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Labor Allocation Patterns in Independent Smallholder Oil Palm Plantations in Muaro Jambi Regency

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Abstract
Background: Independent smallholder oil palm plantations play an important role in supporting rural livelihoods and contributing to the agricultural economy in Indonesia. However, labor allocation in smallholder plantations remains a critical issue due to variations in farm size, household characteristics, production activities, and the availability of hired labor. Objective: This study aims to analyze labor allocation patterns in independent oil palm plantations in Sungai Bahar District, Muaro Jambi Regency. Methods: The research employed a survey method involving independent oil palm farmers as respondents. Data were collected through interviews and observations, focusing on household labor involvement, working time allocation, and labor utilization in various plantation activities, including land maintenance, fertilization, and harvesting. Results: Labor allocation in independent oil palm plantations is influenced by the characteristics of farming households, plantation management practices, and production requirements. Family labor remains an important component in plantation management, while hired labor is mainly utilized for activities requiring specific skills and intensive workloads, particularly harvesting and maintenance activities. The allocation of labor reflects the adaptive strategies of smallholder farmers in managing production efficiency and reducing operational costs. Conclusion: This study highlights the importance of improving labor management capacity, strengthening farmer institutions, and providing appropriate agricultural services to enhance the productivity and sustainability of independent oil palm plantations. The findings provide valuable insights for policymakers in designing strategies to improve the welfare of smallholder oil palm farmers in rural areas.

Keywords: labor allocation; independent oil palm plantations; smallholder farmers; rural livelihood; agricultural labor

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INTRODUCTION

Indonesia's economy has long depended on the agricultural sector, and in it the plantation subsector is one of the main supports, especially through its ability to create jobs in rural areas (1,2). Among plantation commodities, palm oil occupies a strategic position: since 2006 Indonesia has become the world's largest producer of crude palm oil (CPO), and the demand for palm oil and its derivatives continues to increase despite the negative campaign against CPO (3). Indonesia's oil palm area reaches around 16.8 million hectares with a production of around 46,5 million tons of CPO in 2025, of which smallholder/independent plantations account for around 50,95 percent of the total national area (4,5).

Jambi Province is one of the main palm oil production centers in Indonesia, with a total production of around 2.11 million tons in 2025 (5). Within this province, Muaro Jambi Regency has the largest area, which confirms its strategic role in supporting the province's palm oil production (6) Sungai Bahar District is one of the long-developed oil palm centers in Muaro Jambi, where farmers have been cultivating oil palm since the early 1980s and around 80 percent of the population depend on oil palm farming for their livelihood (7).

Labor is one of the most crucial production factors in independent oil palm farming because, in contrast to land or capital, its use varies greatly according to the type of activity and household conditions (8,9). Labor use is generally expressed as labor outpouring, measured in units of Working Days (HOK), where the labor contributions of men, women, and children are converted to the equivalent of one man's workday (10,11) Independent smallholders generally use a combination of in-family labor (TKDK) and out-of-family labor (TKLK); the proportion of both changes according to the land area, the intensity of the activities carried out, and the availability of household labor itself (12,13).

Based on the initial survey conducted at the research site, each wage worker who assists farmers in carrying out their farming is given different wages according to the activities carried out. Wages for daily workers who help farmers are given a wage of Rp. 100,000/day with a working time of 8 hours per day. Harvesting workers with a wholesale system are given a wage of Rp.200,000/Ton. Maintenance activities are given a wage of Rp. 800,000/Kapling.

The difference in the amount of wages shows that the needs and use of labor at each stage of oil palm farming have different characteristics. In practice, independent smallholders utilize a combination of in-family labor/domestic labour (TKDK) and out-of-family labor/hied labour (TKLK), with proportions adjusted based on the type of activity, the area of land cultivated, and the availability of household labor (14) The labor allocation pattern is one of the important factors that determine the efficiency of farming management and production sustainability. However, information on how labor is allocated to each independent oil palm farming activity, especially in Sungai Bahar District, Muaro Jambi Regency, is still relatively limited.

Therefore, this study aims to analyze the pattern of labor allocation in independent oil palm plantations in Sungai Bahar District, Muaro Jambi Regency, by

identifying the use of in-family labor and out-of-family labor in various farming activities, including maintenance, fertilization, and harvesting activities.

METHODS

Study design and setting

This study used a survey method and was carried out in Mekar Sari Makmur Village and Panca Mulya Village, Sungai Bahar District, Muaro Jambi Regency, from June 2026 to August 2026. The two villages were chosen deliberately (purposively) because they are representative independent oil palm plantation centers in the sub-district.

Population, samples and sampling

The study population was 681 independent oil palm farmers (237 people in Mekar Sari Makmur Village and 444 people in Panca Mulya Village). The sample size was determined using the Taro Yamane formula with a precision level of 10 percent, so that a total sample of 87 farmers was obtained, which was allocated proportionally to 30 respondents in Mekar Sari Makmur Village and 57 respondents in Panca Mulya Village (Table 1), which were selected through a simple random sampling method (15).

Table 1. Allocation of the Number of Sample Farmers in Each Village in the Research Area

Number	Village Name	Total Population	Number of Samples
1	Holiday rentals in Makmur	237	30
2	Panca Mulya	444	57
	Quantity	**681**	**87**

Source: Primary Data Processed (2026)

Instruments and criteria

Data were collected using a structured interview questionnaire covering the identity of farmers, farming and production characteristics, and the labor devoted to each plantation activity (fertilization, spraying, pruning/maintenance, and harvesting), disaggregated by in-family labor (TKDK), out-of-family labor (TKLK), and gender.

Procedure and data collection

Primary data was collected through structured interviews and direct field observations, while secondary data was obtained from the Jambi Provincial Plantation Office, the Central Statistics Agency (BPS), the Ministry of Agriculture, and related village and sub-district offices. The data analyzed in this paper include the identity of farmers, characteristics of farming and production factors, as well as the allocation of labor in each plantation activity, which is measured in HOK units per year per hectare using a mathematical formula (11).

$$\text{H OK} = \frac{\sum TK \; x \; Hk \; x \; Jk}{8}$$

Where:
HOK = Working People's Day (Working Day)
TK = Workforce (People)
HK = Weekday (Day)
JK = Working Hours (Hours)

Statistical analysis

Data were analyzed descriptively (frequency, percentage, mean) to describe the characteristics of respondents and to calculate the total and average labor outpouring (HOK/year/ha) for each plantation activity, disaggregated by labor source (domestic labour/TKDK or hired labourTKLK) and gender.

Ethical concideraions

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of XXX (approval institution.

RESULTS

Overview of Research Locations

Sungai Bahar District has an area of 156.30 km² and consists of 11 villages, 28 hamlets, and 135 neighboring villages, with the government center in Marga Village. Around 26,554 hectares of land in this sub-district are allocated for plantations, dominated by rubber and oil palm. The population of this sub-district was recorded at 28,359 people in 2020, with the agricultural sector, especially oil palm being the dominant livelihood: around 38 percent of the population in the study site worked as independent smallholders and another 26 percent as farm laborers.

Characteristics of Respondent Farmers

The 87 sample farmers were generally in the productive age, with an age range of 26 to 70 years; the largest group (27.6 percent) was in the age range of 56–60 years, indicating that most respondents were still physically able to manage their fields. The number of family members ranges from one to five, with two- and three-person households being the most common (34.5 percent each), most of whom help directly with garden work. In terms of education, 43 percent of farmers have completed high school education, while only 5 percent have attained higher education, showing moderate capacity to adopt new farming management practices. Farming experience ranged from 5 to 39 years, with the largest group (25 percent) having 20–24 years of experience, reflecting the well-established farming traditions passed down between generations at the research site. However, age and length of farming experience are not always significantly related to the amount of labor output of a farmer, as found in paddy rice farming in Kupang Regency, where the variables of age and experience do not have a significant effect on labor outflow compared to land area factors (16).

An Overview of the Independent Oil Palm Plantation Business

The average land area at the research site was 2.5 hectares, ranging from 2 to 6 hectares, with all respondents cultivating their own land. Planting years varied between 2011 and 2020 following a government-supported replanting program, so the plant lifespan ranged from about 4 to 12 years at the time of the survey, with a standard planting distance of 8 × 9 m using TN1 and Lonsum varieties. Fertilization is carried out twice a year as recommended, with the most used KCl fertilizer (average 379 kg/year) and the least Phonska (4 kg/year); Spraying of herbicides, especially Gramoxone (an average of 4.9 liters/year), is also carried out twice a year to control weeds. Farmers used nine types of standard equipment, including egrek, dodos, and spray kep and achieved an average production of fresh fruit bunches (FFB) of 10–20 tons/year for the majority of respondents (69 percent), with a small percentage of farmers achieving production of up to 80 tons/year.

These characteristics show that the independent oil palm plantation business in Sungai Bahar District is managed on a relatively small scale, owned by the family itself, using conventional production facilities and equipment, and heavily reliant on household labor in daily operations, conditions that directly shape the labor allocation pattern discussed in the following section.

Labor Allocation by Plantation Activities

According to (17), labor allocation is a problem related to labor resources. Labor allocation is a way that farmers do in order to produce goods or services. The labor allocation is the amount of labor devoted in each process of oil palm farming production activities. The workforce used comes from family labor and non-family labor.

The allocation of labour in independent oil palm plantations in Sungai Bahar District was analysed for four main activities, fertilisation, spraying, fertilisation, and harvesting, which included both domestic labour (TKDK) and out-of-family labour/hired labour (TKLK), broken down by gender. The outpouring of labor is expressed in the Working People's Day (HOK) per year per hectare.

Fertilization

Fertilization, which is carried out twice a year outside the rainy season, requires the lowest labor outpouring among the four activities: 0.78 HOK/year/ha, where the labor force in the family (0.57 HOK) is greater than the labor force outside the family (0.21 HOK). Male workers in the family alone contribute 0.50 HOK/year/ha. This activity is relatively light and technically simple, so households tend to do it themselves to reduce wage costs.

Spraying

Spraying to control weeds, using spray spray with systemic herbicides (Roundup, Rambo) and contact (Gramoxone), requires a total labor outpouring of 1.67 HOK/year/ha. In-family labor again dominates, amounting to 1.07 HOK/year/ha

compared to 0.60 HOK/year/ha for non-family workers. Spraying is carried out primarily by male workers, female involvement is generally limited to mixing herbicides with water, not field applications. This limited and indirect role of women is in line with findings on independent oil palm plantations in Central Kalimantan, where women's working time is more concentrated in light work around the home than in field activities, suggesting that this gender-based division of labor is a common pattern in the independent oil palm plantation system, not just a characteristic of the Bahar River (18).

Completion

Cutting or pruning fronds that are unproductive or disease-afflicted, carried out once a year, requires a total labor outpouring of 1.42 HOK/year/ha, with domestic labor (0.74 HOK) slightly larger than non-family labor (0.68 HOK). The refinement was carried out entirely by male workers at the study site, given the physically strenuous nature of the activity.

Harvesting

Harvesting is carried out about twice a month, or about 24 times a year, is the activity that absorbs the most labor, requiring 7.71 HOK/year/ha, larger than the other three activities combined. In contrast to other maintenance activities, the out-of-family workforce in this activity is larger than the in-family workforce (4.02 HOK/year/ha compared to 3.69 HOK/year/ha), reflecting the time-bound nature of harvesting and requiring additional labor to maintain the quality of FFB in a short harvest period. This dependence on non-family labour for harvesting is reinforced by the prevailing wage system, where out-of-family harvest labour on independent oil palm plantations is generally paid on a wholesale basis, calculated per ton or per kilogram of FFB harvested, rather than per working day, which provides a direct incentive for harvest workers to work quickly while giving farmer households a flexible way to increase their labour at peak harvest times without being tied to the burden of wages daily (19). This scheme helps explain why farmers use out-of-family labour primarily for harvesting, rather than for maintenance activities with more flexible schedules, even though harvesting is a much more labour-absorbing stage. These findings are consistent with the study of oil palm harvesting labor in Bungo Regency, Jambi Province, which also found that harvesting activities are the point with the highest labor needs and are most sensitive to late completion compared to other maintenance activities (20).

Allocation of Labor Use in Oil Palm Plantations

The labor used by farmers in the research area is human labor consisting of workers who come from within the family and outside the family. Based on the results of the study, it was obtained that the labor devoted to several types of activities can be seen in Table 2.

Table 2. Average Labor Outflow in Oil Palm Plantations in the Research Area

No.	Types of Activities	Labor Outflow (HOK/Year/Ha)				Quantity
		TKDK		TKLK		
		L	P	L	P	
1	Fertilization	0,5	0,07	0,2	0,01	0,78
2	Spraying	1	0,07	0,58	0,02	1,67
3	Completion	0,74	0	0,68	0	1,42
4	Harvesting	3,08	0,61	3,85	0,17	7,71
Quantity		**5,32**	**0,75**	**5,31**	**0,2**	**11,58**

Source: Primary Data Processed (2026)

Overall, the total labor outpouring in the four activities was 11.58 HOK/year/ha, of which harvesting itself accounted for 66.6 percent, confirming this activity as the stage that absorbed the most labor in independent oil palm farming, followed by spraying (14.4 percent), finishing (12.3 percent), and fertilization (6.7 percent). Across all activities, male labour (10.63 HOK) was much more dominant than female labour (0.95 HOK), in line with the highly physical nature of oil palm activities and previous findings that male labour did most of the production activities on oil palm plantations (21).

Expressed in working hours, the same pattern also applies: total labor use is 92.64 hours/year/ha, with harvesting again dominating at 61.68 hours/year/ha (66.6 percent of total working hours), followed by spraying (13.36 hours), weaning (11.36 hours), and fertilization (6.24 hours). Since farmers generally work eight hours per day (08.00–16.00), the low need for labor in fertilization and finishing activities reflects both the small land area per household (average 2.5 ha) and the technical simplicity of these activities compared to harvesting.

Overall, these results show that in-family labor remains the backbone of routine maintenance activities such as fertilization, spraying and weaning that allow households to reduce cash expenditure on wages, while out-of-family labor is more used in harvesting activities, where the need to immediately process FFB as well as the physical intensity of cutting and transporting bunches exceeds the capacity that some can meet on their own large households. This division of labor is in line with the findings of previous research on the use of labor in independent oil palm plantations in other regions of Sumatra, where domestic labor also dominates land maintenance activities while labor outside the family is concentrated in harvesting and transportation activities (22).

DISCUSSION

Comparing these results with other recent independent smallholder studies puts labor patterns in the Bahar River in a broader regional trend. A survey of independent smallholders in Tulang Bawang, Lampung, also found that labor and fertilizer costs are the largest components of production costs, and that the ratio of in-family labor to

out-of-family labor changes systematically according to the scale of the business, with narrower land relying more on family labor, while larger areas using labor outside the family are proportionally larger (23).

A comparison of gender-based labour inflows between rubber and independent oil palm farming in West Kalimantan also found statistically significant differences in labour use between the two commodities as well as between male and female labour, reinforcing the pattern found in this study in which male labour dominates almost all stages of oil palm cultivation (24).

Another study in Banyuasin Regency, South Sumatra, also confirms that the productivity of harvest labor is greatly influenced by work experience and the wage incentive system, not just the number of available labor, which strengthens the argument that the efficiency of harvesting labor allocation in Sungai Bahar is also inseparable from the wage institution factor (25). Taken together, these studies suggest that the documented predominantly harvesting and male labor structure in Sungai Bahar is not an isolated local pattern, but rather a more common structural feature in self-help oil palm farming, where the balance of family and non-family labor primarily changes at land scale, not location.

CONCLUSIONS

Independent oil palm plantation businesses in Sungai Bahar District, Muaro Jambi Regency, are characterized by relatively small land ownership (average 2.5 ha), self-ownership, moderate levels of formal education, and long experience in farming, managed mainly by domestic workers. The allocation of labour in the four main activities of plantations is uneven: fertilisation, spraying and weeding together absorb only about one-third of the total annual labour outflow and rely on in-family labour, while harvesting itself absorbs two-thirds of the total labour outflow (7.71 out of 11.58 HOK/year/ha) and is more dependent on labour outside the family due to its time-bound nature and high physical labour. Male labor dominates all activities, reflecting the physical demands of oil palm cultivation. These findings suggest that policies to improve the welfare of independent smallholders should prioritize support for the harvesting workforce, such as fair wage mechanisms, the establishment of harvester groups, and skills training, while still supporting family-based labor patterns in routine maintenance activities as a cost-effective strategy that most households have been implementing.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

During the preparation of this manuscript, the authors used artificial intelligence (AI)-assisted language tools, including Grammarly, solely to improve the quality of the writing. These tools were employed to refine grammar, enhance sentence structure, and improve the overall clarity and readability of the manuscript. All intellectual content, including the study design, data collection, data analysis, interpretation of findings, and final conclusions, was developed and verified by the authors. The authors carefully reviewed and edited all AI-assisted outputs and accept full responsibility for the accuracy, originality, and integrity of the content presented in this manuscript.

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