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

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THE RESTORATION CHALLENGE

- Degradation in Ethiopia's drylands—driven by deforestation, overgrazing, and unsustainable cultivation—has reduced vegetation cover, soil fertility, and livelihood options.
- Banaka-Bako Sub-Watershed in Malle District represents this challenge: severely degraded, near-bare land with high erosion and low productivity.

RESEARCH QUESTION

Which restoration strategy most effectively combines vegetation recovery, soil protection, and livelihood benefits?

FIELD EVIDENCE | BEFORE → AFTER

Fig. 1: Near-bare degraded slope → vegetated, productive landscape after restoration

WHY SWC MATTERED

T2 and T4 included fanya juu terraces and soil/stone bunds. These structures:

- slowed runoff and erosion
- improved soil-water retention
- stabilized degraded slopes
- created favourable conditions for regeneration and planted trees
- supported vegetation recovery and productivity

The strongest responses occurred when SWC was combined with either natural regeneration (T2) or enrichment planting (T4).

TREATMENTS & FIELD DESIGN

T1	Natural regeneration · No SWC
T2	Natural regeneration + SWC
T3	Enrichment planting · No SWC
T4	Enrichment planting + SWC

RCBD · 3 replications · 50 × 50 m permanent plots
Established 2021 under area exclosure · monitored through 2025

WHAT WAS MEASURED?

VEGETATION
- Tree density, DBH, RCD, height
- Seedlings and saplings
- Species richness, Shannon-Wiener, Simpson, evenness

SOIL HEALTH
- Organic matter, total N, available P, CEC, pH, bulk density
- 0–15 and 15–30 cm soil depths

LANDSCAPE & LIVELIHOODS
- Sentinel-2 NDVI and NDMI
- Tree-product income and adoption
- Participatory farmer monitoring

KEY VEGETATION RESPONSE

TREE DENSITY	350 trees/ha	T4 · highest
SPECIES RICHNESS	10 species	T4 · highest
DBH	8.0 cm	T4 · highest
SEEDLINGS	1,000 /ha	T4 · highest
SAPLINGS	600 /ha	T4 · highest

SOCIO-ECONOMIC OUTCOME

T4: 8,400 ETB/ha/year · 90% adoption

T2: 7,200 ETB/ha/year · 80% adoption

T4 combined enrichment planting + SWC and produced the highest income and adoption. T2 was close behind and was identified as a comparatively cost-effective restoration option.

RESULTS | DIVERSITY, GROWTH & ADOPTION

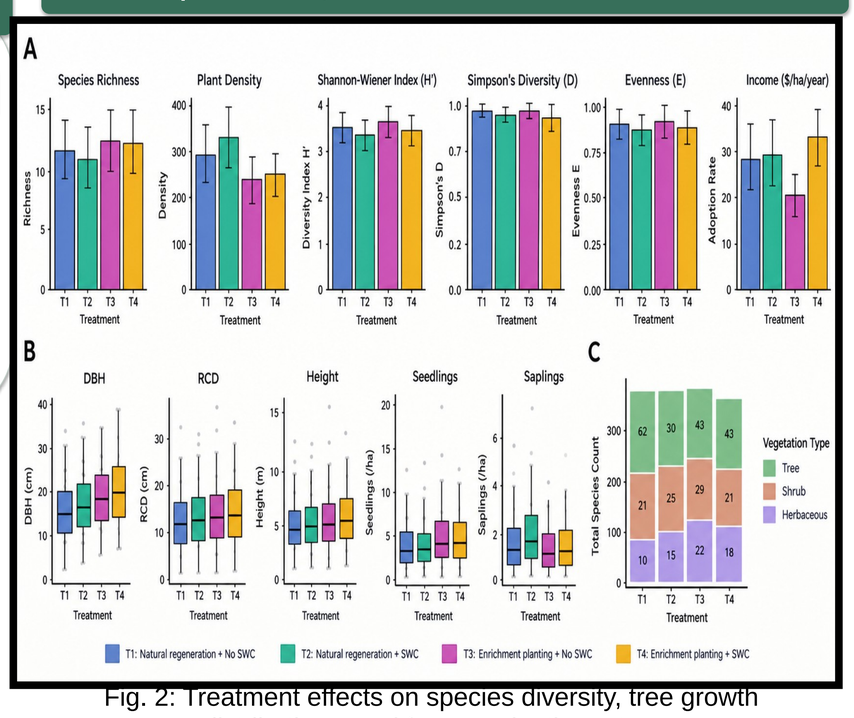

Fig. 2: Treatment effects on species diversity, tree growth distributions, and farmer adoption rates.

Soil Health Parameters by Treatment (2021 and 2025)

Soil health indicator	2021	2025	Change	Interpretation
pH	5.60	6.37	+0.77	Less acidic
Organic matter (%)	0.17	1.07	6.3×	Strong improvement
Total N (%)	0.01	0.07	7.0×	Strong improvement
Available P (ppm)	11.0	24.83	2.3×	Improved
CEC (meq/100 g)	7.50	12.08	61%	Improved nutrient retention
Available K (ppm)	110	298	171%	Strong improvement
Bulk density (g cm^{-3})	1.55	1.46	0.09	Better soil physical condition

Fig. 4: showing soil parameter change from 2021 to 2025

Treatment highlights in 2025

- **T2:** Highest **OM (3.44%)**, **TN (0.10%)**, and **available P (32.77 ppm)** at Depth 1.
- **T4:** Highest **available K (402–490 ppm)** and near-neutral **pH (6.57–6.74)**.
- **T2:** Lowest **bulk density (1.30 g cm^{-3})**, suggesting better soil physical condition.
- **T3:** Highest pH (**6.71–6.72**).

Spatial Assessment of Vegetation Health and Moisture Content in Banaka-Bako Watershed (2021 & 2025)

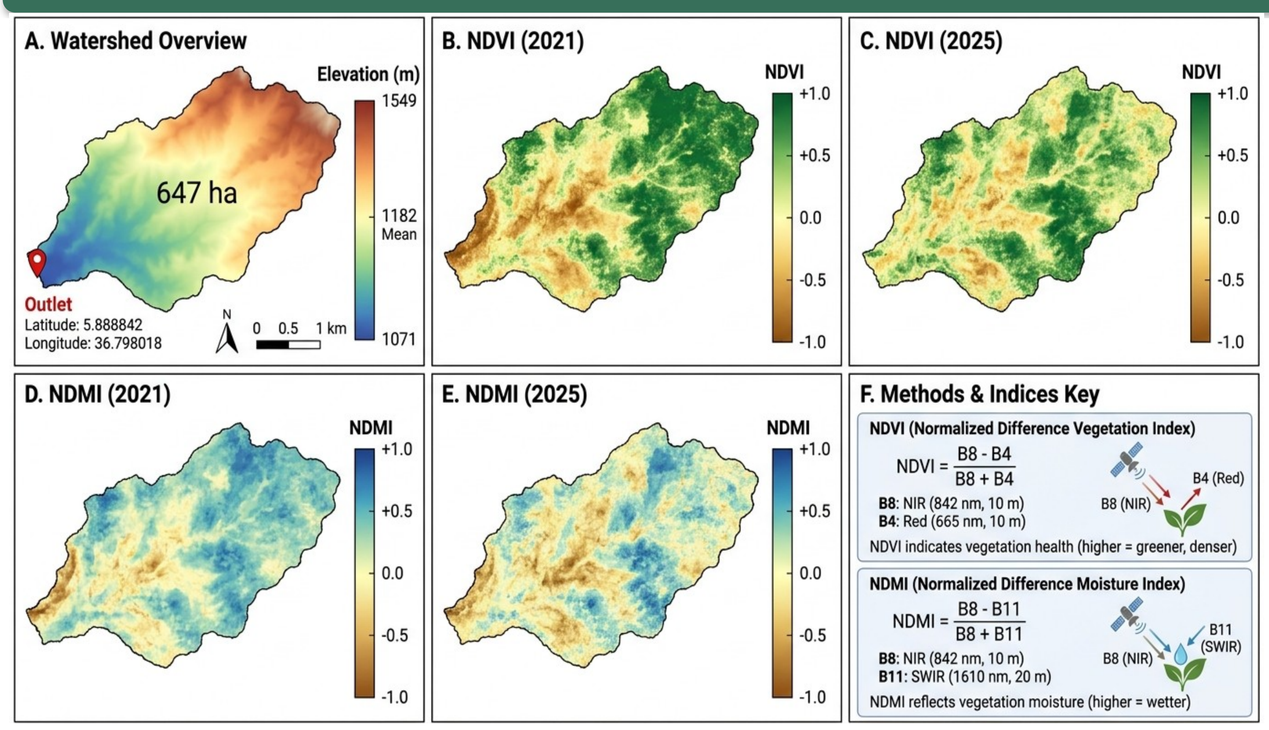

Fig. 3: Shows (A) Watershed, (B & C) Normalized Difference Vegetation Index of 2021 & 2025, (D & E) Normalized Difference Moisture Index of 2021 & 2025, and (F) methods and indices key

REMOTE-SENSING SIGNAL

NDVI recovery
T4: 0.65 (+30%) · T2: 0.60 (+25%)
T1: 0.20 · T3: 0.25

NDMI recovery
T4: 0.45 · T2: 0.40
T1 and T3 remained below 0.15

Higher greenness and moisture conditions were concentrated in treatments with SWC.

THE MAIN MESSAGE

Combining vegetation recovery with soil- and water-conservation measures can transform severely degraded drylands into more diverse, productive, and climate-resilient agro-ecosystems.

PRIORITY FOR SCALING | T2: Natural regeneration + SWC · T4: Enrichment planting + SWC

Recommendation: prioritize fanya juu terraces and stone/soil bunds together with locally suitable regeneration or enrichment planting, area exclosures, and farmer-led monitoring.

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