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Detection of Land Use Changes in the 2013-2024 Period Using Landsat 8 Image Processing and Analyzing its Effects (Case Study: Miandoab City)

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Abstract

Background and Objective: Land use and land cover (LULC) are among the most critical indicators of human-environment interaction, reflecting how societies exploit and transform the natural landscape. Understanding temporal changes in land use is essential for sustainable planning, environmental management, and agricultural policy development. This study aims to detect and analyze land use changes in Miandoab County over the period 2013 to 2024 using remote sensing techniques.

Methodology: Landsat 8 OLI/TIRS satellite images for the years 2013 and 2024 were used as the primary data source. After applying radiometric and geometric preprocessing, the images were classified using the Maximum Likelihood Classification (MLC) algorithm, which relies on the statistical distribution of spectral data and assigns each pixel to the most probable class. Eight land use categories were defined: built-up areas, soil, roads, farmlands, orchards, water bodies, salt flats, and saline soils. The classification accuracy was assessed using overall accuracy and Kappa coefficient.

Results and Findings: The classification results revealed significant land use changes over the 11-year period. Farmlands increased from 3,183 ha in 2013 to 4,963 ha in 2024, indicating a major shift toward agricultural expansion. Conversely, orchards and soil areas showed marked decreases, likely due to water scarcity and urban encroachment. Built-up areas expanded to 1,849 ha, reflecting urban development. The classification achieved high accuracy levels (94.07% in 2013 and 94% in 2024), validating the reliability of the MLC approach. The study demonstrates that remote sensing and supervised classification are effective tools for land use monitoring. The observed trends highlight the need for integrated land management strategies to balance development with environmental sustainability in Miandoab.

Keywords: Sustainable Land Management, Remote Sensing, Maximum Likelihood Classification, Urban Expansion, Miandoab.

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Extended Abstract

Introduction

Land use and land cover (LULC) are among the most critical indicators of human-environment interaction, reflecting how societies exploit and transform the natural landscape. Understanding temporal changes in LULC is essential for effective sustainable planning, comprehensive environmental management, and the formulation of robust agricultural policy development. This dynamic interplay between human activities and natural processes necessitates continuous monitoring and analysis. This study aims to meticulously detect and analyze the land use changes that have occurred within Miandoab County over the specific period from 2013 to 2024, employing established remote sensing techniques to provide a quantitative assessment of these transformations. The findings are intended to offer valuable insights for regional planners and environmental stakeholders.

Methodology

The primary data source for this investigation comprised Landsat 8 OLI/TIRS satellite images acquired for the years 2013 and 2024, ensuring a consistent sensor type for comparative analysis. To minimize seasonal effects and ensure data comparability, images were selected with acquisition dates less than three days apart within similar periods of the respective years. Prior to classification, the images underwent essential radiometric and geometric preprocessing steps to correct for atmospheric interferences and sensor-specific errors, thereby enhancing data quality. Subsequently, the preprocessed images were classified using the Maximum Likelihood Classification (MLC) algorithm. This supervised classification technique relies on the statistical distribution of spectral data within predefined training samples and assigns each pixel in the image to the land use class to which it most probably belongs. Eight distinct land use categories were defined for this study, encompassing the primary cover types in the region: built-up areas, soil (barren land), roads, farmlands, orchards, water bodies, salt flats, and saline soils. The accuracy of the resulting classified maps was rigorously assessed using the overall accuracy and the Kappa coefficient metrics, comparing the classified outputs against ground reference data.

Results and Discussion

The classification results derived from the Landsat 8 imagery revealed significant and quantifiable land use changes across Miandoab County over the 11-year study period. Notably, farmlands demonstrated a substantial increase, expanding from 3,183 hectares in 2013 to 4,963 hectares in 2024. This represents a major shift toward agricultural expansion and intensification within the region. In parallel, built-up areas also expanded, reaching 1,849 hectares by 2024, clearly reflecting ongoing urban development and population growth. Conversely, areas classified as orchards and soil (barren land) exhibited marked decreases during the same period. These reductions are likely attributable to a combination of factors, including increased water scarcity impacting orchard viability and the encroachment of urban and agricultural activities onto previously undeveloped or fallow lands. The Maximum Likelihood Classification algorithm achieved high levels of accuracy for both study years, with an overall accuracy of 94.07% for the 2013 classification and 94% for the 2024 classification. The Kappa coefficients were 0.9291 for 2013 and 0.9165 for 2024, further validating the reliability and robustness of the MLC approach for this specific application and dataset. These changes are attributed to a combination of human factors, such as urban and agricultural development, and climatic factors, including drought and a reduction in available water resources.

Conclusion

This study successfully demonstrates that remote sensing technologies, coupled with supervised classification algorithms like Maximum Likelihood Classification, are highly effective and reliable tools for monitoring and quantifying land use and land cover changes over time. The observed trends in Miandoab County, particularly the expansion of agricultural and built-up areas at the expense of orchards and soil/barren lands, underscore the pressing need for integrated and sustainable land management strategies. Such strategies are crucial for balancing developmental pressures with the imperative of environmental sustainability to ensure the long-term ecological health and resource availability in the region. The findings provide a quantitative basis for informed decision-making and policy formulation aimed at achieving this balance.

Declarations

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