Tropentag, September 16-18, 2026, hybrid conference

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Do water bunds work? Remote sensing-based impact evaluation and pastoral community voices on soil and water conservation in Kenya

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Abstract

Land degradation in semi-arid sub-Saharan Africa poses a growing threat to ecosystem function and rural livelihoods. Water bunds, low earthen structures that slow surface runoff and promote infiltration, have been widely promoted as a low-cost nature-based solution for land restoration, yet rigorous causal evidence of their environmental effectiveness and socio-economic benefits remains scarce. This study evaluates the impact of water bund interventions implemented across 32 project sites in Kenya (approximately 689,000 bunds constructed between 2016 and 2025) using a mixed-methods design that combines remote-sensing-based impact evaluation with qualitative fieldwork.

The quantitative component employs a spatial panel design using a 1 km $\times\times$ 1 km grid observed annually from 2014 to 2025. Treatment is defined at the grid level based on the presence of bunds within a 500-meter buffer. Control cells, i.e., never-treated grids beyond 1,000 m from any bund, are selected by propensity score matching to be comparable to treated cells on pre-intervention observables including elevation, slope, rainfall, temperature, vegetation cover, and nightlight. To ensure robustness, we also test alternative control group selection procedures. Environmental outcomes, including vegetation greenness (NDVI from Sentinel^{-2}), soil moisture (SMAP), and evapotranspiration (FAO WaPor), are estimated using a staggered event-study Difference-in-Differences estimator following Callaway and Sant'Anna (2021), which avoids contamination bias under staggered rollout. Pre-treatment parallel trend tests serve as validity checks.

The qualitative component draws on Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) conducted across project sites. These capture socio-economic outcomes not visible in satellite data, including impacts on pastoral productivity and livelihoods, forage and water availability for livestock, and household food security. The qualitative work also documents community-perceived timelines of benefit and reveals heterogeneity in outcomes across wealth groups, gender, and proximity to bunds.

Together, the quantitative and qualitative strands provide a comprehensive picture of how landscape restoration translates into environmental recovery and livelihood improvements. This evidence directly supports scaling decisions by restoration practitioners and policymakers pursuing climate-resilient, multifunctional agroecosystems across arid and semi-arid landscapes in Africa.

Keywords: Difference-in-differences, Kenya, landscape restoration, pastoral communities, remote sensing, water bunds

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