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APPLICATION OF REMOTE SENSING AND GIS TECHNOLOGIES IN MAPPING DEGRADED

Agricultural Lands

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Annotation: *This article analyzes issues related to improving the efficiency of agricultural land use based on remote sensing technologies and Geographic Information Systems (GIS). Within the scope of the study, modern approaches for the identification, assessment, and mapping of degraded agricultural land areas were developed. Satellite imagery was utilized to determine land degradation conditions using software tools such as SaSPlanet, Google Earth, and ArcGIS. Through polygon-based analysis and the application of Selection Manager functions, the precise boundaries of degraded land parcels were delineated, and their spatial distribution was represented cartographically. The obtained results provide a scientific and practical basis for enhancing agricultural land monitoring systems, promoting rational land resource management, and mitigating land degradation processes. The findings of the study are of practical significance for land cadastre systems, agro-cluster management, and territorial planning.*

Keyword: *remote sensing, land degradation, agricultural lands, GIS technologies, SaSPlanet, Google Earth, ArcGIS, polygonal analysis, Selection Manager, satellite imagery, land monitoring, digital mapping.*

INTRODUCTION

In recent years, the issue of rational and efficient use of land resources has become one of the most pressing scientific and practical challenges in ensuring the sustainability of agricultural production. Population growth, climate change, increasing water scarcity, and intensified anthropogenic pressure have accelerated land degradation processes, leading to a decline in soil fertility and a reduction in the overall efficiency of land use. These negative processes are particularly evident in irrigated agricultural areas, where salinization, erosion, soil compaction, and degradation of vegetation cover are widely observed.

Traditional methods of land accounting and monitoring often fail to provide timely and accurate assessments over large areas. As a result, identifying the actual degree of land degradation, classifying affected areas, and making effective land management decisions become increasingly complex. This situation necessitates the adoption of modern, technology-based approaches capable of delivering reliable and up-to-date spatial information on land conditions.

Remote sensing technologies and Geographic Information Systems (GIS) offer effective tools for continuous monitoring of agricultural land, detection of degradation-prone areas, and comprehensive spatial analysis of land resources. Satellite imagery enables the assessment of land surface changes, evaluation of vegetation conditions, and identification of degradation dynamics over time. These technologies are distinguished by their ability to cover extensive territories within a short period and to process large volumes of data efficiently.

From this perspective, mapping degraded agricultural lands based on remote sensing data and conducting scientifically grounded assessments of their condition are of significant importance. Spatial analysis of land degradation processes allows for the identification of problem areas, determination of their extent and distribution patterns, and development of targeted measures aimed at improving land-use efficiency. The present study is devoted to addressing these issues, and its findings can be effectively applied in land cadastre systems, territorial planning, and agricultural land management practices.

Research Results: The primary objective of this study is to enhance the efficient use of existing land and water resources, increase agricultural production, ensure food security, and further expand export potential through scientifically grounded spatial analysis. Particular attention is given to the rational allocation of technical crops, cereal grains, legumes, oilseed crops, melons, vegetables, potatoes, and fodder crops, as well as the establishment of orchards, vineyards, and mulberry plantations based on land suitability and degradation conditions.

Within this framework, the study aims to develop and improve a remote sensing–based mapping system for agricultural lands, enabling accurate identification of degraded areas and informed decision-making in land-use planning. The integration of satellite imagery and GIS technologies allows for the creation of detailed thematic maps that support sustainable agricultural development and optimize crop placement according to environmental and resource constraints.

Furthermore, the research seeks to formulate scientifically substantiated recommendations and practical measures aimed at strengthening the economic and financial stability of agricultural producers. By applying modern remote sensing methodologies, the proposed approach contributes to improved land management efficiency, long-term soil fertility preservation, and the sustainable utilization of agricultural resources.

Advantages of Remote Sensing in Land Studies Remote sensing provides a wide range of advantages for the assessment and monitoring of land resources, particularly in agricultural and environmental studies. One of its key strengths is the ability to acquire repeated imagery of the same geographic area over time, allowing for continuous observation and near–real-time analysis of land surface changes. This capability is essential for monitoring dynamic processes such as land degradation, crop growth, and seasonal variations.

Another significant advantage of remote sensing lies in the spectral sensitivity of sensors. Unlike the human eye, which can perceive only a limited portion of the electromagnetic spectrum, remote sensing sensors are capable of detecting a much broader range of spectral bands. This feature enables more detailed analysis of soil conditions, vegetation health, and moisture content through multispectral and hyperspectral data.

Modern remote sensing sensors can simultaneously analyze individual pixels or groups of pixels across single or multiple spectral bands. This allows for precise classification and quantitative assessment of land surface features using automated and semi-automated image processing techniques. In addition, remotely sensed data are provided in geographically referenced and projection-ready digital formats, which ensures seamless integration with Geographic Information Systems (GIS) for spatial analysis and mapping.

Many remote sensing platforms are designed to operate under various environmental conditions, including different seasons, nighttime observations, and unfavorable weather situations. This all-weather and day-and-night capability significantly enhances the reliability and continuity of land monitoring processes. Furthermore, remote sensing enables the rapid acquisition of imagery at different spatial scales, making it possible to analyze land resources at local, regional, and national levels.

Remote sensing can be defined as the process of detecting, observing, and recording information about objects and phenomena from a distance in a digital format. An important characteristic of remotely sensed imagery is spatial resolution, which refers to the size of the smallest object on the Earth’s surface that can be detected and represented in an image. In practical terms, spatial resolution describes the ground area covered by a single pixel in an image. For example, a spatial resolution of 15 × 15 m indicates that one pixel represents a ground surface area of 225 square meters. Higher spatial resolution allows for more detailed and accurate interpretation of land surface features (**Figure 1**).

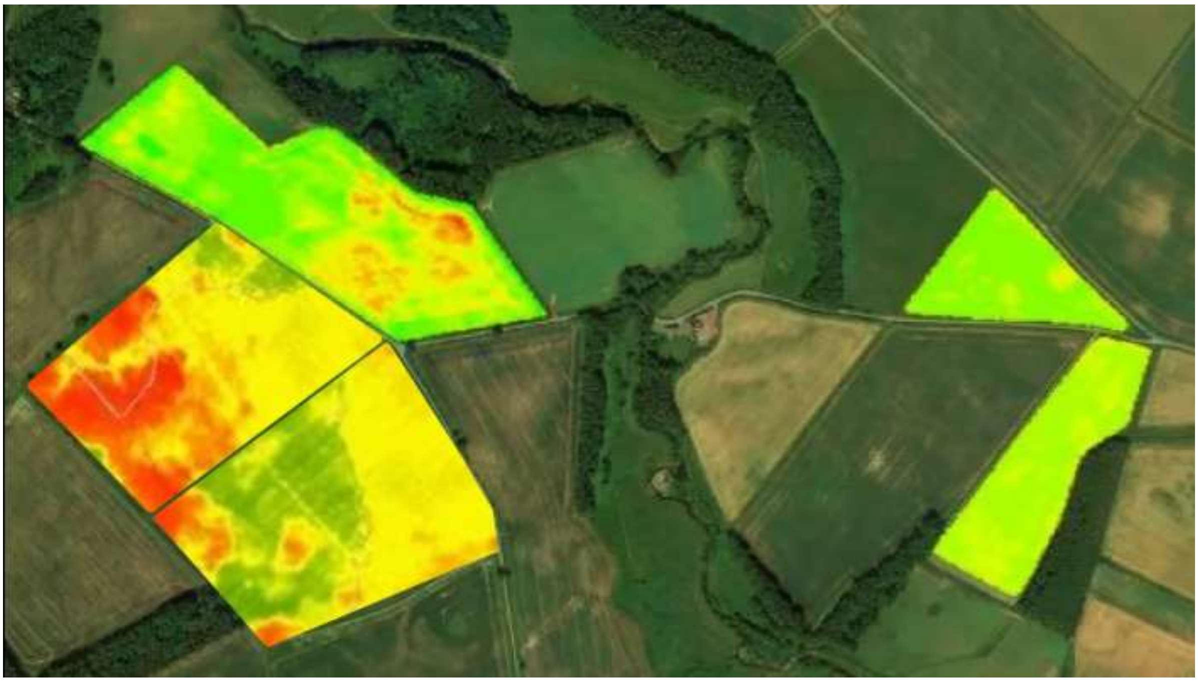

Figure 1. Spatial Distribution of Agricultural Land Degradation Based on Remote Sensing Analysis

Causes of Land Degradation Land degradation occurs as a result of a combination of natural factors and human-induced activities, with anthropogenic pressure playing a dominant role in agricultural regions. One of the primary causes of land degradation is the implementation of unsustainable agricultural practices that fail to consider soil conservation principles and long-term land productivity. Intensive cultivation, improper crop rotation, excessive use of agrochemicals, and inadequate irrigation management contribute significantly to the deterioration of soil structure and fertility.

Another major factor leading to land degradation is the overexploitation of pasture lands. Continuous and uncontrolled grazing beyond the carrying capacity of rangelands results in vegetation loss, soil compaction, and increased susceptibility to erosion. As a consequence, the regenerative capacity of pasture ecosystems is reduced, accelerating degradation processes.

Deforestation and the removal of natural vegetation cover also play a critical role in land degradation. Forests and other forms of vegetation serve as natural protective layers that regulate water balance, prevent soil erosion, and maintain ecological stability. The destruction of these covers exposes soil surfaces to wind and water erosion, disrupts nutrient cycles, and negatively affects overall land productivity.

Overall, irrational land use practices, excessive pressure on natural resources, and the loss of vegetation cover are among the key drivers of land degradation. Addressing these factors requires the adoption of sustainable land management strategies supported by modern monitoring tools such as remote sensing and GIS technologies.

Mapping of degraded dand boundaries and data processing methods the boundaries of degraded land areas within the study massif are primarily manifested as a result of irrational agricultural practices. These include excessive use of irrigation water in irrigated farmlands, wind and water erosion of the upper soil layer, soil compaction leading to the formation of a dense subsurface layer, soil salinization, and various forms of soil contamination. Such processes significantly reduce soil productivity and negatively affect sustainable agricultural land use. Acquisition of Satellite Imagery To conduct the analysis, a specific agricultural massif was selected for satellite image acquisition.

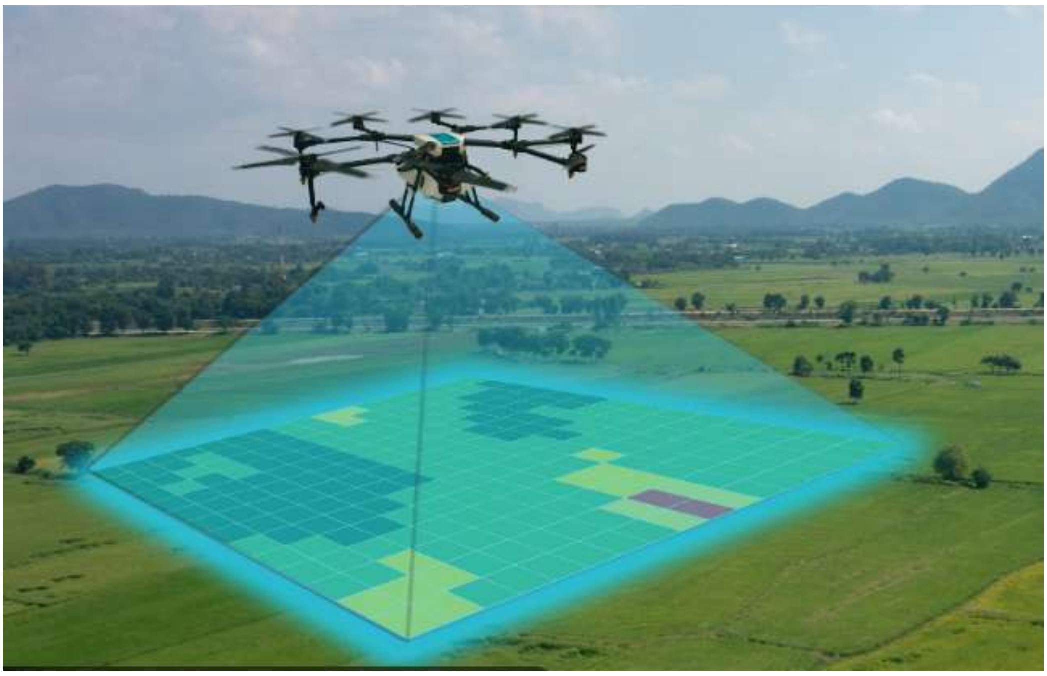

Figure 2. UAV-Based Remote Sensing for High-Resolution Mapping of Agricultural Land Degradation

After completing the required payment procedures through the responsible organization, high-resolution satellite imagery of the selected district (massif) was obtained either via the internet or on digital storage media. These satellite images served as the primary data source for identifying land degradation patterns. Using the SAS.Planet (version 120808) software, high-resolution satellite imagery from Google Earth was downloaded. The target study area was selected, and the confirmation marker was activated using the cursor.

The software allows satellite imagery to be saved together with additional overlay layers, ensuring the preservation of spatial context during data processing. The workflow applied during the image acquisition process is illustrated in (**Figure 2**). For image extraction, the Selection Manager –

Polygonal tool was used to delineate the exact boundaries of the massif. After defining the polygonal extent, the Stitch function was applied to export the imagery in formats such as ECW, BMP, JPG, and PNG. The zoom level was set to achieve a spatial resolution equivalent to approximately 20–21 m, ensuring sufficient image clarity for detailed analysis.

To enable georeferencing, auxiliary files such as .map, .dat, .kml, and .tab were generated. Image quality parameters for JPG and ECW formats were adjusted within the 90–100 range to maintain high visual and analytical accuracy. GIS-Based Processing and Mapping

In the monitoring of agricultural lands across regional districts, the use of Google Earth Pro and its regularly updated satellite imagery has become a widely adopted approach. This software facilitates the rapid incorporation of recent land-use changes into agricultural maps, enabling high-precision monitoring within short time intervals.

An electronic digital map at a 1:2000 scale, created in the ArcGIS environment, was used as the base spatial framework. According to the date of field assessment, all landowners and land users, including individual farming enterprises, were identified. Land parcel boundaries were digitized by contour, and updated topographic elements such as irrigation canals and roads were incorporated into the electronic map following established cartographic standards.

When satellite imagery was saved in ECW format, it was added to ArcGIS as a raster layer without ground control points. However, in cases where coordinate inaccuracies were present, raster and vector layers did not align with sufficient precision. Additionally, the Georeferencing function could not be activated for ECW files under such conditions. To resolve this issue, imagery was alternatively imported in BMP or JPG formats, enabling proper georeferencing and spatial alignment.

Conclusion This study demonstrates that the integration of remote sensing technologies and Geographic Information Systems (GIS) provides an effective and reliable approach for identifying, assessing, and mapping degraded agricultural lands. The application of satellite imagery, combined with GIS-based spatial analysis, enables the accurate delineation of degraded land boundaries and supports the evaluation of degradation intensity across agricultural massifs.

The results confirm that irrational agricultural practices, including excessive irrigation, soil compaction, erosion, salinization, and contamination, are the primary drivers of land degradation in irrigated farming systems. The use of polygon-based analysis and high-resolution imagery allows for detailed visualization of these processes, facilitating timely detection and spatial interpretation of degradation patterns. This approach significantly improves the efficiency and accuracy of land monitoring compared to conventional field-based methods.

Furthermore, the study highlights the practical importance of modern remote sensing tools, such as satellite platforms and UAV-based observations, in updating agricultural land maps and supporting sustainable land-use planning. The integration of these technologies into land cadastre systems and agricultural monitoring frameworks enhances decision-making processes aimed at improving land productivity, ensuring food security, and strengthening the economic stability of agricultural producers.

Overall, the findings emphasize that remote sensing and GIS-based mapping are indispensable tools for sustainable agricultural land management. Their systematic application contributes to the prevention of further land degradation, supports rational resource utilization, and provides a scientific foundation for the development of effective land restoration and management strategies.

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