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Sustainable Harvesting, Management and Commercialization of Non-Timber Forest Products: An Integrated Framework for Resilient Rural Enterprises

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Abstract

Sustainable harvesting of non-timber forest products (NTFPs) is increasingly important for strengthening rural livelihoods while conserving biodiversity, ecosystem services and climate-resilient natural-resource systems. This study reviews literature published primarily between 2000 and January 2026 to develop an integrated framework for sustainable NTFPs harvesting, management and commercialization. A systematic literature-review approach informed by PRISMA 2020 principles was used to examine evidence on NTFPs ecology, sustainable harvesting, commercialization, value chains, governance, technology, innovation, finance and markets. The review demonstrates that sustainable NTFPs enterprise development depends on the interaction of ecological, institutional, technological, financial and market factors. Sustainable supply requires resource inventories, ecosystem assessment, population and regeneration monitoring, species-specific harvesting guidelines and adaptive management. Commercialization requires secure resource rights, effective governance, community participation, appropriate processing technologies, value addition, entrepreneurial capacity, finance, market intelligence and equitable value-chain arrangements. The study proposes an Ecological–Institutional–Technical–Financial–Market (EITFM) framework that links sustainable resource management with enterprise development and commercialization. The framework shifts NTFPs development from reactive extraction towards evidence-based, adaptive and community-centred management supported by technology and periodic resource assessment. Integrated application of these dimensions can enable NTFPs to contribute simultaneously to biodiversity conservation, climate resilience, rural employment, income generation and viable forest-based enterprises.

Keywords: NTFPs Sustainability; Sustainable Harvesting; Biodiversity Conservation; Community-Based Management; Commercialization

Introduction

Non-timber forest products (NTFPs) comprise biological products obtained from forests, other wooded land and trees outside forests, including wild fruits, vegetables, medicinal plants, mushrooms, honey, fibres, resins, gums, seeds and nuts. They contribute to food security, health, cultural practices, employment and household income, particularly among rural and forest-dependent communities (FAO, 2000, 2002; Ndoye and Sunderland, 2004).

Since the early 2000s, research has shown that NTFPs commercialization can improve livelihoods and create incentives for forest conservation. However, outcomes depend strongly on production systems, resource rights, governance, markets and benefit distribution (Belcher et al., 2005; Belcher and Schreckenberg, 2007). Commercial demand may encourage sustainable management where communities receive meaningful benefits, but may also increase overharvesting where monitoring and governance are weak. In Eswatini, Dlamini and Geldenhuys (2009) demonstrated the socioeconomic significance of the NTFPs subsector. More recent research positions NTFPs within the forest-based bioeconomy, emphasizing value addition, innovation, inclusive value chains and enterprise development (Lovrić et al., 2024; Magry et al., 2024; Rosenfeld et al., 2024). Nevertheless, an important gap remains in connecting ecological sustainability with investment readiness and commercial viability. This paper therefore synthesizes evidence from 2000–January 2026 to develop an integrated framework for sustainable NTFPs harvesting, management and commercialization. It focuses on four interrelated dimensions: sustainable ecological supply; governance and institutions; technology, innovation and finance; and markets, value addition and enterprise development.

Methodology

A systematic literature review covering 2000 to January 2026 was undertaken using multidisciplinary academic databases and authoritative institutional sources, including Web of Science, ScienceDirect, Emerald Insight, Inderscience and FAO publications. Search terms included *non-timber forest products*, *non-wood forest products*, *sustainable harvesting*, *NTFPs commercialization*, *value chains*, *enterprise development*, *innovation*, *value addition*, *forest-based bioeconomy*, *community enterprises*, *governance*, *markets* and *finance*. The review was informed by the PRISMA 2020 reporting principles (Page et al., 2021). Priority was given to peer-reviewed empirical studies, systematic reviews, influential publications and institutional reports relevant to developing countries and forest-dependent communities. Literature was thematically synthesized into four areas: (1) ecological sustainability and resource supply; (2) governance, tenure and community institutions; (3) technology, management, innovation and finance; and (4) markets, value addition and value chains. Findings were subsequently integrated into the proposed EITFM framework.

Results and Discussion

Sustainable supply and ecological management

Sustainable supply is the foundation of NTFPs enterprise development. Sustainable harvesting depends not simply on the volume removed but on species biology, population structure, regeneration, harvesting method and frequency, seasonality, plant parts collected and ecosystem condition (Ticktin, 2004; Guariguata et al., 2010; Stanley et al., 2012). NTFPs development should therefore begin with resource inventories, ecosystem mapping and identification of important harvesting areas. Baseline information should include species abundance, distribution, productivity, regeneration, harvesting intensity, seasonality and threats. Scientific assessments should be complemented by local and indigenous knowledge, which can provide valuable information on resource distribution, seasonal availability and regeneration (Dovie et al., 2002; Shackleton et al., 2007). Species-specific management is essential because harvesting roots, bark or entire plants generally presents greater ecological risks than harvesting renewable products such as fruits, seeds or leaves. Rising commercial demand can increase harvesting pressure, making continuous monitoring and adaptive management necessary (Ticktin and Shackleton, 2011). Where wild populations cannot support projected demand, domestication, cultivation, enrichment planting and regeneration should be promoted. Thus, sustainable supply is both an ecological and commercial prerequisite. Enterprise expansion should only occur where there is credible evidence that the natural-resource base can support harvesting over the long term.

Governance, tenure and community participation

Governance determines who can access, harvest, manage, process and trade NTFPs. Effective systems require secure tenure and resource-use rights, transparent permits, environmental safeguards, enterprise regulation, quality standards and market compliance (FAO, 2024; Robinson et al., 2021). Secure tenure encourages communities to invest in resource conservation because it provides greater certainty that they will benefit from sustainable management. However, formal regulatory systems should recognize customary institutions and local ecological knowledge. NTFPs governance commonly involves interactions among statutory law, customary systems, community rules and market institutions (Ingram et al., 2014). Forest User Groups, cooperatives and community enterprises can improve stewardship, collective marketing and bargaining power when participation and benefit-sharing are meaningful. Conversely, unclear rights, excessive transaction costs and weak institutional capacity can undermine both sustainability and profitability (Tieguhong et al., 2016).

Consequently, regulatory and institutional assessment should be incorporated into every NTFPs feasibility study, including analysis of tenure, permits, environmental requirements, taxation, trade standards, compliance costs and institutional responsibilities.

Technology, innovation, management and finance

Technology and value addition can transform NTFPs from low-value raw materials into competitive products. Priority technologies include sustainable harvesting tools, propagation, drying, storage, grading, processing, packaging, quality assurance and product formulation. Technology choices should correspond to enterprise scale, skills, infrastructure, energy availability, environmental conditions and financial capacity. Enterprise management must integrate sustainable procurement, production, quality control, human resources, financial management, marketing and risk management. Innovation extends beyond machinery to include new products, production processes, organizational models, digital systems and market channels. Research in the forest sector emphasizes organizational capability, knowledge, networks and financial resources as important determinants of innovation (Weiss et al., 2020, 2021). Access to finance remains a major constraint for community and small-scale NTFP enterprises. Capital is required for infrastructure, equipment, working capital, product development, certification and market expansion. Appropriate financing mechanisms include community savings, cooperative finance, grants, commercial loans, equity, development finance and blended finance.

Financial feasibility should consider investment requirements, operating costs, revenues, cash flows, break-even points, returns, debt-servicing capacity and sensitivity to market and resource risks. Importantly, financial performance must be assessed alongside biological sustainability because resource degradation ultimately undermines enterprise profitability. Recent research also highlights innovation capacity as a critical determinant of NTFP enterprise competitiveness (Dumenu et al., 2026).

Markets, value addition and commercialization

Market access converts sustainable resources into economically viable enterprises. Market feasibility should examine consumer demand, product specifications, prices, competitors, market size, buyer reliability, distribution channels and growth prospects (Marshall et al., 2003). NTFPs enterprises should progressively move from selling unprocessed products towards cleaning, grading, drying, processing, formulation, packaging, branding and product diversification. Value addition can increase producer returns, reduce post-harvest losses and improve competitiveness (Ingram et al., 2019; Lovrić et al., 2024). Value-chain analysis should map relationships from resource owners and collectors to aggregators, processors, transporters, wholesalers, retailers and consumers. Costs, margins, risks, bargaining power and information flows should be assessed to identify where value is created and captured. Weak bargaining power and dependence on intermediaries can significantly reduce community benefits (Schimetka and Ingram, 2024; Nakanyete et al., 2025). Digital technologies provide additional opportunities through e-commerce, market-information systems, product traceability, digital branding and direct buyer engagement. However, these benefits depend on connectivity, digital skills and enterprise capacity. The emerging forest-based bioeconomy offers opportunities to integrate NTFPs into higher-value markets while supporting conservation. Commercialization should nevertheless proceed only when sustainable resource supply, effective governance, appropriate technology, finance and market demand are jointly established.

Integrated EITFM Framework

The review supports an integrated Ecological–Institutional–Technical–Financial–Market (EITFM) framework for sustainable NTFPs enterprise development (Figure 1). The framework synthesizes evidence that successful NTFPs commercialization depends on the interaction of ecological sustainability, secure institutions, technological and innovation capacity, financial viability and functioning markets, rather than on resource availability or market demand alone (Belcher and Schreckenberg, 2007; Ingram et al., 2019; Lovrić *et al.*, 2024; Rosenfeld *et al.*, 2024).
Ecological dimension: assesses resource abundance, population dynamics, regeneration, ecosystem condition, harvesting intensity and climate risks. These factors establish the sustainable resource base and determine whether extraction can occur without compromising regeneration, biodiversity and ecosystem functions (Ticktin, 2004; Guariguata *et al.*, 2010; Stanley, Voeks and Short, 2012; FAO, 2024). Increasing attention to climate change further reinforces the need for adaptive resource assessment and monitoring in forest-based production systems (IPCC, 2022).

Institutional dimension: addresses tenure, legal access, customary rights, Forest User Groups, governance, regulation and equitable benefit-sharing. Secure rights and effective local institutions can strengthen incentives for sustainable resource management, while governance arrangements influence participation, distribution of benefits and the performance of NTFPs value chains (Belcher and Schreckenberg, 2007; Tieguhong *et al.*, 2016; Nakanyete, Matengu and Revilla Diez, 2025).

Technical and innovation dimension: covers sustainable harvesting methods, processing, value addition, quality assurance, management systems, digital technologies and enterprise innovation. Appropriate technologies and innovation capabilities can improve product quality, processing efficiency, market differentiation and enterprise competitiveness, while technological choices need to remain appropriate to local resource, infrastructure, skills and investment conditions (Ingram, Tieguhong, Nkamgnia and Schure, 2019; Weiss, Ludvig and Živojinović, 2020; Dumenu, Meinhold and Darr, 2026).

Financial dimension: considers investment and working capital, profitability, risk, financial sustainability, development finance and blended-finance opportunities. Financial capacity is critical because NTFPs enterprises require resources for harvesting, processing, storage, certification, value addition, marketing and market development. Financial mechanisms should therefore be aligned with enterprise scale, risk, cash-flow characteristics and investment requirements (Ingram *et al.*, 2019; Lovrić *et al.*, 2024).

Market dimension: assesses demand, prices, quality, branding, distribution, buyer relationships, digital markets and value-chain governance. Commercialization can generate livelihood opportunities and incentives for sustainable management, but market expansion does not automatically produce conservation or equitable development outcomes. These outcomes depend on how value chains are governed, how benefits are distributed and whether resource extraction remains ecologically sustainable (Belcher, Ruiz-Pérez and Achdiawan, 2005; Marshall, Newton and Schreckenberg, 2003; Tieguhong *et al.*, 2016; Schimetka and Ingram, 2024).

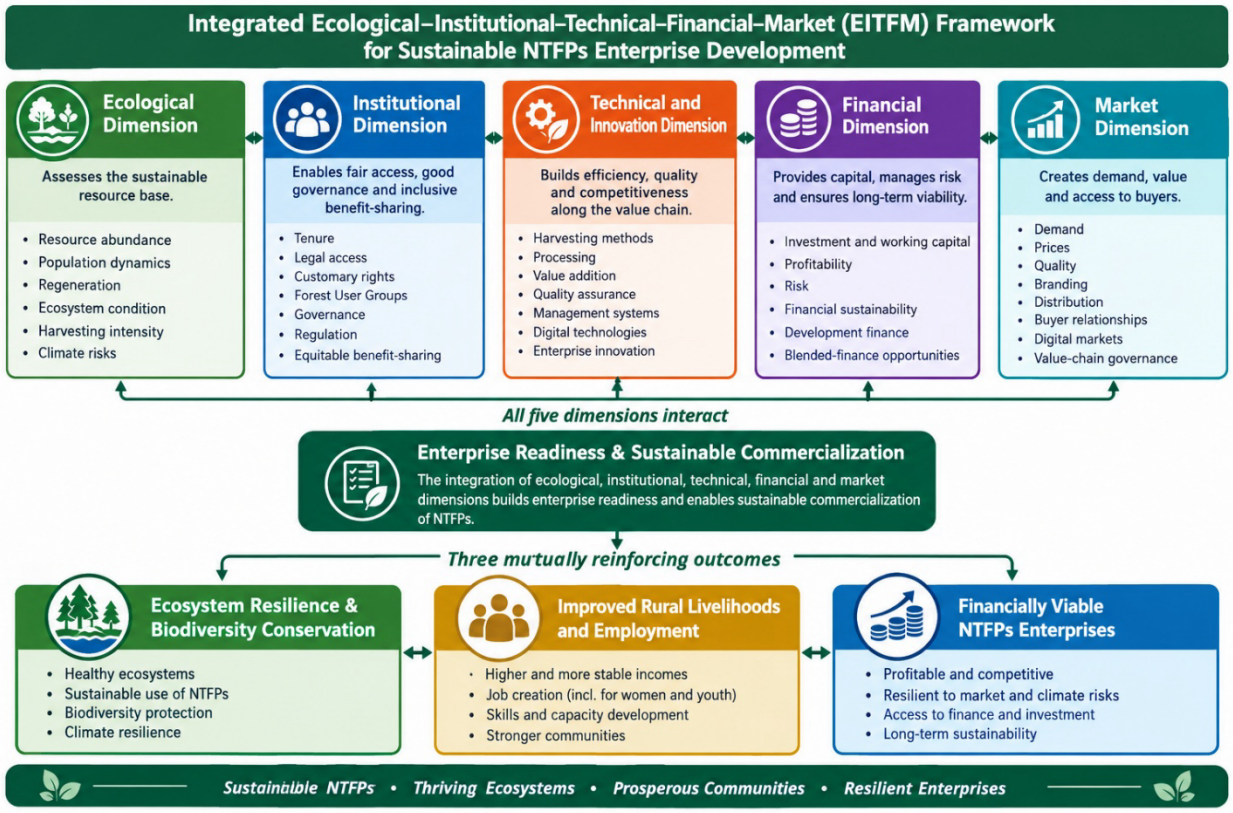


Fig. 1. EITFM framework

The five dimensions interact to determine enterprise readiness and sustainable commercialization. Their successful integration should produce three mutually reinforcing outcomes: (i) ecosystem resilience and biodiversity conservation; (ii) improved rural livelihoods and employment; and (iii) financially viable NTFPs enterprises. This integrated perspective is consistent with recent discussions of NTFPs within forest-based bioeconomies, which emphasize the need to reconcile economic opportunities with forest conservation and sustainable resource use (Lovrić *et al.*, 2024; Rosenfeld *et al.*, 2024).

The framework therefore replaces a linear "harvest–sell" model with an adaptive cycle:
Assess → Harvest sustainably → Monitor → Process/value-add → Market → Reinvest → Regenerate → Adapt → Assess.

This adaptive cycle emphasizes continuous learning, monitoring and feedback. Sustainable harvesting requires information on resource dynamics and harvesting impacts (Ticktin, 2004), while commercialization requires continued adaptation to technological, financial and market conditions. The framework consequently recognizes that ecological sustainability, enterprise profitability and community welfare must be managed as interconnected objectives, with evidence from monitoring and market performance feeding back into resource management, investment, technology, governance and enterprise decisions.

Conclusion

Sustainable NTFPs development requires simultaneous attention to ecological, institutional, technological, financial and market conditions. Sustainable harvesting provides the resource foundation but cannot

independently guarantee enterprise success. Secure rights, effective governance, community participation, appropriate technology, management capacity, finance, value addition and reliable markets are equally necessary. Commercialization should therefore be treated as a managed pathway rather than an end in itself. Increased market demand can create incentives for conservation when communities receive equitable benefits, but may accelerate degradation when monitoring and governance are weak. The forest-based bioeconomy offers opportunities to increase NTFPs value through innovation, processing, branding, digital marketing and stronger value-chain integration.

Recommendations

The study recommends that governments, communities, development agencies and investors:

1. Establish resource inventories and continuous monitoring before expanding commercial harvesting.
2. Develop species-specific harvesting guidelines based on population dynamics and regeneration.
3. Strengthen tenure security, customary rights and Forest User Groups.
4. Integrate ecological sustainability into enterprise feasibility and investment assessments.
5. Promote domestication, cultivation, enrichment planting and regeneration of high-demand species.
6. Invest in appropriate processing, storage, packaging and value-addition technologies.
7. Develop tailored financing mechanisms, including development and blended finance.
8. Strengthen market intelligence, quality assurance, branding, digital marketing and direct buyer linkages.
9. Build community capacity in business planning, financial management, resource management and innovation.
10. Establish standardized sustainability and enterprise-readiness indicators for NTFP investments.

Future research should focus on species-level harvesting thresholds, long-term ecological monitoring, climate-change impacts, digital resource monitoring, value-chain economics, consumer demand and governance effectiveness. Addressing these areas will help scale NTFP enterprises while protecting biodiversity, ecosystem integrity and the livelihoods of resource-dependent communities.

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CSD and NNK conceived the concept, wrote and approved the manuscript.

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