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Enrichment planting and soil-water conservation: Restore degraded dryland agro-ecosystems in Ethiopia

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Abstract

Degraded dryland agro-ecosystems threaten food security, livelihoods, and climate resilience across semi-arid sub-Saharan Africa. In Ethiopia's Banaka-Bako sub-watershed (Malle district, South Ethiopia Region), decades of deforestation and overgrazing have rendered vast areas nearly bare, undermining the multi-functional services these landscapes could provide. This study evaluated four land restoration approaches to identify optimal strategies for rehabilitating degraded agro-ecosystems while enhancing climate resilience and rural livelihoods: T1 (natural regeneration, no soil and water conservation [SWC]); T2 (natural regeneration + SWC); T3 (enrichment planting, no SWC); and T4 (enrichment planting + SWC). Established in 2021 under area-exclosure using a randomised complete block design, treatments were monitored over four years (2021–2025) through participatory methods engaging 50 farmers and 10 community members. Indicators included vegetation diversity and growth (tree density, DBH, species richness, and Shannon-Wiener index); soil health (organic matter, total nitrogen, available phosphorus, CEC, and bulk density); socio-economic outcomes (income and adoption rates); and remote sensing indices (NDVI and NDMI via Sentinel^{-2}). Initially, all plots were near-bare (tree density: 4–6 $^{\text{trees}}/_{\text{ha}}$; NDVI: 0.12–0.18; soil OM: 0.14–0.21 %). By 2025, T4 demonstrated outstanding ecosystem recovery: tree density reached 350 $^{\text{trees}}/_{\text{ha}}$ (+6,900 %); species richness, 10; NDVI, 0.65 (+30 %); soil OM, 1.21%; and household income, 8,400 $^{\text{ETB}}/_{\text{ha}}$/year, with 60 % farmer adoption. T2 performed comparably (300 $^{\text{trees}}/_{\text{ha}}$, NDVI 0.60, OM 3.44 %, income 7,200 $^{\text{ETB}}/_{\text{ha}}$), significantly outperforming both T1 and T3 ($p < 0.01$). Fanya juu terraces and stone bunds proved critical, enhancing soil moisture retention and stabilisation. These results demonstrate that combining enrichment planting with SWC structures creates a powerful synergy for transforming degraded wastelands into productive, multi-functional agro-ecosystems—delivering biodiversity gains, climate adaptation, and improved rural incomes simultaneously. The approach aligns with Ethiopia's Green Legacy Initiative and offers a scalable, community-driven model for climate-resilient landscape restoration across the Horn of Africa.

Keywords: Area closure, forest landscape, rehabilitation, soil and water conservation practices

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