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ORIGINAL ARTICLE

A comparative analysis of land use classification methods using Landsat and ancillary data in urban mapping

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Abstract
This study compares the performance of parametric (LDA) and non-parametric (CTA, RF, SVM) classification algorithms in mapping urban and surrounding land cover types in Balikesir, Türkiye, using Landsat 8 OLI/TIRS imagery and ancillary data. Seven land cover classes—built-up areas, roads, water bodies, forests, meadows, agriculture, and barren land—were classified based on 2,480 ground truth points. The Random Forest (RF) classifier achieved the highest overall classification accuracy (Kappa = 0.90) and an F1-score of 0.99 for the built-up class, outperforming LDA (Kappa = 0.86), SVM (0.83), and CTA (0.78). The integration of the Digital Elevation Model (DEM) with spectral wavebands improved classification performance, particularly in distinguishing urban areas from spectrally similar classes such as barren land and roads. In contrast, additional indices like NDBI and SAVI provided only marginal improvements. Results suggest that incorporating DEM enhances model robustness and spatial accuracy, while the sole use of ancillary indices may introduce redundancy. The study underscores the importance of selecting appropriate classifier–data combinations and highlights the utility of the F1-score, alongside Kappa, for evaluating class-specific accuracy. This research contributes to urban land cover mapping by offering a comparative framework that integrates ancillary variables, helping to refine classification strategies in heterogeneous landscapes.

Keywords Urban detection · Land use classification techniques · Satellite indices · Remote sensing

Introduction

While only 30% of the world's population lived in urban areas until the 1950s, this rate increased to 50% in 2007. In addition, with the expansion of urban centers and the increasing world population, this rate is expected to reach 70% in the 2050s (Wu 2010; He et al. 2015). Urban sprawl, especially in developing countries, inevitably brings with it various environmental problems (such as land cover changes, habitat fragmentation, deforestation, air and water pollution) (He et al. 2015; Hasanah and Wu 2023; Urban et al. 2024; Wu et al. 2024; Enock and Isaac 2025). The spatial expansion of urban areas exerts profound impacts on ecosystem structure and functioning, often leading to the disruption of ecological processes and the decline of ecosystem services (Song et al. 2022; Chen et al. 2024; Saxena 2025). These environmental transformations have underscored the necessity of integrating sustainable development principles into urban planning agendas (Chettry 2023; Yi et al. 2023; Wang and Ren 2025). In response to growing concerns regarding environmental change and sustainable development, *Land Change Science (LCS)* has evolved into a distinct interdisciplinary field that investigates the dynamics, causes, and consequences of land system transformations (Byrne et al. 2024; Du et al. 2024; De Queiroz et al. 2025). In recent years, the scope and methodologies of LCS have been significantly expanded, incorporating advances in remote sensing, geospatial analysis, and socio-ecological modeling (Serra and Salvati 2022; Mohr et al. 2024). A central focus within LCS is Land Use and Land Cover Change (LUCC), which in recent decades has been largely driven by urban expansion at the expense of natural and agricultural landscapes. LUCC is now recognized as a critical driver of global environmental change (Briassoulis 2020). One of its most ecologically disruptive outcomes is

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