

Industrial symbiosis and scalability of smallholder farming in Uganda

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ABSTRACT

This study explored smallholder farmers' perceptions of scalability, the industrial symbiotic practices they undertake, and the contribution of industrial symbiosis to farm scalability in Uganda. A multiple case study design was adopted, involving a purposive sample of 35 smallholder farmers from registered farmer groups in Luwero District, with data saturation reached at the 29th interview. Data were collected through semi-structured interviews conducted in the local language to ensure depth and clarity. It was then analyzed using thematic content analysis to identify key patterns and themes. The findings indicate that smallholder farmers perceive scalability as a multidimensional, practice-based process characterized by increased production, market expansion, efficient resource utilization, and enhanced operational capacity. Scalability is viewed as a dynamic process embedded in everyday farming activities. Industrial symbiosis is practiced through waste reuse, crop-livestock integration, alternative feed production, resource sharing, and knowledge exchange. These practices improve productivity, efficiency, and income, making industrial symbiosis a practical strategy for achieving farm scalability in resource-constrained settings. The study contributes to knowledge by providing a contextually grounded understanding of smallholder farm scalability, moving beyond linear interpretations. It offers empirical evidence on farm-level industrial symbiosis and demonstrates how these practices enhance productivity, efficiency, and adaptive capacity, providing novel insights into how resource-constrained farmers in Uganda achieve scalability.

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1. Introduction

Scalability is crucial for transforming subsistence farming into a more commercial and sustainable agricultural system. For smallholder farms, scalability presents the capacity to expand agricultural practices, technologies, and innovations from a limited scale to a larger one to enhance production, improve livelihoods, and strengthen food security (Hansen et al., 2022). As a result, scalable farms increase their revenue faster than their costs, allowing them to grow without significant resource constraints (Ainembabazi & Mugisha, 2014). This approach unlocks the potential of smallholder farms to expand their operations and output in response to market changes and growth opportunities (Hultberg & Pal, 2021). In addition, scaling farms develop innovative solutions that are beneficial to the economy, society and the environment in general (Aldieri & Vinci, 2021). This results in food security, poverty reduction, rural development, market integration and improved standards of living in both developed and developing economies (Gulati et al., 2022).

For Uganda in particular, scalability of smallholder farms is crucial since they contribute 80% to the country's food crop production, 25% of national GDP, employ 70% of the labour force, and enhance community resilience against economic shocks and food insecurity (Achieng et al., 2025; Apanovich &

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