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Mapping four decades of agricultural land abandonment in the Moroccan Anti-Atlas: A deep-learning approach combined with Landsat temporal segmentation

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Abstract

Terraced agroecosystems (TAS) in the Moroccan Anti-Atlas Mountains have historically sustained local Amazigh communities. These rainfed systems integrate tree crops, cereals, and traditional water-harvesting infrastructure, providing essential ecosystem services such as erosion control and biodiversity support on steep slopes. During the last decades, these traditional landscapes have been steadily degrading due to rural out-migration, recurrent drought, and shifting agricultural priorities. Despite the widespread extent of this transformation, a spatially explicit, long-term record of land abandonment in the Anti-Atlas is still lacking. The absence of empirical data limits the ability of policymakers and conservation practitioners to plan targeted interventions. To address this, our study reconstructs agricultural land abandonment from 1985 to 2025 across a ≈1,200 km^2 corridor in the western Anti-Atlas (Ait Baha–Tanalt). We apply a two-phase remote sensing framework to map and monitor these changes. Phase 1 utilises a deep learning model integrating the Landsat archive with topographic features to classify land cover at 30 m resolution into four states: active terraces, abandoned terraces, natural vegetation, and bare surfaces. Trained and validated on a robust dataset of 2,000 ground-truth points, preliminary validation yields an overall accuracy of 90 %. Crucially, initial results indicate that abandoned terraces currently cover 68,073 hectares (41.9 % of the landscape), which is more than 2.5 times the extent of actively managed cropland (25,433 hectares; 15.6 %). Building on this validated baseline, Phase 2 applies the LandTrendr temporal segmentation algorithm to the multi-decadal Landsat series of three complementary spectral indices (NDVI, NBR, and MSAVI2) to identify the year of abandonment for each abandoned parcel, with results stratified by Landsat-sensor era to control for variation in observation density across the record. Our study delivers the first long-term empirical reconstruction of agricultural decline in the Anti-Atlas, comprising a validated 40-year map of abandonment and a per-pixel year-of-loss layer. These outputs establish the empirical baseline needed to assess the climate sensitivity of vegetation, understand landscape-pattern evolution, and design informed, climate-resilient restoration strategies for mountain agroecosystems.

Keywords: Agricultural land abandonment, Anti-Atlas Mountains, climate resilience, deep learning, Landsat time series, LandTrendr, Morocco, terraced agroecosystems

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