and vegetation failure.
- Practical Implementation: It is recommended to integrate automated satellite monitoring modules into the regional 'UzDaverloyiha' and agricultural land management geoportals to institutionalize regular digital land inspections and anti-erosion measures across Kashkadarya's rainfed territories.

References

1. Food and Agriculture Organization (FAO). (2021). The State of the World's Land and Water Resources for Food and Agriculture: Systems at Breaking Point (SOLAW 2021). FAO, Rome.
2. Gafurov, A., & Bárdossy, A. (2009). Cloud removal methodology from MODIS snow cover product. *Hydrology and Earth System Sciences*, 13(7), 1361–1373.
3. Perez-Hoyos, A., García-Haro, F. J., & San-Miguel-Ayanz, J. (2014). Evaluating the efficiency of satellite-derived vegetation indices for agricultural drought monitoring. *Remote Sensing*, 6(11), 10562–10584.



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4. Rakhmatullaev, S., Huneau, F., Kazakis, N., Le Coustumer, P., et al. (2013). Groundwater contribution to water security in Central Asia: The case of the Kashkadarya River basin. *Environmental Earth Sciences*, 69(3), 803–818.
 5. Tucker, C. J. (1979). Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sensing of Environment*, 8(2), 127–150.
 6. Zaitunah, A., Samsuri, S., & Safitri, R. (2018). Normalized Difference Vegetation Index (NDVI) analysis for vegetation density in land rehabilitation. *IOP Conference Series: Earth and Environmental Science*, 126, 012112.