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Balancing act: A meta-analysis of ecological and economic outcomes in latin american tropical agriculture

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Abstract

Agricultural intensification threatens biodiversity in tropical regions, yet quantitative understanding of management impacts on ecological and economic outcomes remains limited. This meta-analysis synthesizes evidence from 118 studies examining coffee, cacao, and banana cropping systems across Latin America, analysing 3,470 comparisons from three perspectives: vegetation complexity (112 studies), input management (24 studies), and shade cover (24 studies).

Our findings reveal consistent biodiversity-productivity trade-offs across management practices. As agroecosystems become more ecologically complex or less dependent on external inputs, biodiversity metrics improve while yields typically decline. Vegetation complexity demonstrates the strongest biodiversity enhancement patterns, with high-diversity agroforests reaching biodiversity metric levels close to those of natural forests, and showing a sharp increase compared to monocultures. Improvements tend to be more pronounced in abundance than in richness. Carbon storage patterns are inconsistent; while agroforests store less carbon than natural systems, the relationship between agroforestry complexity and carbon sequestration remains ambiguous. Compared to monocultures, yield reductions occur across all three comparison perspectives, ranging from minor decreases to substantial declines.

The examined literature includes considerably more studies on biodiversity outcomes than on socioeconomic impacts. Future research incorporating household income or livelihoods could strengthen the case for high-diversity systems by accounting for secondary products and household wellbeing rather than relying primarily on crop yield as the primary economic indicator. This would provide a broader perspective on the real-life implications of the adoption of biodiversity-friendly practices.

This study provides important quantitative evidence for developing management recommendations that optimise multiple benefits in tropical agricultural landscapes. The findings will assist agricultural organisations, policymakers, and stakeholders in balancing conservation and production goals across Latin American coffee, cacao, and banana systems.

Keywords: Abundance, agricultural inputs, agroforestry, banana, biodiversity, cacao, carbon capture, coffee, Latin America, monoculture, polyculture, richness, shade

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