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## Impact Of Grafting Technology On Coffee Farmers' Income And Poverty Reduction: Evidence From Rural Bengkulu, Indonesia

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### ABSTRACT

*This study aims to examine the income levels and poverty status of coffee farmers in Bengkulu Province, Indonesia, by comparing outcomes between those adopting grafting techniques and those using conventional cultivation methods. The study applies the poverty classification framework, using rice equivalent income thresholds, and incorporates rural poverty literature related to agricultural productivity and institutional access. Primary data were collected through structured interviews with 326 purposively selected coffee farmers. Income analysis was employed to determine income level, and poverty analysis was used to examine the level poverty among farmers. The findings reveal that farmers who adopted grafting techniques achieved a higher average income (USD 1,340.8) compared to those using conventional methods (USD 1,154.7). The adoption of grafting reduced the poverty rate by 22.71%, assuming land ownership. The study suggests that promoting technological adoption and strengthening farmer institutions are crucial for reducing rural poverty. This study provides empirical evidence on the economic impact of grafting in smallholder coffee farming and offers actionable insights for rural development policies. It contributes to the broader discourse on sustainable agriculture and poverty alleviation in developing economies.*

**Keywords :** coffee farmers; grafting; income; productivity; poverty; rural development



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## INTRODUCTION

Indonesia ranks as the fourth-largest coffee producer globally, contributing approximately 7.22% of the world's coffee supply, with an average annual production of 613,874.6 tons (ICO, 2017). Between 1990 and 2015, Indonesia's coffee production increased at an average rate of 2.11% per year, supported by a 0.63% annual expansion in coffee plantation area (Rosiana et al., 2018). However, the global crisis and a sharp decline in international coffee prices have significantly affected domestic coffee prices (Fitriani et al., 2021). According to (Wahyudi et al., 2020) Coffee holds significant potential to drive rural economic development in Indonesia, as long as existing policies are effectively enhanced to support competitiveness, inclusivity, and sustainability in the sector.

Poverty remains a persistent challenge in Indonesia, particularly among rural farming communities (Hill, 2021; van Leeuwen & Földvári, 2016). As a developing country, Indonesia continues to grapple with high poverty rates despite ongoing interventions. Addressing poverty is not only a national priority but also a global imperative, as emphasized by the first goal of the Sustainable Development Goals (Kartiasih & Pribadi, 2020). Poverty undermines many aspects of national development, contributing to poor health outcomes (Gitterman et al., 2016), malnutrition (Siddiqui et al., 2020), and low educational attainment (Claro et al., 2016).

While various poverty reduction programs have been launched by national and regional

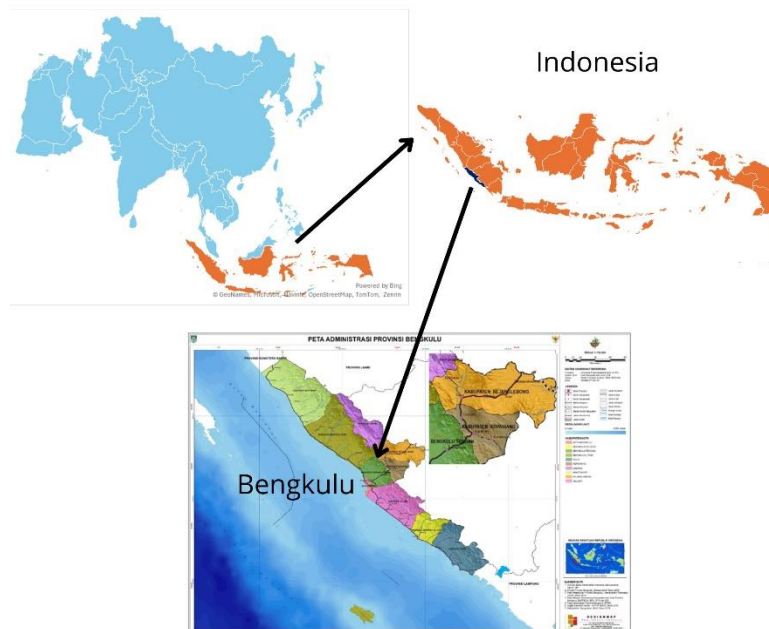
governments (Nugroho et al., 2021), many rural households, particularly farming families continue to experience economic hardship. In Bengkulu, a province known for its coffee production, the incidence of poverty among coffee farmers highlights structural and systemic issues in rural livelihoods (Irawan, 2025; Silamat et al., 2024a). Despite ongoing government support, internal and external factors continue to hinder poverty reduction efforts in this sector.

In response to these challenges, the Department of Agriculture of Bengkulu Province launched a coffee grafting program aimed at improving the productivity and quality of local coffee plants (Irawan, 2025; Silamat et al., 2024a). This program employs genetic improvement techniques to enhance indigenous coffee varieties. Unlike traditional planting methods, grafting reduces the time required for coffee plants to begin yielding crops, thereby accelerating the production cycle (Silamat et al., 2024a). The objective is to develop superior coffee plants that can generate higher yields and better quality beans, leading to improved market prices and increased income for farmers (Koutouleas et al., 2023; Myers et al., 2020).

This study is motivated by the persistent poverty experienced by coffee farmers in Bengkulu, despite the implementation of technological and policy innovations. It aims to assess the income and poverty levels of coffee farmers under different cultivation systems, particularly those involving grafted plants. The findings are expected to inform future strategies for enhancing rural livelihoods and reducing poverty in coffee-producing regions of Indonesia.

## RESEARCH METHODS

The study was carried out in Bengkulu Province between October 2022 and April 2023, with a deliberate plan. In two coffee-producing regions Kepahiang Regency and Rejang Lebong Regency (**Figure 1**) which are the biggest producers in Bengkulu province (Murtiningrum et al., 2024), a total of 326 farmers from a population of 2176 were selected from 12 villages across four sub-districts and interviewed using a questionnaire.



**Figure 1. Research site location**

This number was derived using the formula (Cochran, 1991) after the sample was established using the multi-stage sampling method:

$$n = \frac{n_0}{1 + \left(\frac{n_0 - 1}{N}\right)} \quad (3)$$

$$n_0 = \frac{Z^2 pq}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} = 384$$

With  $n$  being the necessary sample size,  $Z$  being the  $t$  value at the normal table's 95% confidence level (1.96),  $p$  being the likelihood that the respondent possesses measurable qualities,  $q$  being the probability that the respondent does not possess measurable features, and  $e$  being the 5% significance level. Assuming that 50% of respondents possess the quantifiable traits, the sample size can be determined using the formula below:

$$n = \frac{384}{1 + \left(\frac{384 - 1}{2176}\right)} = 326 \text{ farmers} \quad (4)$$

In the meantime, group proportions are used to calculate the number of samples in each group of coffee producers who use grafting and those who do not using the formula:

$$p_{ij} = \frac{N - n_{ij}}{N} \quad (5)$$

Where:

$P$  = A portion of the population under study

$n$  = The population's (sample) total size

$N$  = The region's total population

$i-j$  = The whole population of every group

There were 120 grafted coffee farmers from a population of 801 and 206 coffee farmers non shoot grafting (conventional) from 1375 populations as samples.

#### INCOME ANALYSIS

The difference between revenue and expenses is known as income. When it comes to farming, revenue is the product of production volume and pricing. The following formula is used to determine agricultural revenues from each farming pattern that is implemented, while costs are divided into fixed and non-fixed costs (Kay et al., 2012; Tenriawaru et al., 2020):

$$TR = PxQ \quad (6)$$

To calculate farmer income, use the following formula:

$$\pi = TR - TC \quad (7)$$

Using the poverty line criterion, the poverty level of coffee producers in Bengkulu province was determined (Sajogyo, 1996). Using the "rice exchange rate equivalent" (kg/person/year) based on local rice prices, the poverty line is stated in IDR/month. This is still very relevant, because the majority of Indonesia's 220 million people make rice their staple food (McCulloch & Peter Timmer, 2008). For that reason rice is among Indonesia's most significant agricultural products.

Farmers in Bengkulu province's rural areas are considered coffee farmers for the purposes of this study. The three categories of poverty are determined by the classification system: Poor family spending falls below 320 kg of rice exchange rate per person per year; extremely poor food insufficiency falls below 240 kg of rice exchange rate per person per year; and the poorest spend less than 180 kg of rice exchange rate per person per year. Next, we convert the data in the form of US dollar exchange rates. This aims to prevent exchange rate fluctuations.

#### POVERTY LEVEL ANALYSIS

In this study, coffee farmers were identified as rural residents engaged in coffee cultivation in Bengkulu Province, Indonesia. To assess poverty levels among these households, a rice-based expenditure approach was employed, which is commonly used in Indonesian rural poverty assessments. This method considers rice as a staple commodity that reflects basic consumption needs, making it a suitable proxy for estimating minimum living standards (Panuju et al., 2013).

Poverty classification was conducted by converting annual household income into rice-equivalent consumption per household member. The formula used to determine this conversion is as follows:

$$\text{Rice Equivalent (kg/person/year)} = \frac{\text{Annual Household Income (IDR)}}{\text{Household Size} \times \text{Rice Price} \left(\frac{\text{IDR}}{\text{kg}}\right)} \quad (8)$$

Based on the rice equivalent, households were categorized into three poverty levels:

Poor: < 320 kg of rice equivalent per person per year

Very poor: < 240 kg of rice equivalent per person per year

Extremely poor: < 180 kg of rice equivalent per person per year

This classification is adapted from the method developed by (Sajogyo, 1996) and reflects income insufficiency in terms of staple food purchasing power. The average market price of rice at the time of the survey was used in the calculation, ensuring contextual accuracy of the income-to-rice conversion.

**RESULTS AND DISCUSSION**

The socio-demographic profile of coffee farmers in the study area, as presented in Table 2, shows that farmers using both grafting and traditional (lane) methods shared similar characteristics in terms of education level (average 9 years, equivalent to junior high school) and household size (5 members). However, a clear distinction was found in institutional participation. Approximately 92.5% of grafting farmers were members of farmer groups, compared to only 46.7% among lane farmers. This difference has substantial implications, as group membership is often associated with better access to training, input subsidies, and credit, which in turn enhance productivity and income (Arsyad et al., 2018; Othman et al., 2020). (Brako Ntiamoah et al., 2016) emphasize the critical role of institutional support in improving smallholder agricultural performance.

Most farmers in both groups operated their own land (95.8% for grafting; 92.7% for lane), which suggests that land tenure insecurity was not a major barrier in this region. Yet, access to credit remained low in both groups (15.0% for grafting; 11.6% for lane), indicating structural constraints in rural financial systems. This aligns with findings from (Dawood et al., 2019), which noted that many rural poor in Indonesia remain excluded from formal financial services.

**Table 1. Socio-demographic characteristics of coffee farmers**

Variable	Grafting	Lane
Farmer’s age (year)	48.0	47.0
Education (year)	9.0	9.0
Number of family members (person)	5.0	5.0
Experience (year)	21.0	23.0
Job status (%)	85.0	83.0
Land status (%)	95.8	92.7
Distance from land to house (km)	3.5	3.5
Farmers (%)	92.5	46.7
Government assistance (%)	67.5	50.5
Credit access (%)	15.0	11.6
Number of plants (stem)	3028.0	4673.0
Plant age (year)	4.5	10.2

From a production standpoint, the data in Table 3 show that grafting farmers achieved better outcomes than lane farmers in both total and per-hectare productivity. Grafting farmers produced 1,138.75 kg of coffee per farm per season or 856.2 kg per hectare, while lane farmers yielded 1,030.83 kg or 722.37 kg per hectare. Although the difference in land area was minimal, the higher productivity among grafting farmers illustrates the effectiveness of the grafting technique. (Koutouleas et al., 2023; Silamat et al., 2024b) highlighted that vegetative propagation such as grafting can accelerate plant maturity and produce more uniform yields, contributing to better output quality and marketability. This is supported by the slightly higher price received by grafting farmers (USD 1.35/kg) compared to lane farmers (USD 1.34/kg), likely reflecting the better consistency in bean quality.

**Table 2. Average land area, production, and coffee price**

Description	Grafting (Avg/season/ UT)	Grafting (Per ha)	Lane (Avg/season/U T)	Lane (Per ha)
Land area (ha)	1.33	1.0	1.43	1.0
Production (kg)	1,138.75	856.2	1,030.83	722.37
Price (USD/kg)	1.35		1.34	

The economic implications of these production differences are evident in Table 4. Grafting farmers had higher gross income (USD 1,535.5) and net profits (USD 839.5) compared to lane farmers (USD 1,383.3 gross; USD 744.3 net). The cost structures also reveal differences, particularly in non-cash expenses, likely related to the older plant age among lane farmers (average 10.2 years) compared to grafting farmers (4.5 years), which may result in higher maintenance and replacement costs. These findings support the theoretical perspective of (Fisher, 2009), which defines income as the return on productive assets, indicating that the use of grafting technology functions as a productive enhancement tool in this context.

**Table 3. Average income and costs of coffee plantation businesses**

Revenue (USD)		Cost (USD)				Income (USD)			
Grafting	Lane	Grafting		Lane		Grafting		Lane	
		Cash	not Cash	Cash	not Cash	Profit	Gross Profit	Profit	Gross Profit
535,5	1383,3	194,7	301,3	228,6	410,3	839,5	1340,8	744,3	1154,7

Poverty analysis using Sajogyo’s rice-equivalent method indicates significant disparities between farmer groups (Sajogyo, 1996). Table 5 shows that 31.6% of grafting farmers were classified as poor, compared to 54.4% of lane farmers. When analyzed based on cultivation status (i.e., non-landowners), poverty rates increased dramatically, with 79.2% of grafting cultivators and 83.0% of lane cultivators falling into poor or very poor categories. Notably, 46.1% of lane cultivators fell into the “poorest” category, highlighting the critical role of land ownership in rural poverty alleviation. (Lawry et al., 2017; Ravallion, 2016) have argued that secure land tenure not only improves access to credit and investment opportunities but also provides stronger incentives for long-term productivity improvements. In this study, land ownership appears to buffer against extreme poverty, particularly among farmers applying improved cultivation methods.

**Table 4. Level of economic conditions of coffee farmers**

Category (USD)	Grafting (Cultivator)	Lane (Cultivator)	Grafting (Owner)	Lane (Owner)	Classification
>186 - 248	28 (23.33%)	35 (16.99%)	19 (15.83%)	38 (18.45%)	Poor
>139 - 147	30 (25.00%)	41 (19.90%)	16 (13.33%)	55 (26.70%)	Very poor
<139	37 (30.83%)	95 (46.12%)	3 (2.5%)	19 (9.22%)	The poorest

These findings mirror broader rural poverty patterns. (Castañeda et al., 2018) reported that 75% of the moderately poor in developing countries reside in rural areas, while (Barati et al., 2022) observed that multidimensional rural poverty, including lack of education and infrastructure, affects agricultural households. The present study confirms that beyond land ownership, technological adoption and institutional inclusion play a key role in shaping economic outcomes for rural farmers (Barzola Iza et al., 2020).

The limited access to credit, just over 13% on average, further reinforces the structural challenges faced by coffee farmers, especially those using traditional methods. Without financial access, farmers are less able to invest in improved practices such as grafting or to withstand price and climate shocks (Silamat et al., 2024a). Institutional support through farmer groups can partially bridge this gap, but coverage remains uneven.

Based on these findings, promoting the adoption of high-yield technologies like grafting, strengthening farmer organizations, and improving access to financial services are critical steps. Moreover, ensuring land tenure security will be essential for long-term improvements in productivity and rural welfare. Empowering coffee farmers through innovation and institutional strengthening offers a viable pathway toward rural economic development and poverty reduction.

However, this study is not without limitations. The analysis relied on cross-sectional survey data, which limits the ability to capture long-term trends and causal relationships. Furthermore, unobserved variables such as soil fertility, labor availability, or household consumption patterns may influence outcomes but were not measured. Future research would benefit from incorporating panel data and exploring the behavioral aspects of technology adoption to better inform policy design.

Despite these limitations, the findings provide a valuable foundation for understanding the socioeconomic impacts of cultivation practices and institutional engagement in rural coffee farming systems.

## CONCLUSION

The coffee plant development program through grafting (top-grafting) has proven effective in increasing the income of coffee farmers and reducing poverty rates in Bengkulu Province. Farmers who applied grafting techniques earned an average gross income of USD 1,340.8 per harvest season, which is USD 186.1 higher than those using conventional (lane) methods, who earned USD 1,154.7. Furthermore, assuming land ownership, the poverty rate among grafting farmers decreased to 31.66%, representing a 22.71% reduction compared to the 54.37% poverty rate observed among non-grafting farmers.

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