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Strengthening Landscape Resilience through Agroforestry

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Policy Insights for Resilient Landscapes

This publication is part of a thematic series on socio-ecological production landscapes (SEPLS) — integrated landscape and seascape systems shaped by long-term interactions between people and nature. Across the globe, SEPLS are maintaining biodiversity and supporting local livelihoods, cultural values and sustainable resource management.

Drawing on UNU-IAS research with national and international partners, the series translates scientific evidence into actionable guidance for strengthening landscape resilience, biodiversity conservation, inclusive governance and sustainable livelihoods. It supports policymakers and practitioners in implementing the Kunming–Montreal Global Biodiversity Framework, National Biodiversity Strategies and Action Plans, recommendations of the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the objectives of the Satoyama Initiative.

Executive Summary

Agroforestry is a land-use system that integrates woody perennials with crops, mushrooms, non-timber forest products and/or livestock, thereby enhancing socio-ecological resilience by buffering shocks, sustaining ecosystem functions and maintaining landscape multifunctionality. Evidence from enset-based homegarden agroforestry in southern Ethiopia demonstrates how agroforestry functions as resilience infrastructure, contributing to food security, adaptation and stability. Yet current policies and practices often prioritize short-term productivity through mono-culture cultivation over the systemic resilience benefits of agroforestry. To fully realize its potential, policymakers must strengthen targeted support, landscape conservation and resilience-focused monitoring that integrates ecological, social and governance dimensions.

Policy Recommendations

- Mainstream agroforestry as resilience infrastructure.
- Embed landscape heterogeneity through spatial planning.
- Secure tenure and strengthen inclusive local governance.
- Align innovations with socio-ecological practices.
- Institutionalize adaptive monitoring and learning systems.

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The Policy Context: Rising Vulnerability in Production Landscapes

Socio-ecological production landscapes and seascapes (SEPLS) are dynamic mosaics of land and sea use and habitats maintained through long-term stewardship, in which biodiversity, ecosystem services, livelihoods and cultural practices are integrally interconnected (Takeuchi 2010). These landscapes are increasingly vulnerable to compounding climatic, ecological and socio-economic pressures, threatening the stability of agrifood systems and rural livelihoods. Global assessments identify land-use change, direct exploitation, climate change, pollution and invasive alien species as the primary direct drivers of biodiversity loss (IPBES 2019). Land-use change is consistently ranked among the most significant contributors to ecosystem degradation and the loss of nature's contributions to people (IPBES 2019). Biodiversity, along with essential ecosystem services such as soil formation, pollination, pest regulation and water regulation, is declining across numerous production contexts, thereby weakening the biophysical foundations of long-term productivity and resilience (FAO 2019).

Landscape simplification and agricultural intensification contribute to increased vulnerability, often accompanied by habitat loss, fragmentation, diminished functional diversity and a decline in regulatory ecosystem services (IPBES 2019; Estrada-Carmona et al. 2022). Intensified production systems can generate significant environmental externalities and weaken essential ecological processes that sustain yields over time, including biological control, nutrient cycling, soil quality and hydrological stability (Tscharntke et al. 2012; Emmerson et al. 2016). Such changes diminish ecological redundancy and constrain the range of responses available to stressed landscapes, thereby heightening their vulnerability to climatic extremes, market fluctuations and disturbance events.

Vulnerability is also influenced by the deterioration of institutional capacity, tenure security and intergenerational knowledge transfer, which act as slow variables that stabilize social-ecological systems (SES) through stewardship, coordination, learning and long-term investment (Folke et al. 2005; Ostrom 2009). From an SES perspective, resilience is defined as the capacity to absorb disturbances, adapt and sustain functions without transitioning into undesirable states (Walker et al. 2004; Folke et al. 2010). When governance capacity and knowledge systems diminish, balancing feedback that supports sustainable management may be supplanted by reinforcing feedback that intensifies degradation, thereby entrapping production landscapes in states characterized by low functionality and low diversity (Dornelles et al. 2020; Wang et al. 2023; Mastrangelo et al. 2024).

Despite these risks, policy and investment frameworks frequently remain focused on short-term productivity gains and sectoral interventions, with limited acknowledgment of resilience as a fundamental criterion in the design of agrifood systems and landscape planning. This deficiency is particularly impactful for SEPLS, where multifunctionality, cultural practices and livelihood diversity are essential in preserving ecosystem functions and adaptive capacity. In this regard, agroforestry — particularly perennial, diversified systems integrated into landscape mosaics — presents a strategic approach to enhancing resilience by restoring regulatory functions, diversifying livelihood portfolios and strengthening stewardship institutions. Nevertheless, current policy and investment frameworks tend to prioritize simplified, input-intensive systems, whereas agroforestry receives comparatively limited dedicated financial assistance despite its numerous ecological advantages. Policy instruments such as payments for ecosystem services (PES), climate finance and targeted incentives present significant opportunities to more effectively align economic incentives with carbon sequestration, biodiversity conservation and landscape restoration (FAO 2011; Benjamin & Sauer 2018). However, their application within agroforestry and SEPLS contexts remains relatively constrained due to institutional, financial and implementation barriers (Chisika et al. 2022).

Agroforestry as a Structural Pathway to Resilience

Agroforestry is a land-use system in which woody perennials are integrated with crops, mushrooms, non-timber forest products and/or livestock to enhance ecological and economic interactions (Lundgren 1982; FAO 2015). It constitutes a pathway toward resilience in SEPLS. Agroforestry sustains critical variables such as soil fertility, vegetation, water regulation and habitat connectivity, thereby supporting long-term stability. By augmenting functional and response diversity and accommodating diverse user interests, from livelihood security to biodiversity conservation and cultural stewardship, agroforestry operationalizes fundamental resilience principles within SEPLS (Jay & Plieninger 2025).

While landscape simplification and input-intensive agriculture damage biodiversity and ecosystem services (Tscharntke et al. 2012; Emmerson et al. 2016; FAO 2019), agroforestry enhances ecological functions such as nutrient cycling, soil stabilization, microclimate regulation, carbon storage and pest management, reducing climate and resource vulnerabilities (Kremen & Merenlender 2018; Dobhal et al. 2024).

These functions add redundancy and response diversity, improving recovery from shocks and reducing the risk of cascading failures. Agroforestry also enhances resilience by mitigating risks through diversification and by providing stable livelihoods. By managing multiple species, products and income streams across seasons, households become less dependent on single crops or markets, mitigating economic and climate shocks (FAO 2023). These practices are often rooted in local knowledge, customary rules and collective governance, which foster adaptive learning and stewardship (IPBES 2018; 2019). Such institutional and cultural factors act as stabilizing feedback within SEPLS, supporting coordination, monitoring and adaptive management.

In this context, agroforestry should be regarded not merely as a strategy for agricultural diversification but as a socio-ecological infrastructure that enhances resilience.

By concurrently reinforcing ecological regulation, diversifying livelihoods and strengthening governance capacity, agroforestry presents a systemic approach to maintaining multifunctional production landscapes amidst the increasing pressures of social and environmental change.

Evidence from Enset-based Homegarden Agroforestry in Ethiopia

Enset-based homegarden agroforestry in southern Ethiopia provides empirical evidence that perennial, diversified production systems augment resilience within SEPLS. Enset (*Ensete ventricosum*) is a traditional Ethiopian crop utilized for its starchy foods (kocho, bulla or amicho), as well as for fiber, fodder, construction materials and cultural purposes (Sahle et al. 2018). It is frequently cultivated alongside other crops, trees and livestock within complex systems managed

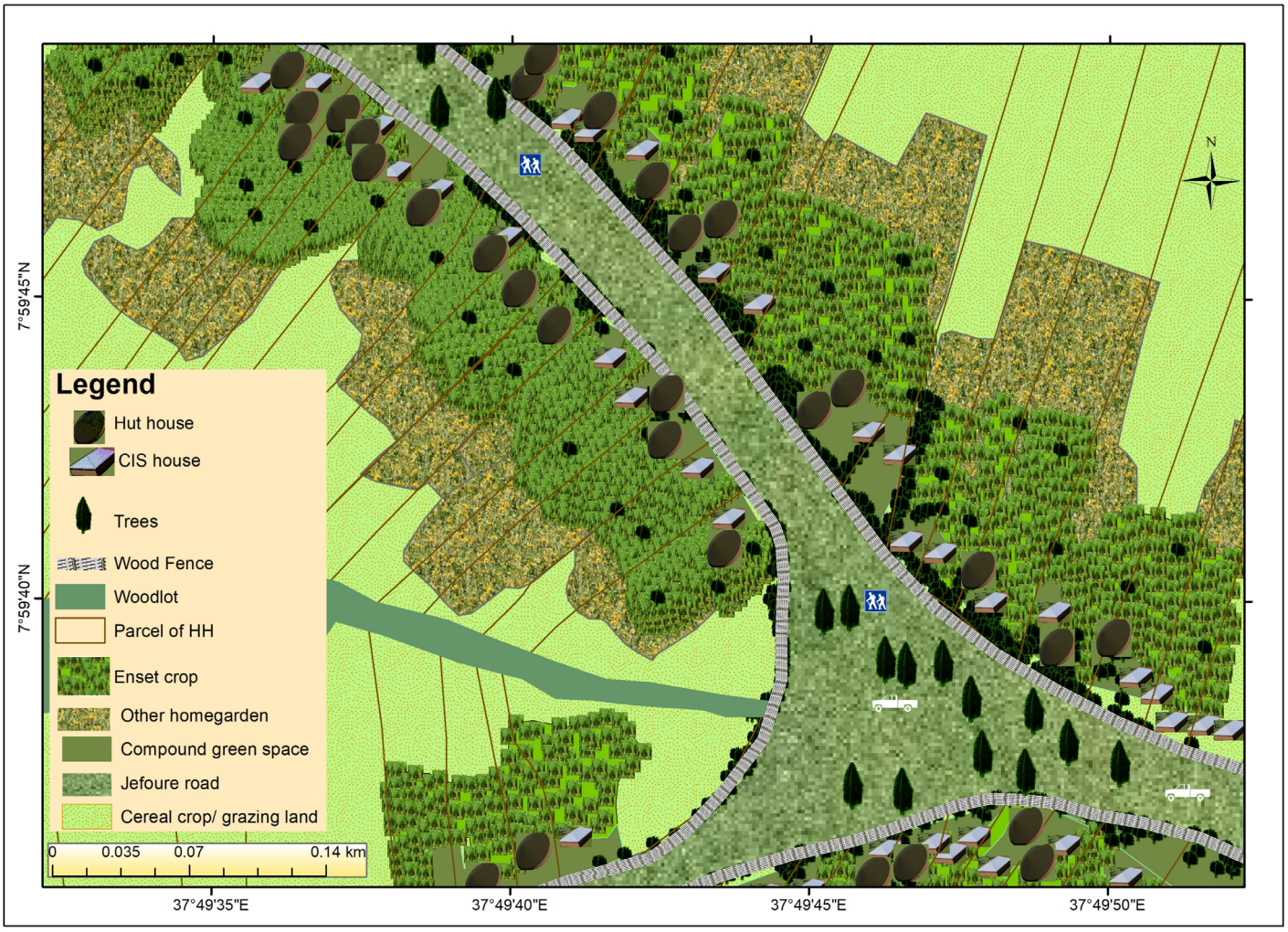

Figure 1: Enset-based homegarden agroforestry in Gurage, Ethiopia. Sketched from orthophoto mosaic (Sahle et al. 2022).

Figure 2: Enset-based homegarden agroforestry in Gurage, Ethiopia. Drone photograph (Guzo Ethiopia 2025).

through Indigenous and local knowledge (ILK) (Brandt et al. 1997; Borrell et al. 2019; Sahle et al. 2021). In these systems (Figure 1 & 2), enset serves as the structural and functional core, cultivated concurrently with trees, annual crops and livestock within spatially intricate, ecologically integrated homegardens (Brandt et al. 1997; Sahle et al. 2022). Managed through established ILK and customary stewardship practices, these systems exemplify the interactions among ecological regulation, livelihood diversification and local governance to sustain multifunctionality over time (Sahle et al. 2021; Sahle et al. 2023).

The resilience benefits of enset-based agroforestry stem from its functions:

1. Shock buffering through perennial food reserves
Enset functions as a perennial "living reserve" that can be harvested flexibly over multiple years, allowing households to respond to droughts, crop failures and market disruptions (Sahle et al. 2021). Spatial supply–demand analysis shows that, despite an uneven distribution across agro-ecological zones, enset-based homegardens substantially stabilize local food availability relative to annual crop systems (Sahle et al. 2018). Comparative studies similarly highlight enset's drought tolerance and harvest flexibility as key resilience traits (Borrell et al. 2019; Woldesenbet et al. 2022; Sherka et al. 2025).

2. Maintenance of slow ecological variables
As a keystone species, enset sustains soil fertility, moisture retention and microclimate regulation, reducing sensitivity to environmental stress and supporting recovery after disturbance (Sahle et al. 2021; Woldesenbet et al. 2022; Sahle et al. 2023; Dilebo 2025). These regulatory functions align with broader evidence that diversified, tree-based systems maintain ecosystem processes essential to long-term stability (Emmerson et al. 2016; Kremen & Merenlender 2018).

3. Landscape diversity and spatial structure
Enset-based homegardens are embedded in heterogeneous landscape mosaics comprising forests, woodlots, grazing land, annual crops and settlements. Spatial characterization shows that distinct home-garden types, aligned with agro-ecological conditions, spread risk across space and land uses, thereby enhancing system stability (Mellisse et al. 2018; Sahle et al. 2022; Garbole et al. 2025).

4. Social–institutional resilience
Indicator-based assessment shows strong governance, ecosystem protection and social equity, reflecting customary stewardship in enset-based homegarden agroforestry, whereby households maintain diverse perennial crops and transfer cultivation knowledge, processing skills and management practices across generations (Sahle et al. 2023). However, declining intergenerational knowledge transfer, reduced youth engagement and increasing livelihood pressures signal emerging social–institutional vulnerabilities that may weaken long-term resilience.

Despite demonstrated resilience, such systems face pressures from climate change, disease outbreaks, labour constraints, market limitations and policy neglect (Borrell et al. 2019; Sahle et al. 2021). Without supportive institutional frameworks, their stabilizing functions may erode.

Policy Recommendations

Strengthening resilience in SEPLS requires policy frameworks to shift priorities from short-term productivity to long-term multifunctionality, stability and adaptive governance. Evidence from agroforestry systems demonstrates that resilience emerges from the interaction of ecological regulation, livelihood diversification and institutional stewardship (Folke et al. 2010; Sahle et al. 2023). To translate these insights into practice, the following policy recommendations offer implementation-ready guidance for decision-makers.

1. Mainstream agroforestry as resilience infrastructure.
Integrating agroforestry into national resilience strategies is crucial. Governments should embed agroforestry goals within their National Biodiversity Strategies and Action Plans (NBSAPs) and Nationally Determined Contributions (NDCs) to align biodiversity, climate action and land restoration efforts. This approach requires dedicated financial mechanisms such as PES schemes, targeted subsidies and climate finance instruments. Additionally, agricultural extension systems should be restructured to promote locally adapted agroforestry models through demonstration sites and farmer training programmes. Primary responsibility for implementation lies with ministries of environment, agriculture and finance, with support from national climate agencies and development partners. Success can be measured by indicators such as the percentage of land under agroforestry, the number of farmers practising agroforestry, and the integration of agroforestry targets into national policies.

2. Embed landscape heterogeneity through spatial planning.
This is essential for maintaining ecological stability and reducing systemic risks. Policymakers should adopt integrated land-use planning approaches that incorporate agroforestry mosaics and multifunctional land uses into zoning frameworks at the national and sub-national levels. This includes introducing regulatory and incentive-based measures to limit the expansion of monocultures and deploying geospatial support tools to guide land allocation and monitor landscape diversity. This process should be led by ministries responsible for land, planning and environment, in collaboration with local governments and spatial planning authorities. Key indicators include landscape heterogeneity metrics, rates of monoculture expansion and the adoption of integrated land-use plans across administrative levels.

3. Secure tenure and strengthening inclusive local governance.
This is fundamental to sustaining long-term stewardship and collective action. Governments should formalize land tenure rights, including the recognition of customary and communal systems, while establishing or reinforcing multi-stakeholder governance platforms that enable participatory decision-making. Investments in local institutional capacity — particularly conflict resolution, coordination and adaptive management — are necessary to maintain system resilience. Land administration authorities, local governments, customary institutions and civil society organizations play central roles in implementation. Measurable outcomes include the proportion of land under secure tenure, the number of functional governance platforms and reductions in land-use conflicts.

4. Align innovations with socio-ecological practices.
Aligning innovation systems with existing socio-ecological practices ensures that technological and institutional advancements support, rather than weaken, local resilience. Policy frameworks should focus on research and development of climate-resilient species, pest and disease control, and productivity improvements across diverse agroforestry systems. They should also encourage co-production of knowledge by combining scientific expertise with ILK. Enhancing value chains through certification programs, better processing facilities and improved market access is crucial to maintaining economic viability without oversimplifying complex systems. Achieving this requires coordinated efforts by research institutions, government ministries, the private sector and community groups. Indicators of progress include widespread adoption of jointly developed innovations,

increased market value of agroforestry products and active participation of local communities in innovation efforts.

5. Institutionalize adaptive monitoring and learning systems.
This is essential to promote evidence-based policies and ongoing improvements. Governments should develop participatory, indicator-driven monitoring frameworks that incorporate ecological, livelihood and governance dimensions, combining scientific data with ILK. These frameworks must align with national reporting standards and international goals, including those in the Kunming–Montreal Global Biodiversity Framework (KMGBF). They should also feature feedback mechanisms allowing monitoring results to guide policy changes and adaptive management. Key actors include national statistical offices, environmental agencies, research institutions and local communities. Indicators of success include operational monitoring systems, the frequency of data-driven policy updates and the degree of integration of local knowledge into monitoring practices.

Contribution to Global Agendas and Pathways for Systemic Transformation

Strengthening agroforestry within SEPLS directly advances internationally agreed agendas by operationalizing integrated, landscape-based approaches that jointly deliver biodiversity outcomes, climate resilience and livelihood security. This approach aligns closely with the KMGBF, particularly Target 1 (integrated spatial planning), Target 2 (ecosystem restoration), Target 10 (sustainable production systems) and Target 14 (mainstreaming biodiversity across sectors). It also supports the 2030 Agenda for Sustainable Development by contributing to SDG 2 (zero hunger), SDG 13 (climate action), SDG 15 (life on land) and SDG 17 (partnerships for the goals) through diversified production, risk reduction and strengthened capacity for sustainable land management.

Scaling up local practices such as enset-based homegarden agroforestry to achieve broader impact requires policy frameworks that explicitly prioritize multifunctionality over homogenization, resilience capacity over short-term yield maximization and stewardship institutions over extractive trajectories. In practice, this means embedding agroforestry as core development infrastructure in land-use planning, agrifood strategies and investment portfolios, rather than treating it as an optional add-on for marginal areas.

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