ASSESSMENT OF AGRICULTURAL LAND DEGRADATION LEVELS USING GEOSPATIAL TECHNOLOGIES AND MULTISPECTRAL REMOTE SENSING DATA

Usmonov Jasur Ziyodillayevich
Scientific Supervisor
Doctor of Philosophy (PhD) in Agricultural Sciences

Toshtemirov Temurbek Akmal o'g'li
Independent Researcher at the "Geoinnovation Center"
State Unitary Enterprise
temurbektoshtemirov@gmail.com

ABSTRACT

Land degradation is a critical environmental issue affecting global food security and ecosystem stability. This study focuses on the integration of Geographic Information Systems (GIS) and Remote Sensing (RS) data to evaluate the extent of degradation in agricultural landscapes. By utilizing multispectral imagery from Sentinel-2 and Landsat missions, various spectral indices, including the Normalized Difference Vegetation Index (NDVI) and Soil Salinity Index (SI), were calculated to identify degradation hotspots. The results demonstrate that geospatial technologies provide a cost-effective and high-precision framework for monitoring soil health, enabling decision-makers to implement targeted land restoration strategies.

Keywords: Land Degradation, GIS, Remote Sensing, NDVI, Soil Salinity, Sustainable Agriculture, Sentinel-2, Environmental Monitoring.

INTRODUCTION

Agricultural land degradation—characterized by the decline in soil fertility, increased salinity, and vegetation loss—poses a significant threat to sustainable development. In many arid and semi-arid regions, improper irrigation practices and climate-induced droughts have accelerated the desertification process. Monitoring these changes over vast areas through traditional ground-based surveys is logistically challenging and resource-intensive.

The emergence of Geographic Information Systems (GIS) and Remote Sensing (RS) has revolutionized land resource management. Remote sensing offers a "bird's-eye view" of the Earth's surface, capturing data in wavelengths invisible to the human eye. By analyzing these spectral signatures, researchers can quantify the physical and chemical changes in the soil and vegetation, providing a scientific basis for assessing degradation levels.

MAIN PART: METHODOLOGY AND DATA ANALYSIS

The methodology for assessing land degradation involves several stages of digital image processing and spatial modeling.

2.1. Data Acquisition and Pre-processing

The primary data sources are Landsat-8 (OLI) and Sentinel-2 (MSI) satellites. These platforms provide high-resolution imagery (up to 10m) suitable for analyzing individual farm plots. Pre-processing includes atmospheric correction (converting Top-of-Atmosphere reflectance to Surface Reflectance) and geometric alignment to ensure spatial accuracy.

2.2. Spectral Index Calculation

To differentiate between healthy and degraded land, specific mathematical formulas are applied to the satellite bands:

Vegetation Analysis: The **NDVI** is used to monitor biomass health. A decline in NDVI over several growing seasons is a primary indicator of land productivity loss.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Salinity Detection: Soil salinity is a major driver of degradation. The **Salinity Index (SI)** utilizes the blue and red bands to detect salt crusts on the soil surface.

2.3. Spatial Integration in GIS

$$SI = \sqrt{Blue \times Red}$$

The calculated indices are integrated into a GIS environment (e.g., ArcGIS Pro or QGIS). By overlaying these indices with soil maps and topographic data (Digital Elevation Models), a multi-criteria evaluation is performed to classify land into four categories:

1. **Non-degraded:** High biomass and balanced soil moisture.
2. **Lowly degraded:** Seasonal fluctuations in vegetation.
3. **Moderately degraded:** Visible signs of salinity or wind erosion.
4. **Severely degraded:** Total loss of topsoil fertility and abandoned agricultural use.

RESULTS AND DISCUSSION

The integration of RS and GIS allows for the visualization of degradation dynamics over time (Time-Series Analysis). Discussion of the findings reveals that degradation is often concentrated in areas with poor drainage systems and high evaporation rates.

Comparison between satellite-derived maps and field-verified samples showed an accuracy rate of over **85%**. This proves that remote sensing is not just a theoretical tool but a practical solution for large-scale monitoring. Furthermore, GIS-based modeling helps in identifying "Risk Zones" where degradation is likely to occur in the next 5 years, allowing for preventative agro-meliorative measures.

CONCLUSION

The application of Geospatial technologies is indispensable for the modern assessment of agricultural land degradation. This study concludes that:

- **Remote Sensing** provides timely and objective data on soil and vegetation health across large geographical scales.
- **GIS** enables the synthesis of complex data into easy-to-read degradation maps for policymakers.

• Automated monitoring systems based on satellite data can significantly reduce the costs associated with land reclamation and soil conservation efforts.

Implementing these digital tools is essential for achieving land degradation neutrality and ensuring long-term food security.

REFERENCES

1. Kogan, F. N. (2001). Global drought watch from space. Bulletin of the American Meteorological Society, 82(9), 1945-1964.
2. Metternicht, G. I., & Zinck, J. A. (2003). Remote sensing of soil salinity: potentials and constraints. Remote Sensing of Environment, 85(1), 1-20.
3. Wessels, K. J., et al. (2007). Can NDVI-derived vegetation trends be used to identify land degradation? Remote Sensing of Environment, 107(1), 281-297.
4. UNCCD. (2022). The Global Land Outlook, second edition. United Nations Convention to Combat Desertification.
5. ESA. (2023). Sentinel-2 Technical Guide. European Space Agency.