FACTORS INFLUENCING LABOR ALLOCATION IN RUBBER PLANTATIONS IN MUARO JAMBI REGENCY

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Abstract

Background: Production and the number of smallholder rubber farmers in Muaro Jambi Regency have decreased over the past ten years. The decrease in production and the number of rubber farmers are believed to be caused by a decrease in the labor allocation in rubber plantations. Rubber farmers now focus on more than just one commodity, and farmers have diversified their income resources, such as oil palm plantations and off-farm work. As a result, household economic decisions will be related to labor allocation.
Purpose: This study aims to analyze the labor allocation in rubber farmer households and identify the factors influencing labor allocation in rubber plantations in the Muaro Jambi Regency.
Design/methodology/approach: This research used primary data from one hundred rubber households using a multistage random sampling method. The estimation was done in two steps: in the first step, shadow wages were estimated using the production function to get the value marginal product of labor, and in the second step, the instrumental variable method was used to determine the factors influencing labor allocation in rubber plantations.
Findings/Results: The estimation shows that shadow wages, oil palm labor allocation, and non-rubber income significantly influence rubber labor allocation. This result indicates that the existence of oil palm plantations does not cause a decrease in rubber labor allocation, and shadow wages can be a determining factor in labor allocation.
Originality/value (State of the art): This study focuses on how rubber farmer households allocate their labor across rubber plantations, other farms, and off-farm work in the context of the presence of other commodities, particularly oil palm, which is developing alongside rubber in the research area. The results show how farmers make decisions regarding their rubber plantations, switch to oil palm, or do off-farm work, which is the reason why they began reducing labor allocation to their rubber farms.

Keywords: labor allocation, household economics, shadow wages, instrumental variable, rubber plantations

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INTRODUCTION

Rubber is one of Indonesia's leading plantation commodities that plays an essential role in the country's economy and provides a source of employment. Many people depend on rubber plantations for their livelihoods. In 2022, 1.79 million households relied on the sector (Ditjenbun, 2023). Most rubber plantations in Indonesia are smallholder plantations managed by households, accounting for 91.73% of the total rubber plantation area in 2022. Therefore, resource allocation decisions in farm management are largely determined by the households (Kusnadi, 2005). However, smallholder rubber plantation development faces several challenges, including low productivity and fluctuations in rubber prices (Nicod et al. 2020; Nugraha et al. 2018). Low and unstable rubber prices negatively affect the socioeconomic conditions of rubber farmers who rely solely on income from rubber plantations, decreasing income and purchasing power (Syarifa et al. 2016; Ali & Manoj, 2020). The decrease in income will affect farmers' ability to meet their household needs. If this situation continues, a rational household will seek alternative, more profitable activities to sustain their livelihoods, such as seeking employment outside rubber plantations (Mara & Sativa, 2022; Ali & Manoj, 2020).

In fact, a decrease in rubber production and the number of farmers has already happened in Jambi Province, one of Indonesia's production centers. Production decreased from 319,470 tons in 2018 (Ditjenbun, 2019) to 291,746 tons, and the number of households cultivating rubber decreased from 220,817 to 155,632 in 2022 (Ditjenbun, 2023). A similar trend is evident in Muaro Jambi Regency, which has also experienced a decrease in production and number of farmers. Currently, the rubber production in Muaro Jambi Regency is 28,041 tons, with 9,534 households. A decrease averaging 0.02% annually over the past 10 years (Ditjenbun, 2023). In addition, there is an ongoing issue in the region regarding the conversion of rubber land to oil palm plantations, raising concerns about the emergence of competing substitute commodities (Syamsafitri et al. 2023; Afrizon et al. 2021). Thus, the decrease in production and the number of farmers in Muaro Jambi Regency is believed to result from changes in labor allocation in rubber plantations. Many farmers have decided to stop farming, which affects input use, planting activities, harvesting, and marketing (Goh et al. 2016). As a result, rubber plantations are becoming less efficient (Fernandez-Cornejo et al. 2007), leading to a decrease in rubber income. Putri et al. (2022) found that rubber income currently contributes little to total household income. If the primary occupation's income is insufficient to meet the household's needs, farmers will allocate their labor to other activities between agricultural and off-farm work (Zahri & Febriansyah, 2014; Erlina et al. 2019). Li et al. (2021) found that farmers who also work outside of farming influence agricultural production decisions, other activities can reduce farm labor time and negatively affect agricultural production efficiency (Bagamba et al. 2009). In other words, labor allocation in rubber plantations will decrease (Tongkaemkaew & Chambon, 2018; Elly, 2009). Therefore, studying how farmers allocate labor is essential.

Several previous studies have discussed labor allocation in rubber plantations (Wahyuni et al. 2021; Yuni et al. 2018; Tongkaemkaew & Chambon, 2018; Husin 2012). However, due to the rapid growth of other prospective commodities in the research area and issues related to land conversion, especially to oil palm plantations (Azzahra et al. 2017; Schwarze et al. 2015), there is a need for literature that highlights the impact of these developments concerning labor allocation. Lifianthi et al. (2018) found an influence on the labor allocation between rubber and oil palm plantations. The results of this study will fill this gap in the existing literature by providing empirical evidence on how farmers allocate resources in the form of labor in rubber plantations amidst the rapid development of oil palm commodities. In addition, this study highlights an opportunity to better understand the factors influencing labor allocation in rubber plantations and provides valuable insights into developing policies that support the future growth of rubber plantations through efficient resource allocation, especially labor.

The hypothesis in this study is that the presence of oil palm plantations in terms of labor allocation, off-farm work, and other related factors are important factors affecting labor allocation in rubber plantations. Based on this description, this study aims to analyze the labor allocation in rubber farmer households and the factors influencing it in the Muaro Jambi Regency.

METHODS

This research was conducted in Muaro Jambi Regency, Jambi Province, from January to March 2024 to collect data. The data used in this study are cross-sectional data from the last year (February 2023–January 2024). Data were obtained through direct interviews with rubber farmer households using questionnaires, making this primary data. The primary data collected includes farmers' characteristics and socio-economic conditions, labor allocation, rubber plantation data, non-rubber farming activities, and off-farm work activities. Secondary data were collected from relevant government agencies, literature from previous research, books, and journals that support this research. Respondents were selected using a multistage random sampling method. From the total of eleven sub-districts, four were selected: Sekernan, Mestong, Jambi Luar Kota, and Sungai Gelam. These locations were purposely selected as they represent the centers of rubber production in Muaro Jambi Regency. Each sub-district consisted of one to four selected villages to obtain 100 rubber farmer households using the simple random sampling method.

This study's data analysis consists of descriptive and quantitative analysis. Descriptive analysis was used to provide an overview and explanation of the characteristics of the respondent farmers and their labor allocation. The quantitative analysis was done in two steps. In the first step, because the rubber plantation in this study does not use hired labor, the use of shadow wages is suitable. In estimating shadow wages, the value of the marginal product of labor (VMPL) is measured and derived from the Cobb-Douglas production function, which is transformed into a logarithmic form as follows:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \varepsilon_i \quad (1)$$

Where: Y= Rubber production (Kg/year); X_1 = Labor (HKP/year); X_2 = Land area (Ha); X_3= herbicide (Liters/year); X_4= Stimulant (Liters/year); X_5 = Tapping frequency (times); ε_i = error term. The expected coefficient values are $0 < \beta_1 < 1$ for all i.

After estimating the production function, the value marginal product of labor can be calculated to estimate shadow wages (Skoufias, 1994; Kusnadi, 2005) as follows:

$$VMPL = \partial Y/(\partial X_1) = \beta_1 . X_1^{\beta 1} / X_1 . P \quad (2)$$

Where: VMPL = Value of the marginal product of labor; β_1 = Labor regression coefficient from the production function; X_1= rubber labor allocation (HKP/year); P = Price of rubber (Rp/kg).

The second step was to estimate the factors influencing labor allocation using the instrumental variable method. This method controls for simultaneity between labor allocation and shadow wages, which are endogenous variables (Skoufias, 1994). Therefore, the instrumental variable method is used to control for these sources of endogeneity (Gujarati, 2003). Rubber production, rubber price, and off-farm labor allocation are used as instrumental variables because they are expected to influence shadow wages but do not affect the error term. The model can be expressed as follows in the context of simultaneous equations:

$$tkkr_i = \beta_0 + \beta_1 sw_i + \beta_2 tksw_i + \beta_3 incnonk_i + \beta_4 lsawit_i + \beta_5 potk_i + u_i \quad (3)$$

$$sw_i = \pi_0 + \pi_1 Y_i + \pi_2 P_i + \pi_2 tknonut_i + v_i \quad (4)$$

Where: sw = Shadow wages (thousand/HKP); tkkr = rubber labor allocation (HKP/year); Y = Rubber production (Rp/year); P = rubber price (Rp/kg); tknonut = off-farm labor allocation (HKP/year); tksw = oil palm labor allocation (HKP/year); incnonk = Gross income from non-rubber and off-farm work (million/year); lsawit = Area of oil palm plantations (Ha); potk = Potential labor of family members aged > 16 years (person); i = Farmer; v_i dan u_i = error terms.

The conceptual framework of this research is illustrated in Figure 1. The decrease in rubber production requires farmers to diversify into activities other than rubber plantations. Rubber farmer households work on other commodities such as oil palm and off-farm work, so labor allocation is also affected by the presence of other commodities and off-farm work, so the proportion of labor allocated to rubber plantations will decrease. The use of labor in rubber plantations can be measured by shadow wages. The shadow wage is expected to be affected by rubber production, rubber price, and off-farm labor allocation. This is because the higher the production and the price of rubber plantations, the more farmers are likely to allocate to their agricultural activities, increasing shadow wages. Therefore, the labor allocation in rubber plantations is influenced

by the shadow wages, oil palm labor allocation, non-rubber income, oil palm area, and the potential labor of family members. The shadow wage is measured by the value of the marginal product of labor (VMPL) derived from the Cobb-Douglas production function, while the factors influencing the labor allocation in rubber farming are estimated by a labor supply function using the instrumental variable method (IV).

Hypothesis

The expected coefficient values are β_1 and $\beta_5 > 0$, indicating a positive impact on labor allocation in rubber plantations, while β_2, β_3, and $\beta_4 < 0$, indicating a negative impact on labor allocation in rubber plantations. The estimation of parameters for the labor supply function and the shadow wages function are estimated simultaneously using the two-stage least squares method (2SLS).

RESULTS

Characteristic of Farmer

The characteristics of the respondents are shown in Table 1. The average of the respondents (heads of households) is 49 years, indicating that the respondents are in the productive age group. In addition, the educational level of heads of household ranges from elementary school to university degrees, with an average of 9 years of schooling, and the average experience on rubber plantations is 21 years. Education level and farming experience influence farmers' ability to adopt technology, make production decisions, and allocate inputs to maximize profits (Syarifa, 2020).

The respondents have an average number of two family members. The number of family members influences consumption expenditure, as family size increases, the higher the consumption needs and expenses. On the other hand, the number of family members can also provide labor to help manage the farm, reducing the need for hired labor, and these family members can also contribute to the family's income (Ngadi & Meilianni, 2020). The average potential family labor force is about two people.

The rubber farms managed by the respondent farmers are, on average, self-owned, with an average land size of 1.86 hectares. The land used for farming is an essential resource for production, as it generates income (Juliansyah & Riyono, 2018). Generally, the larger the land being farmed, the higher the possibilities for increased productivity. Based on this, the respondent farmers can be categorized as medium-scale farmers. Simanjuntak et al. (2018), found that rubber farmers in Muaro Jambi Regency are still large-scale farmers. This suggests that the decrease in rubber land ownership represents land use conversion from rubber plantations to other commodities (Afrizon et al. 2021). This view is supported by the fact that many farmers are also involved in other commodities, particularly oil palm plantations, with 62% of respondents involved and 80% of respondents deriving their income from other commodities or off-farm work in addition to rubber plantations.

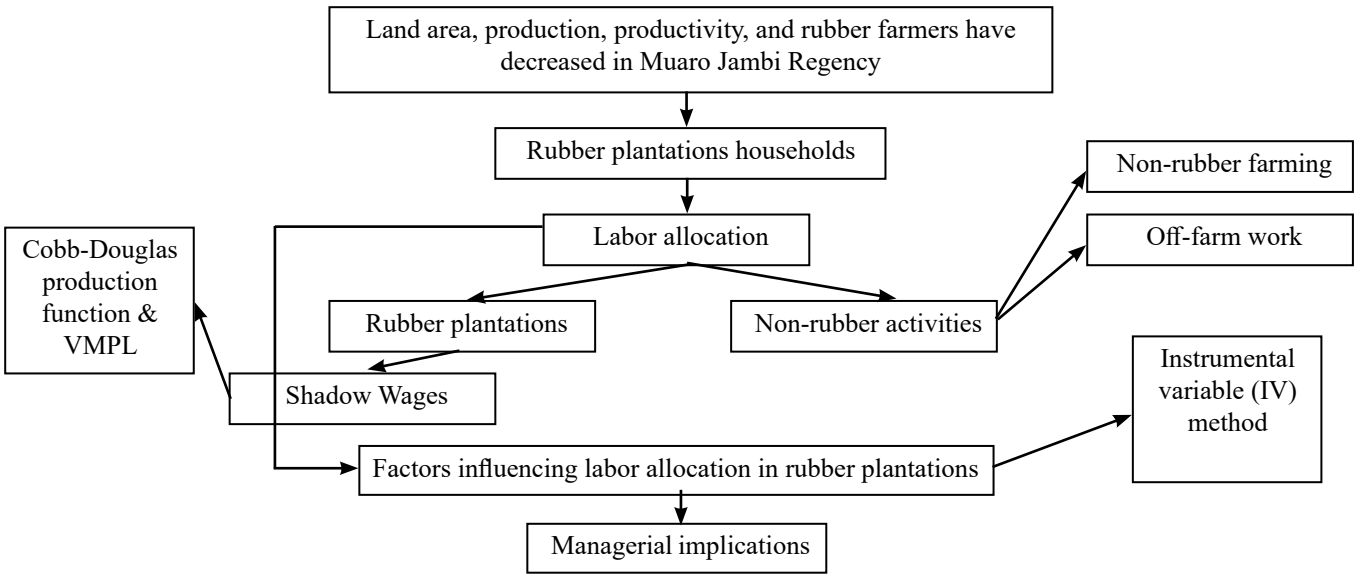

Figure 1. Research framework

Labor Allocation

Labor allocation refers to time or hours spent on an activity by working-aged men and women. Farming households generally work from more than one income source. Farmers participate in both on-farm and off-farm work. In rubber plantations, only family labor is used because hiring labor would increase production costs, especially in terms of wages (Rosmiati, 2012). Therefore, the labor used comes from within the family. Both men and women are involved, while children do not assist with farming activities (Yuni et al. 2018). The labor allocation calculated in this study includes the labor allocation for rubber plantations, non-rubber farming, and off-farm work, as shown in Table 2.

The household members' labor allocation to rubber plantations remains the primary activity at 53.77%. However, its contribution began to be competed with by other activities, with off-farm work becoming the second-highest labor allocation. This suggests that the income from off-farm work is significant for farmers, prompting them to devote more time to these activities. This finding aligns with the study by Ngadi & Meilianni (2020), which found that nearly half of the total income in rural areas comes from off-farm work and that agriculture is no longer the sole source of income. The activities associated with rubber plantations include fertilization, spraying, collection and coagulation, and transportation as shown in Table 3.

The average labor allocation in rubber plantations is 124.12 HKP/year, equivalent to 869 hours/year, where 1 HKP is equivalent to 7 working hours. The result of labor allocation is significantly lower compared to studies by Yuni et al. (2018) and Ariyani et al. (2022), where labor allocation in rubber plantations was 187 HKP/year and 420.85 HKP/year. This decrease is because the respondents no longer apply fertilizer and chemicals at the recommended frequency. Besides a decrease in input use, this also indicates a change in labor allocation from rubber plantations to other commodities or off-farm work that offers better prospects. A portion of rubber farming households have other jobs to increase their income is 86.49%, while only 13.51% depend totally on rubber farming. The distribution of labor allocation to activities other than rubber plantations is shown in Table 4.

Table 1. Statistic descriptive of farmers' characteristic variables

Variable	Description	Mean	Std Dev
Age	Age of household head (years)	49.42	10.55
Education	Years of education of household head	9.06	3.35
Farming experience	Years of experience in rubber farming	20.91	10.30
Farm size	Owned land in hectares	1.86	0.85
Household size*	Number of family members	2	2
Potential workers*	Number of family members aged over 16 years	2	2
Land ownership status*	= 1 if the land is owned by a household, 0 otherwise	1	1
Oil palm plantations*	= 1 if the farmers have oil palm, 0 if not	1	1
Other sources of income*	= 1 if income is only from rubber farming, 0 if has other income	0	0

Notes: * nominal and discrete data using the mode and median

Table 2. Average labor allocation in rubber farmer households

Type	Labor allocation (HKP/year)				Total	(%)
	Husband	(%)	Wife	(%)		
Rubber plantations	84.87	54.64	39.25	51.96	124.12	53.77
Palm oil plantations	14.25	9.17	5.41	7.16	19.66	8.52
Other farming	1.16	0.75	0.67	0.89	1.83	0.79
Cattle	5.37	3.46	7.45	9.86	12.82	5.55
Off-farm work	49.67	31.98	22.76	30.13	72.43	31.37
Total labor allocation	155.32	100	75.54	100	230.86	100

Table 3. Average farmer households' labor allocation on rubber plantation activities

Type	Labor allocation (HKP/year)				Total	(%)
	Husband	(%)	Wife	(%)		
Fertilization	0.07	0.08	0	0	0.07	0.06
Spraying	0.86	1.01	0.01	0.03	0.87	0.70
Tapping	62.94	74.16	31.35	79.87	9429	75.96
Collect and coagulation	13.83	16.30	7.89	20.10	21.72	17.50
Transport	7.17	8.45	0	0	7.17	5.78
Total labor allocation	84.87	100	39.25	100	124.12	100

Table 4. Types of work other than rubber plantations

Type	Frequency	Percentage (%)
Oil palm plantations	62	41.89
Cattle	29	19.59
Village apparatus	7	4.73
Teachers or employees	9	6.08
Trader	9	6.08
Services	10	6.76
Retiree	2	1.35
No additional work	20	13.51
Total	148	100

There are seven types of non-rubber activities in the study area, with oil palm plantations being the most common (41.89%). Rubber farmers widely grow oil palms because the profits are higher as the price and yield of palm oil are more stable than rubber. Moreover, oil palm is only harvested 18–24 times a year (Sofian et al. 2023). Next, cattle, especially chicken farming, is also famous, owned by 19.59% of the farmers. However, chicken farming here is mainly for personal consumption to reduce household food expenses. At the same time, cattle are raised for sale.

Other jobs include various services like farm labor, construction work, driving, and hairdressing. Commercial activities include grocery stores, wood businesses, water depots, food sales, and fertilizer shops. Regarding education or employment, some household members work as private employees, such as in palm oil companies, as security guards or teachers. The variety of jobs indicates that the employment sector in Muaro Jambi Regency has developed considerably and is no longer dependent on plantation products.

Estimation of Shadow Wages

To estimate the shadow wages, estimating the production function from equation (1) is first necessary. The results shown in Table 5 indicate that the land and labor variables have significance levels of 1% and 5%, while the herbicide and tapping frequency variables have a significant effect at the 10% significance level. The stimulant variable does not affect production because of the current trend of reduced input use in rubber plantations.

The average shadow wages in rubber, measured using equation (2), is IDR58,623.14/HKP. The lowest shadow wage is IDR20,998.58, and the highest is IDR168,488.5. The shadow wage is relatively low compared to the net wage/salary of formal workers in Muaro Jambi regency, which is IDR2,536,515, and the net wages/salary of informal agricultural workers, which is IDR1,926,986 in 2023 (BPS, 2024). When converted based on HKP, which is seven working hours, the wage/HKP according to the formal workers is IDR110,972.53, and for informal agricultural workers, it is IDR77,079.44. The shadow wages in this study contrast with Hardiani's (2011) research, where the shadow wages in rubber plantations are twice as high as Muaro Jambi's UMK, indicating that labor productivity in rubber plantations has become more unproductive. According to Syahfrudin et al. (2011), the decrease in rubber production has also led to decreased labor productivity. Therefore, shadow wages were found to be lower in this study.

Factors Influencing Labor Allocation in Rubber Plantations

In estimating the factors influencing labor allocation in rubber plantations, equation (3) and equation (4) are used simultaneously. The results are presented in Table 6. Shadow wages, non-rubber income, and oil palm plantations' labor allocation significantly affect the labor allocation in rubber plantations. Shadow wages have a positive effect, meaning that the higher the shadow wages, the higher the labor allocation to rubber plantations. This result is consistent with the study by Widyarini & Subagyo (2007), which found that labor is compensated according to its productivity, thus, higher productivity leads to higher wages, which attracts farming households to work in rubber. However, Hardiani's (2011) study indicates that shadow wages have a negative effect on the labor allocation in rubber plantations, because the income effect is more dominant than the substitution effect, meaning that wage increases reduce farmers' willingness to work. Initially, an increase in wages will increase the willingness to work. However, once the wage increase reaches an optimal point, further wage increases will reduce the willingness to work, a phenomenon known as a backward-bending labor supply curve (McConnell et al. 2021).

The negative sign indicates a decrease in labor allocation to rubber plantations along with an increase in non-rubber income. Non-rubber income includes income from on-farm activities besides rubber and off-farm work. This suggests that when farmers have more profitable activities, they begin to neglect rubber plantations, with some even planning to abandon them. In line with the research by Baruwadi et al. (2019) and Norfahmi et al. (2020), it has been proven that with the presence of other activities, farmers will substitute their labor for other on-farm and off-farm activities. As a result, labor allocation for rubber plantations decreases and becomes less optimal.

The labor allocation to oil palm has a positive and significant effect on the labor allocation to rubber. This result contrasts Elly's (2009) research, which found that increasing labor allocation to one on-farm work would reduce labor allocation to another due to family labor substitution. This difference is because rubber farmers with large land areas also tend to own large oil palm plantations (Table 7). As the use of labor in oil palm increases, labor use on rubber also increases because the larger the area, the more labor is required (Jodi et al. 2023). This statement is further supported by the research of Elvawati et al. (2019) and Boncinelli et al. (2018), which show that farmers with larger land holdings tend to have greater access to capital. Therefore, as land ownership increases, farmers are better able to expand into other sectors.

Table 5. Cobb-Douglas rubber plantations production function

Independent Variable	Coefficient	Std Err	t
Constant	5.648	0.574	9.84
Labor	0.280**	0.112	2.50
Area	0.347***	0.086	4.07
Herbicide	0.019*	0.011	1.87
Stimulant	0.001	0.009	0.11
Tapping frequency	0.274*	0.145	1.89
R-squared	0.329		

Notes: *** Significant at α=1%, ** Significant at α=5%, * Significant at α=10%

Table 6. Factors influencing labor allocation on rubber plantations in Muaro Jambi Regency

Exogenous variable	Coefficient	Std Err	Z
Constant	85.654	17.961	4.77
Shadow wages	0.337*	0.201	1.68
Oil palm labor allocation	0.795**	0.391	2.03
Non-rubber income	-0.324*	0.180	-1.80
Oil palm area	-2.322	5.078	-0.46
Potential labor of family members	5.200	4.711	1.10

Notes: ** Significant at α=5%, * Significant at α=10%

Table 7. Oil palm area based on rubber area

Rubber area (Ha)	Average oil palm area (Ha)
1-2	2.04
>2	2.52

The issue of land use conversion is also a reason why labor allocation in oil palm has a positive impact on labor allocation in rubber plantations. In this study, 74% of the respondent farmers had planned to replace their rubber plantations with oil palm once the rubber plantations were no longer productive. However, their method of land conversion is nondirect; instead, they practice intercropping with oil palm or plant the two crops side by side (Setyawati et al. 2023; Nengsih, 2016). This means that labor allocation for rubber plantations will also be allocated to oil palm plantations. These results may also explain why the factor of oil palm land area has a negative impact but is not significant.

Family labor potential does not significantly affect labor allocation but has positive signs. This result means that the more family labor potential a household has, the higher the labor allocation to rubber, as the need for hired labor is reduced. This result is also evidenced by Yuni et al.'s (2018) and Chi & Nguyen's (2023) research.

Managerial Implications

The presence of oil palm plantations does not decrease labor allocation for rubber plantations, suggesting that there is no competition between these commodities. In this case, focus on the government and agricultural instructors to encourage farmers not to cut down all their rubber trees or possibly have two commodities in a balanced state to flexibly utilize labor as needed in both sectors. This will make farmers make better labor allocation decisions for long-term prospects rather than just momentary price fluctuations.

In addition, since the shadow wages for labor on rubber plantations are lower than the net wage/salary of formal and informal workers in Muaro Jambi Regency, it suggests that the current wage system may need to be revised. Therefore, the government could reform the wage system to be more equitable and linked to productivity, motivating them to improve the efficiency of their labor allocation.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Shadow wages, labor allocation to oil palm plantations, and non-rubber income influence labor allocation in rubber plantations. The result indicates that there is no competition between rubber and oil palm plantations; it is complementary. Thus, the presence of oil palm plantations does not cause a decrease in the labor allocation in rubber plantations. However, the existence of off-farm work affects labor allocation, making future allocation dependent on off-farm opportunities. This finding raises concerns about the sustainability of rubber plantations, where farmers will begin to leave their rubber plantations. Therefore, it is crucial to explore other related issues in more depth and encourage stakeholders to take further action to address these potential challenges.

Recommendations

The government and agricultural instructors should continue to develop policies that encourage farmers to stay engaged in rubber plantations, focusing on both production and marketing, as current support for these plantations is limited. Without such support, there is concern that rubber plantations in Muaro Jambi Regency may eventually disappear given that the farmers' attention has divided and rubber plantations are no longer perceived as profitable. Therefore, the role of policymakers is crucial. Additionally, to enhance the applicability of these findings, future research could examine additional factors not covered in this study and expand the geographic scope to provide a more comprehensive representation.

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