

Monetizing Soil Health-Derived Ecosystem Services: An Ecological-Economic Valuation of Regenerative Coffee Agroforestry in Indonesia

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Abstract

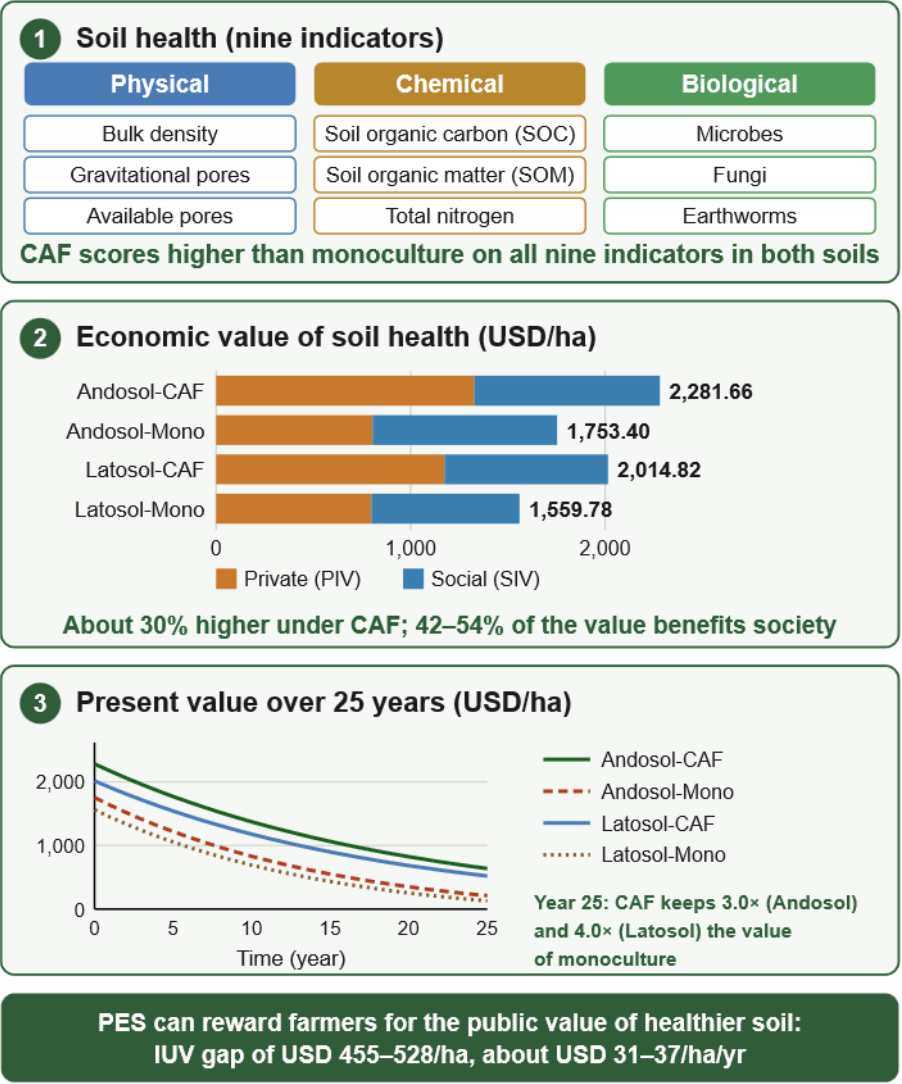
Coffee agroforestry (CAF) is increasingly recognized as regenerative agricultural practices that enhance soil health and sustaining soil ecosystem services (SES). However, the economic benefits associated with improved soil health remain poorly quantified, particularly the indirect use values (IUV) generated through ecosystem functioning. This study developed an ecological-economic valuation framework to quantify the IUV of soil health in Arabica CAF and monoculture systems on Andosol and Latosol soils in Indonesia. Soil health indicators were linked to SES through a locally adapted cascade SES framework and valued using revealed preferences methods. The assessed indicators included bulk density, available and gravitational water pores, soil organic carbon (SOC), soil organic matter (SOM), total nitrogen, and soil biodiversity represented by total earthworms, fungi, and microbes. Results showed that CAF significantly improved multidimensional soil health compared with monoculture, with Andosol soils maintaining higher absolute soil health because of their high SOM stabilization and water-holding capacity, whereas Latosol soils showed larger relative responses (effect sizes). Improved soil health increased both private indirect values, through enhanced nutrient retention and reduced fertilization costs, and social indirect values, through climate regulation and water regulation. Among all indicators, SOC contributed the highest IUV, followed by earthworm abundance under CAF. Total IUV reached USD 2,281.66 ha⁻¹ in Andosol and USD 2,014.82 ha⁻¹ in Latosol under CAF, compared with USD 1,753.40 ha⁻¹ and USD 1,559.78 ha⁻¹, respectively, under monoculture, representing an increase of approximately 30%. Soil erosion reduced long-term IUV by up to USD 46 ha⁻¹ yr⁻¹ in monoculture but only USD 10–14 ha⁻¹ yr⁻¹ under CAF. By the end of a 25-year coffee rotation, the present-value IUV under CAF was approximately 3–4 times that under monoculture. The CAF–monoculture IUV gap remained positive under ±25–50% variation in proxy prices, although it was most sensitive to the vermicompost price assumption. The findings demonstrate that monetizing SES provides a robust economic rationale for promoting CAF and informs payment for ecosystem services, carbon market mechanisms, and soil health

compensation policies, particularly within Indonesia’s social forestry program.

Table of Contents

Coffee agroforestry restores soil health and adds about 30% more soil-derived value

Bandung, West Java | Andosol and Latosol | Coffee agroforestry (CAF) vs monoculture
60 soil samples



Innovative Description: Ecological-economic cascade monetizes soil health: coffee agroforestry raises indirect values 30% over monoculture, with long-term value 3-4 times higher.