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Multi-output production and technical efficiency in maintained NTFP systems: Evidence from the Brazilian Cerrado

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Abstract

Rural development and biodiversity loss remain central challenges in developing regions, where forest-dependent communities depend on natural resources as a primary livelihood strategy. With over 3.5 billion people worldwide relying on Non-Timber Forest Products (NTFPs), with more than half in rural settings, these products play a critical role in supporting vulnerable communities. Sustainable NTFP management practices are widely promoted to protect biodiversity and support forest communities. However, it remains unclear whether these practices come at the cost of productive efficiency. If efficiency losses occur, farmers may be incentivized to specialise, transitioning from diversified maintained systems toward more intensive cultivated production and undermining biodiversity. This is particularly relevant in maintained NTFP systems, an intermediate management stage characterised by diversified multi-output production and low specialisation, which remain relatively understudied compared to single-product or advanced cultivated systems.

This research examines technical efficiency in multi-output NTFP production under maintained management, and assesses whether the adoption of sustainable management practices supports biodiversity and influences productive efficiency. Using data from 173 smallholder farmers in the Brazilian Cerrado and a stochastic frontier analysis, we estimate technical efficiency for multi-output NTFP production. Labor emerged as the only significant binding input, suggesting that improving labour efficiency, rather than expanding land area, is key to productivity gains. High technical inefficiency (mean TE 0.24) and decreasing returns to scale point to substantial room for output gains without additional inputs, but inherent limits to simple scaling up. Notably, technical inefficiency decreases with NTFP diversity, suggesting diversified production systems may simultaneously support both conservation and productivity objectives. Finally, sustainable practice adoption restructures NTFP production from a land-extensive toward a labor-intensive system, with high adopters showing significantly higher labour elasticity despite lower efficiency scores. Findings have potential relevance for other forest-dependent communities that rely on diversified NTFP production systems, with important implications for agricultural extension programmes and agri-environmental policies. Agricultural extension services should support farmers in maintaining and expanding species diversity and prioritise labour efficiency over land-extensive strategies. By examining multi-output NTFP production, this study contributes to a better understanding of how forest-based livelihoods can support both sustainable production and biodiversity conservation.

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