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Intensive silvopastoral systems as a pathway to sustainable cattle transformation in the Peruvian Amazon

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Abstract

Intensive silvopastoral systems (iSPS) are increasingly recognised as important option for the sustainable transformation of cattle farming, particularly in deforestation-prone regions such as San Martín, Peru. By integrating high-quality forages, legumes, and multi-strata woody perennials, iSPS enable a transition from extensive, low-efficiency grazing toward a model of sustainable intensification. These systems enhance biomass availability, increase stocking rates, and improve productivity in both milk and meat production. At the same time, they deliver substantial environmental benefits by acting as carbon sinks, reducing greenhouse gas emissions, and lowering dependence on synthetic fertilisers and agrochemicals through biological nitrogen fixation and improved nutrient cycling. Beyond their environmental advantages, iSPS offer important economic opportunities. Their diversified structure allows ranchers to internalise key production costs while generating additional income streams from timber and non-timber forest products. Given that technology adoption is largely driven by profitability expectations, this study evaluates the economic performance of an iSPS configuration in San Martín using a discounted cash flow approach. The analysis compares a conventional monoculture pasture system (*Urochloa brizantha* cv. Marandú) with a diversified iSPS comprising *Centrosema macrocarpum*, *Tithonia diversifolia*, and timber species such as *Brosimum alicastrum* and *Guazuma crinita*. To account for uncertainty and market variability, probabilistic indicators, such as Net Present Value (NPV) and Internal Rate of Return (IRR), were estimated under pessimistic, base, and optimistic scenarios. The results show a substantial difference in economic performance between systems. The conventional system generates a modest IRR of 8.09 %, whereas the iSPS exhibits significantly higher and more resilient returns of 26.62 %, 29.03 %, and 30.33 % across the respective scenarios. These gains are primarily driven by increased milk productivity and higher stocking densities enabled by improved forage quality and system design. These findings highlight iSPS as a financially viable and environmentally sustainable alternative to conventional cattle systems. Scaling up these systems could play a critical role in improving smallholder livelihoods, enhancing food security, and decoupling livestock expansion from deforestation in tropical regions.

Keywords: Cattle ranching, climate-smart agriculture, deforestation, discounted cash flow, economic analysis, silvopastoral systems, sustainable intensification

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