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The impact of on-farm fuelwood production on collection time in agroforestry systems: panel evidence from Rwanda

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Abstract

Agroforestry systems offer a promising pathway to building resilient and multifunctional landscapes, enhancing provisioning services and reducing dependence on off-farm resources such as natural forests particularly in sub-Saharan Africa. This study examines whether integrating trees into smallholder farming systems reduces household fuelwood collection time, thereby improving provisioning service efficiency, easing the labour burden on households, and reducing pressure on natural forests where extraction is unsustainable. We use a two-wave primary panel dataset from rural households in the Eastern province of Rwanda. A random effects (RE) model combined with a control function approach (CFA) is employed to estimate the impact of on-farm fuelwood harvesting on monthly collection time, while addressing potential endogeneity in the decision to harvest farm fuelwood. Exposure to agroforestry practices is used as an instrument to capture variation in tree adoption and management intensity. Results indicate that harvesting fuelwood from on-farm trees significantly reduces collection time by 27–37 % ($p < 0.01$), depending on model specification. Instrumental variable estimates show that exposure to agroforestry practices increases the likelihood of tree planting and enhances both the density and functional diversity of on-farm tree stocks. This strengthens the case for on-farm biomass supply and reflects a shift toward internalised energy provision within agroforestry systems. These findings highlight that agroforestry systems can contribute to multifunctionality by simultaneously providing fuelwood, reducing related household time burdens, and enhancing tree-based ecosystem functions. By reducing reliance on common-pool forests and increasing tree cover within agricultural landscapes, agroforestry systems support more sustainable and resource-efficient smallholder production systems in Rwanda and similar contexts.

Keywords: Agroforestry systems, biomass and energy, collection time, fuelwood production, panel data, Rwanda, smallholder households

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