MULTI-FUNCTIONAL LANDSCAPES IN LAKE BOSOMTWE: TREE DIVERSITY AND LAND USE AS DRIVERS OF NTFP PROVISION AND CLIMATE RESILIENCE

Prof. Emmanuel Opuni-Frimpong[1]· Kirsten Meuer[2]· Jonathan Dabo[1]· Patience Mansah Gakpetor[1]· Dr. Akwasi Duah Gyamfi[1]· Kwame Sarfo Bonsu[1]· Emmanuel Opoku Asare[1]· Prof. Tobias Cremer[2]

1. CSIR-Forestry Research Institute of Ghana 2. Eberswalde University for Sustainable Development, Germany

Background & Problem Statement

Lake Bosumtwe

- A Unique Biosphere Under Pressure
- Location & Status: Ashanti Region, Ghana — nominated as a UNESCO Biosphere Reserve in 2016; 28,698 ha total area. One of six meteoritic lakes in the world, overlapping the Bosomtwe Range Forest Reserve.
- Ecosystems: Unique mosaic of forests, wetlands, and mountain ecosystems spanning two districts (Bosomtwe and Bosome-Freho); contributing to conservation of vital biodiversity
- Land Use Gradient Studied: Forest → Fallow → Cocoa → Arable — representing a disturbance gradient from near-natural to intensively managed agricultural systems.

Threat Context

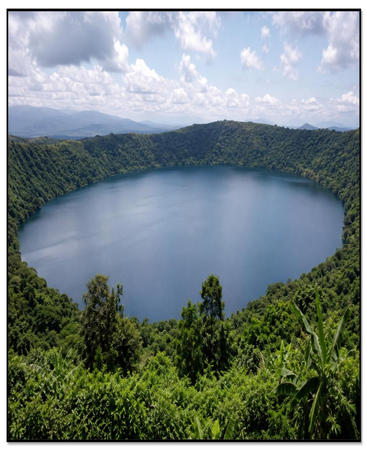
66.3%

Forest Cover Lost Over 34 years (1986–2020)

260%

Built-Up Area Expanded

At 7.7% annually — the highest percentage change of any land use category



Research Gap Addressed: **Quantitative assessment of how this land-use gradient shapes both tree flora diversity and NTFP diversity was lacking; thus, this study fills that gap**

Objectives

- **Assess tree species diversity and composition across closed forest, fallow/secondary forest, cocoa farms, and arable land**
- **Quantify the availability and diversity of key NTFPs of socio-economic importance to local communities**
- **Link tree diversity and structural complexity to indicators of climate resilience across land-use types**

Methods

A rigorous, field-based design: purposive stratified sampling with nine 25×25 m quadrats per land-use type (36 quadrats total). A botanist identified all trees to species level, confirmed using a photo guide of Ghanaian trees. Diversity indices for species richness and Shannon diversity (H′) were computed to compare compositional variation across land-use types.

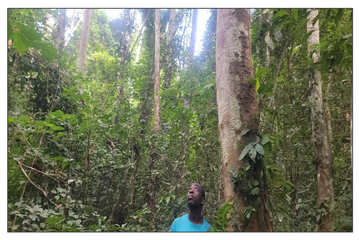
1 Stratified Sampling → 2 Plot Surveys → 3 Species ID → 4 Analysis

Study at a Glance

4	36	9	2
land-use types studied	quadrats total	quadrats per land-use type	diversity indices (richness, Shannon H′)

Four Land-Use Systems Studied

Closed Forest
Highest diversity & structural complexity



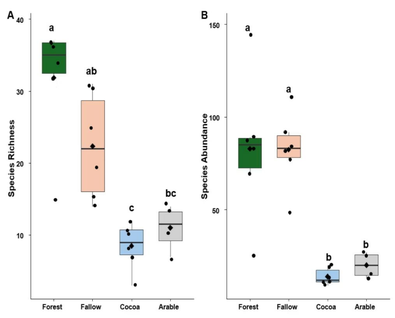
Fallow / Secondary Forest
High richness, recovering structure

Cocoa Farms
Moderate diversity with shade trees

Arable Land
Markedly reduced tree diversity

Results

- Tree Flora Diversity: Forests Dominate, Agriculture Depletes



Species Richness (P < 0.001)
Forest = **98 spp**; Fallow = 66 spp; Cocoa = 35 spp; Arable = 36 spp — richness declines sharply with agricultural intensification.

Abundance — ~6× Collapse
Forest = **497 ind.**; Fallow = 494; Cocoa = 83; Arable = 80 — a near total collapse of tree density in agricultural systems.

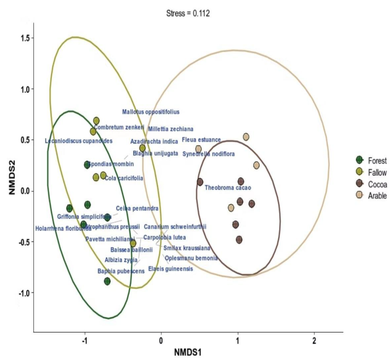
Shannon Diversity H′ (P = 0.004)
Forest = **3.06 ± 0.40** (highest); Cocoa = 1.90 ± 0.50 (lowest); Fallow = 2.56 ± 0.60 (intermediate).

Simpson & Evenness (P > 0.05)
No significant differences (P = 0.126; P = 0.102) — high evenness across all types (0.83–0.94), suggesting relative equity in species distribution where species occur.

Key insight: Fallow lands retain near-forest abundance (494 individuals) — a critical buffer for biodiversity recovery.

- Species Composition: Land Use Explains 38% of Variation

NMDS Ordination — Tree Flora



PERMANOVA Result
$F = 3.676$, $R^2 = 0.380$, $P = 0.001$ — land use type is a significant and strong driver of tree species composition. Land use explains 38% of total variation in tree species composition.

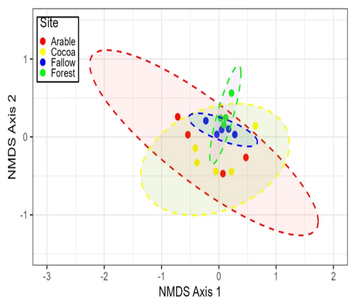
NMDS Pattern (Stress = 0.112)
Forest and fallow plots show **partial overlap** → similar species assemblages. Cocoa and arable form **distinct clusters** → compositional shift under agriculture.

Remaining 62% Variation
Attributable to within-group heterogeneity, microhabitat factors, and stochastic processes — underscoring the complexity of the landscape mosaic.

Ecological Implication
A clear compositional gradient exists from natural/semi-natural habitats to intensively managed systems — not just a loss of richness, but a **fundamental restructuring of community identity**.

Species Uniqueness and Compositional Overlap Across Sites

NMDS — Medicinal Plant Composition



Arable and cocoa sites cluster together; fallow sites are more broadly distributed — supporting both shared and transitional species assemblages.

Shared Species — Resilience Signal
Considerable overlap of NTFPs across land use types indicates some resilience of common species to land use change — not all species are equally sensitive to disturbance.

Habitat-Unique Species
Acacia pentagona and *Alafia barteri* unique to **forests**; *Aspilia africana* unique to **cocoa farms** — irreplaceable habitat-specific biodiversity that cannot be recovered from alternative habitats.

Fallow as a Compositional Bridge
Fallow lands occupy an intermediate ordination space between forests and agricultural systems — supporting a **transitional, heterogeneous medicinal flora** with conservation value.

Critical Implication
Forest loss does not merely reduce species numbers — it **eliminates ecologically and medicinally unique species** that cannot be recovered from agricultural fallback habitats.

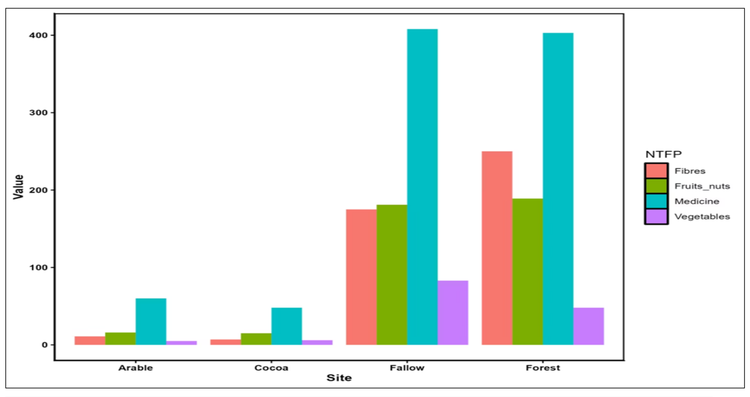
Key Results: Tree Diversity & NTFPs

Closed & Fallow/Secondary Forests
Highest species richness & structural complexity supporting the widest range of NTFPs (food, medicine, materials) and the strongest ecological baseline.

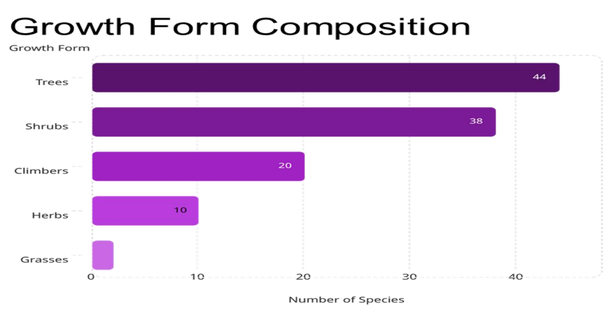
Cocoa Agroforestry
Less diverse than natural forests, but retained meaningful tree cover. Shade-tree integration sustains a valuable NTFP contribution.

Arable Lands
Markedly reduced tree diversity and severely limited NTFP availability were the most ecologically impoverished land-use types studied.

NTFP Diversity: Forests and Fallows Are the Hotspots



Medicinal Flora: The Most Ethnobotanically Significant NTFP



Woody species (trees + shrubs) constitute **82 of 114 medicinal species** — the majority of medicinal flora. Since these are forest-dependent growth forms, continued deforestation directly threatens traditional healthcare resources for ~50,800 biosphere reserve residents.

Recommendations for Policy & Practice

- **Tree Diversity is Key**
A key driver of both NTFP provision and climate resilience across all land-use systems studied.
- **A Mosaic Approach is Optimal**
No single land-use type suffices; integrating forests, agroforestry, and managed fallows works best.
- **Actionable Evidence**
Findings offer evidence-based guidance for tropical landscape management, applicable well beyond Ghana.

Climate Resilience Linkages

- Enhanced carbon storage: higher tree diversity & structural complexity are positively associated with greater carbon storage potential
- Ecosystem resilience: functionally diverse, stress-tolerant species were more prevalent in complex forest systems
- Climate-smart bridge: cocoa agroforestry links agricultural production and forest conservation
- Cocoa agroforestry systems retain considerable tree cover, integrating shade trees to sustain NTFP provision and strengthen climate resilience without abandoning agricultural production

"A landscape that retains its trees retains its future for people, biodiversity, and climate alike."

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