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Assessing Land Use Changes in the Urmia Plain Using Landsat Satellite Imagery (1984-2020)

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Abstract

Background and Objective: The Urmia Plain, as one of the most sensitive ecosystems in western Iran, has undergone extensive land use transformations in recent decades under the pressure of anthropogenic activities and environmental changes. These changes can have irreversible consequences for food security, local livelihoods, and environmental health. This study aimed to identify and quantitatively analyze the trends of land use and land cover (LULC) change in the Urmia Plain over a 36-year period (1984-2020) using Landsat satellite imagery.

Methodology: This study utilized Landsat 5 (TM), Landsat 7 (ETM+), and Landsat 8 (OLI) satellite images from 1984, 2000, and 2020. After performing necessary preprocessing steps, supervised classification using the Maximum Likelihood Classifier (MLC) algorithm was implemented in ENVI software. Land use maps were extracted for six main classes (agriculture and orchard, rangeland, built-up, barren land, water bodies, and salt marshes), and their accuracy was assessed using an error matrix and the metrics of overall accuracy and Kappa coefficient.

Results and Findings: The results indicated that over the study period, the extent of agriculture and orchard lands (increasing from 22% to 26%) and built-up areas increased, while water bodies (33%) and rangelands (22%) experienced a concerning declining trend. Concurrently, the area of barren lands and salt marshes also increased. A comparison of the two time periods revealed that the degradation process has accelerated, particularly after the year 2000, leading to the establishment of a detrimental degradation cycle, which underscores the urgent need for revising management strategies.

Keywords: Change Detection, Remote Sensing, Landsat, Maximum Likelihood Classifier, Urmia Plain.

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EXTENDED ABSTRACT

Introduction

Land use change, as one of the most significant manifestations of human interaction with the environment, plays a decisive role in transforming landscapes and disrupting ecological balances. These changes are particularly critical and have more severe consequences in arid and semi-arid regions, which possess low ecological carrying capacity. The Urmia Plain, as one of the most important and sensitive ecosystems in western Iran, has been the scene of extensive transformations in recent decades. The combined pressures of anthropogenic activities and environmental changes have led to profound alterations in the land use patterns of this region, resulting in outcomes such as an intensified water crisis and loss of biodiversity. Remote sensing technology, with its extensive spatial and temporal coverage, serves as an indispensable tool for monitoring such land use dynamics. Therefore, the primary objective of this study is to identify and quantitatively analyze the trends of land use change in the Urmia Plain over the period 1984-2020 using Landsat satellite imagery.

Methodology

This study relied on Landsat 5 (TM), 7 (ETM+), and 8 (OLI) satellite imagery from the years1984, 2000, and 2020. Following radiometric and atmospheric preprocessing, supervised classification using the Maximum Likelihood Classifier (MLC), a common and well-established method for extracting land use information, was applied to the images. Land use maps were generated for six classes: agriculture and orchard, rangeland, built-up areas, barren land, water bodies, and salt marshes. Their accuracy was assessed using an error matrix and the metrics of overall accuracy and Kappa coefficient. Finally, employing the post-classification comparison method, the quantitative changes for each class, as well as the conversions between land use classes, were identified and analyzed for the two time intervals (2000-1984 and 2020-2000).

Results and Findings

The accuracy assessment confirmed the high reliability of the produced maps (Overall Accuracy: 91% to 96%; Kappa Coefficient: 0.85 to 0.88). The analysis of results indicates significant structural transformations in the region's land use landscape. The area of agricultural and orchard lands (increasing from 22% to 26%) and built-up surfaces (increasing from 15% to 16%) exhibited an upward trend. In contrast, the extent of water bodies faced a 33% reduction, and rangelands decreased by approximately 22%. Barren lands remained the most extensive land use class (39% to 42%), while salt marshes, despite their minor share, experienced 33% growth. Analyzing the changes across the two time intervals revealed a distinct dynamic. Whereas the period 1984-2000 witnessed a slight increase in rangelands and a decrease in barren lands, the trend reversed sharply during 2000-2020, marked by extensive rangeland loss accompanied by an expansion of barren areas. This evidence signifies an intensification of degradation and the establishment of a negative feedback loop post-2000, wherein agricultural and urban development has led to diminished water resources, degradation of natural vegetation cover, and ultimately, the proliferation of desertification and salinization impacts.

Conclusion

The findings of this research clearly demonstrate that the Urmia Plain is undergoing a critical ecological transition, characterized by the dominance of anthropogenic activities and the decline of key natural ecosystems (water and rangelands). The acceleration of changes, particularly after the year 2000, underscores the ineffectiveness of past management strategies in establishing a balance between development and conservation. The principal conclusion of this study is that achieving sustainability in this region necessitates a paradigm shift from conventional development towards adaptive and integrated water and soil resource management. Key priorities include halting agricultural expansion on marginal and low-yield lands, allocating environmental water rights to wetlands, and implementing ecological rangeland restoration programs with the participation of local stakeholders. Without adopting these fundamental measures, the restoration of Lake Urmia and the long-term guarantee of environmental security will not be attainable.

Declarations

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Authors' Contribution

Authors contributed equally to the conceptualization and writing of the article. All of the authors approved the content of the manuscript and agreed on all aspects of the work declaration of competing interest none.

Conflict of Interest

The authors declare no conflict of interest.

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