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RICE FIELD CONVERSION INTO PALM OIL PLANTATIONS IN TINOKKAH VILLAGE, SIPISPIS, SERDANG BEDAGAI REGENCY

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Abstract

Rice remains the staple food of most Indonesian households, yet the sustainability of domestic rice production is increasingly threatened by the conversion of paddy fields into oil palm plantations. This study analyses the factors influencing the percentage of paddy field converted into oil palm plantations in Tinokkah Village, Sipispis Subdistrict, Serdang Bedagai Regency, North Sumatra. Using a census of 29 farmers who had converted part or all of their paddy fields between 2019 and 2025, primary data on sociodemographic, farming, and economic characteristics were collected and analysed using descriptive statistics and a Tobit regression model, with the percentage of converted land (0–100%) as the censored dependent variable. The results show that farmers converted a large share of their land, averaging 80.67%, with conversions concentrated after 2022. The Tobit estimation indicates that rice production cost before conversion has a negative and statistically significant effect on the percentage of converted land ($p < 0.01$), whereas rice farming income and farming experience are not significant. These findings reveal a trade-off between household economic rationality and local food sustainability, implying that maintaining paddy fields requires both regulatory control over land conversion and economic incentives that keep rice farming viable for smallholders.

Keywords: land conversion, paddy field, oil palm, Tobit regression, food sustainability

INTRODUCTION

Rice (Oryza sativa L.) occupies a central position in Indonesia's food system serving as the staple food for most Indonesian households. Based on the September 2022 National Socio-Economic Survey (Susenas), 98.35% of households in Indonesia consume rice. Average consumption reached 79.2 kg per capita per year in 2023 (Pusat Data dan Sistem Informasi Pertanian, 2024) and 86.15 kg per capita per year in 2024 (Pusat Data dan Sistem Informasi Pertanian, 2025). Indonesia is also recorded as the fourth-largest rice consumer in the world, with total consumption of 35.3 million tons in 2023 (BPS, 2023). The high level of consumption indicates that the sustainability of rice production is fundamental to maintaining national food availability.

However, the sustainability of rice production is under significant pressure as a result of changes in agricultural land use. A prevalent form of this change is the conversion of paddy fields into oil palm plantations. Such disruptions to rice production can have far-reaching consequences for food security, household economic ability, and national agricultural development (Hafizah et al., 2020; Susanti et al., 2024; Werdining Pangesti et al., 2023).

Land conversion does not constitute as an irrational decision (Zahri et al., 2019). Farmers typically make land-use decisions by considering some factor such as income potential, production costs, crop failure risks, labor requirements, and market prospects. In Indonesia, oil palm is often perceived as an attractive commodity because it offers market opportunities and potential improving smallholders welfare (Euler et al., 2017; Feintrenie et al., 2010).

A similar pattern of land-use change has been observed in Sipispis Subdistrict, Serdang Bedagai Regency. According to data from the Serdang Bedagai Regency Agriculture Office, the area of paddy fields in Sipispis declined sharply from 364 hectares in 2021 to 182 hectares in 2022. In contrast, oil palm plantation area increased from 3,602.70 hectares to 3,612.66 hectares over the same period. This contrasting trend indicates a structural shift in agricultural land use, in which the food crop land base is shrinking while plantation-based commodities are becoming increasingly dominant.

Table 1. Development of Paddy Field and Oil Palm Plantation Area and Production in Tinokkah Village, Serdang Bedagai, 2018-2022

Year	Paddy Field Area (ha)	Paddy Production (tons)	Oil Palm Plantation Area (ha)	Oil Palm Production (tons)
2018	335	1,967	3,177.50	45,775
2019	348	1,954	3,263.85	35,482
2020	311	1,725	3,249.50	35,326
2021	364	2,257	3,602.70	36,319
2022	182	1,171	3,612.66	36,237

The conversion of paddy fields into oil palm plantations represents not only a physical transformation of agricultural land use, but also a shift in farmers' economic orientation. From the perspective of rational choice theory, farmers are likely to choose farming alternatives that are perceived to generate higher economic returns while minimizing production risks (Pebriyani et al., 2022). Therefore, conversion of paddy fields into oil palm plantations can be interpreted as a rational economic strategy, particularly when oil palm is considered more profitable, less labor-intensive, and more promising in terms of market prospects than rice farming (Chrisendo et al., 2022; Ngadi & Nagata, 2022; Sibhatu et al., 2022).

However, the decision to convert paddy fields into oil palm plantations cannot be explained solely by economic considerations. It is also influenced by the sociodemographic characteristics of farming households, such as age, education level, land tenure status, household size, and farming experience. These characteristics affect how farmers perceive production risks, access market and technical information, mobilize household resources, and assess long-term land-use options. Accordingly, examining the sociodemographic profile of farmers who have undertaken land conversion is important for understanding the structural conditions under which the shift from rice farming to oil palm cultivation becomes a rational household-level strategy.

LITERATURE REVIEW

Agricultural land conversion refers to a land-use transition from one land-use system to another, driven by socioeconomic change, market demand, institutional arrangements, and farmers' land-use decisions (Lambin & Meyfroidt, 2010; van Vliet et al., 2015; Zhang et al., 2023). In the agricultural context, farmers' land-use decisions are shaped by multiple factors, including livelihood conditions, exposure to production and market shocks, and the economic as well as physical characteristics of their location. Accordingly, agricultural land conversion can be understood as a farm household response to changing economic opportunities, resource constraints, and production risks (Nguyen et al., 2017).

In the Indonesian agricultural context, the conversion of paddy fields into oil palm plantations is a significant form of agricultural land-use change. Oil palm is frequently perceived by farmers as a more attractive commodity because it offers clearer market opportunities, higher income potential, and relatively lower labor requirements than several food crops. (Chrisendo et al., 2022) showed that oil palm cultivation contributes to improvements in smallholder household living standards and human capital formation, particularly through asset accumulation and improved access to basic services. Nevertheless, Ngadi & Nagata (2022) highlighted that the expansion of oil palm may create pressure on rice sustainability, especially in regions that previously served as food production bases. Thus, paddy field conversion into oil palm plantations reflects a dual dynamic, it functions as an economic strategy for farm households, while simultaneously posing risks to local food security and the sustainability of rice production.

Previous findings indicate that land conversion is significantly influenced by several socioeconomic and farm-related factors, including farmers' age, land area owned prior to conversion, net income before conversion, land productivity, and farming experience. Meanwhile, formal education level and number of household dependents were found to have no significant effect on farmers' land conversion decisions (Kamilah, 2013).

METHOD

This study examines farmers who have converted paddy fields into oil palm plantations. The explanatory variables include income before land conversion, production costs before land conversion, and farming experience, while the dependent variables are the converted paddy field area and the percentage of land converted into oil palm plantations. Tobit regression model is applied to analyze the percentage of land conversion because the dependent variable is censored within a limited range of 0 to 100%.

The study was conducted from May to June 2025 in Tinokkah Village, Sipispis Subdistrict, Serdang Bedagai Regency, North Sumatra Province. The study site was selected purposively because Sipispis Subdistrict has experienced changes in agricultural land use, particularly the conversion of paddy fields into oil palm plantations. This study used primary data collected directly from farmer respondents who had converted paddy fields into oil palm plantations. The data included farmers' sociodemographic characteristics, land area before and after conversion, rice farming income before conversion, rice farming production costs before conversion, and information on the process and timing of land conversion. The population consisted of all farmers in Tinokkah Village, Sipispis Subdistrict, Serdang Bedagai Regency, who had converted paddy fields into oil palm plantations within the last six years. A census method, also known as total sampling, was employed because the population was relatively small and all members met the research criteria. Accordingly, all 29 farmers were selected as respondents in this study.

Data were analyzed in several stages. First, quantitative descriptive analysis was used to describe the characteristics of farmers who had undertaken land conversion, including gender, age, education level, number of dependents, farming experience, and land area. This analysis aimed to provide a general profile of the respondents and to understand the socioeconomic context of the farmers.

To analyze the factors influencing the percentage of converted land, a Tobit regression model was employed. The Tobit model was chosen because the dependent variable, the percentage of land conversion, is censored within a limited range of 0 to 100 percent. In the data, most respondents recorded a value of 100%, resulting in clustering at the upper limit. Under such conditions, ordinary least squares regression becomes inappropriate as it may produce biased estimates; therefore, the Tobit model is considered more suitable for a limited or censored dependent variable. The Tobit model is specified as follows:

$$Y_i^* = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \varepsilon_i$$

with the observed dependent variable defined as:

$$Y_i = \begin{cases} 0, & \text{if } Y_i^* \leq 0 \\ Y_i^*, & \text{if } 0 < Y_i^* < 100 \\ 100, & \text{if } Y_i^* \geq 100 \end{cases}$$

where Y_i is percentage of paddy field converted into oil palm plantation (%); α is constant; $\beta_{1,2,3}$ is regression coefficients; X_{1i} is rice farming income before conversion (IDR million); X_{2i} is rice production cost before conversion (IDR million); X_{3i} farming experience (years); and εi = error term.

Tobit model was estimated to examine the effects of the explanatory variables on the percentage of converted land, both simultaneously and partially. The simultaneous effect was evaluated using the Likelihood Ratio (LR) test, while the partial effect was assessed through the significance of each coefficient. Model fitness was also evaluated using the Pseudo R-squared. All estimations were performed using STATA statistical software.

RESULTS AND DISCUSSION

Socialdemographic of Land Conversion Farmer

The sociodemographic characteristics of respondents provide an important context for understanding farmers' decisions to convert paddy fields into oil palm plantations. The respondents in this study consisted of 29 farmers who had converted either part or all of their paddy fields into oil palm plantations in Tinokkah Village.

Table 2. Sociodemographic Characteristics of Respondents

Characteristic	Total (n)	Percentage (%)
Gender		
Male	11	37.9
Female	18	62.1
Age group		
≤ 40 years	4	13.8
41–50 years	6	20.7
51–60 years	11	37.9
> 60 years	8	27.6
Education level		
Elementary school	15	51.7
Junior high school	3	10.3
Senior high school	11	37.9

Characteristic	Total (n)	Percentage (%)
Farming experience		
<15 years	4	13,79
16 – 25 years	6	20,69
26 – 35 years	7	24,14
36 – 45 years	6	20,69
46 – 55 years	6	20,69
Paddy Field Area (Ha)		
0,16 – 0,29	8	27,59
0,30 – 0,43	8	27,59
0,44 – 0,57	9	31,03
0,58 – 0,71	3	10,34
0,72 – 0,85	0	0,00
0,86 – 1,00	1	3,45

Based on the survey results, female farmers accounted for the majority of respondents, with 18 farmers or 62.1%, while male farmers represented 37.9%. This indicates that women have a substantial role in agricultural activities and land-use decision-making in the study area. The high participation of women also suggests that land conversion should not be understood only as an individual economic decision, but as a household-level decision.

The education level of respondents was generally low. More than half of the respondents, or 51.7%, had only completed elementary school, while 10.3% completed junior high school and 37.9% completed senior high school. This educational structure may affect farmers' access to information, ability to evaluate long-term economic alternatives, and capacity to adopt agricultural innovations. Nevertheless, low formal education does not necessarily imply weak practical knowledge, as most respondents had long farming experience.

The farming experience of respondents was relatively extensive, with the largest proportion having 20–26 years of farming experience, and most farmers having more than 20 years of experience. This indicates that the decision to convert paddy fields was not made by inexperienced farmers, but by farmers with long exposure to rice farming risks.

Farming, Economic, and Land Conversion Characteristics

The farming and economic characteristics of respondents indicates that rice farming before land conversion relatively generated limited income. The average rice production was 1,084.48 kg, with an average rice price of IDR 6,513.79 per kg. The average rice farming revenue reached IDR 6,957,068.97, while the average total production cost was IDR 4,493,722.00. Consequently, the average rice farming income was only IDR 2,463,347.00. When calculated per hectare, the average rice farming income was IDR 7,210,187.17 per ha, but with a high standard deviation, indicating substantial income variation among farmers. These results suggest that rice farming in the study area provided relatively low and unstable income, especially given the small landholding size of respondents.

Table 3. Farming, Economic, and Land Conversion Characteristics

Variable	Mean	SD	Min	Max
Rice price (IDR/kg)	6,513.79	1,333.02	4,000	8,300
Rice production (kg)	1,084.48	472.66	250	2,750
Rice revenue (IDR)	6,957,068.97	2,965,230.00	1,500,000	15,950,000
Total production cost (IDR)	4,493,722.00	1,827,651.00	1,207,333	9,699,750
Rice farming income (IDR)	2,463,347.00	1,893,757.00	292,667	7,129,167
Income per hectare (IDR/ha)	7,210,187.17	6,235,944.00	760,606	28,739,583
Land area before conversion (ha)	0.40	0.18	0.16	1.00
Land area converted to oil palm (ha)	0.30	0.15	0.04	0.60
Percentage of converted land, %	80.67	27.55	10.00	100.00

The average land area converted into oil palm plantations was 0.30 ha, while the average land area before conversion was 0.40 ha. This indicates that farmers converted a large share of their paddy fields. The average percentage of converted land reached 80.67%, with some farmers converting all of their paddy fields. This high conversion intensity suggests that land conversion in Tinokkah Village was not merely a marginal adjustment, but

represented a substantial shift in farming orientation from food crop-based agriculture to plantation-based agriculture.

Table 4. Year of Rice Land Conversion to Oil Palm

Year of Conversion	Total (n)	Percentage (%)
2019	1	3.4
2020	1	3.4
2021	2	6.9
2022	8	27.6
2023	6	20.7
2024	7	24.1
2025	4	13.8

The distribution of conversion years also shows that land conversion became more intense in recent years. Only one farmer converted land in 2019 and one farmer in 2020. However, the number increased to two farmers in 2021, eight farmers in 2022, six farmers in 2023, seven farmers in 2024, and four farmers in 2025. This pattern indicates that most conversions occurred after 2022 aligns with global crude palm oil (CPO) price dynamics. International CPO prices rose sharply throughout 2021 and reached an all-time high of approximately $1,652 per metric ton in March 2022, a trend further reinforced by turbulence in the global vegetable oil market and Indonesia's palm oil export ban in April 2022, which triggered a price surge.

High price incentives are empirically linked to accelerated oil palm plantation expansion. Gaveau et al. (2022) show that a 1% decline in oil palm prices is associated with a roughly 1.08% decrease in new plantation development; consequently, periods of high prices tend to drive expansion. This mechanism operates through the logic of profitability at the household level found that smallholder farmers in Indonesia tend choose land portfolios with high economic productivity, such as oil palm, and this appeal is reinforced by evidence that oil palm cultivation can improve living standards and foster human capital formation among farming households (Chrisendo et al., 2022; Clough et al., 2016; Euler et al., 2017).

However, this pattern creates a potential risk for local food sustainability. Oil palm land-use change can place pressure on rice sustainability, especially in areas that were previously food production centers (Ngadi & Nagata, 2022). This is relevant to the case of Tinokkah Village because the conversion of paddy fields reduces the local land base for rice production and may increase dependence on rice supply from outside.

Factors Affecting The Land Use Conversion

To identify the factors influencing the percentage of land conversion, this study employed a Tobit regression model, as specified in the Method section. The dependent variable was the percentage of paddy field converted into oil palm plantations (0–100%), which is censored at the upper bound because many farmers converted all of their land. The independent variables were rice farming income (X1), rice production cost (X2), and farming experience (X3).

Table 5. Model fit summary

Model fit measures	Value
Number of observations (n)	29
Censored observations at the upper limit (100%)	18
LR chi-square, Prob > chi^2	0,003**
Pseudo R-squared (McFadden)	0,100
Sigma	41,63
Log-Likelihood	-64,35

The LR chi-square, Prob > chi^2 value is 0.003 (which is less than 0.05) indicates that the three independent variables collectively have a significant effect on the percentage of land conversion. The Pseudo R^2 value of 0.100 indicates that the Tobit regression model used in this study is only able to explain 10% of the variation in the dependent variable, namely the percentage of land-use conversion. In other words, 90 % of the variation in the percentage of land-use conversion is influenced by other factors not included in this study's model.

Table 6. Tobit Regression Estimate on Factor affecting the percentage of land use conversion

Variabel	Coefficients (B)	Std. Error	Sig. (p)	note
Constant	177,553	16,902	0,000	significant
Rice farming Income (X_1)	4,041	5,601	0,471	not significant

Rice Production Cost (X_2)	-22,713	4,949	0,000	significant
Farming Experience (X_3)	0,995	0,798	0,213	not significant

The estimation results indicate that paddy farming income before land conversion has a positive but statistically insignificant effect on the percentage of converted land. The coefficient of 4.041 suggests that higher paddy farming income tends to be associated with a higher percentage of land conversion, but this relationship is not statistically significant at conventional levels. This implies that the percentage of land converted into oil palm plantations cannot be explained solely by the income obtained from rice farming before conversion. Farmers may consider broader factors beyond current rice income, such as future income expectations from oil palm, market certainty, labor requirements, production risks, and social influence from other farmers.

This finding is relevant to the broader literature on oil palm adoption and smallholder livelihood strategy. Previous studies have shown that oil palm is often perceived as an attractive commodity because it can improve household welfare and provide long-term livelihood opportunities for smallholders. Chrisendo et al. (2022) found that oil palm cultivation in Sumatra was associated with improvements in living standards and human capital formation, including nutrition, education expenditure, asset ownership, and access to electricity. Therefore, farmers' decisions to convert land may be driven not only by the actual income from rice farming, but also by expectations of future welfare improvements from oil palm cultivation.

Production cost before land conversion has a negative and statistically significant effect on the percentage of land conversion at the 1 percent level. The coefficient of -22.713 indicates that an increase in production cost is associated with a decrease in the percentage of land converted into oil palm plantations, using the measurement unit applied in the dataset. This result may appear counterintuitive because higher production costs are often expected to encourage farmers to abandon rice farming. However, in the context of this study, higher production costs may reflect more intensive rice farming practices, better input use, or stronger commitment to maintaining rice production. Farmers who continue to invest more in rice farming may still perceive paddy cultivation as economically or socially important, and therefore tend to convert only part of their land rather than all of it.

Another possible explanation is that production cost functions as a proxy for farming scale and cultivation intensity. Farmers with higher production costs may manage relatively larger or more intensively cultivated paddy fields, allowing them to maintain part of their land for rice while allocating another portion to oil palm. In contrast, farmers with lower rice farming costs may operate on smaller plots or have already reduced rice farming intensity before conversion, making full conversion more likely. This supports the argument that land conversion is not only a response to profitability differences, but also reflects household resource allocation and long-term livelihood strategy. Hendrawan & Musshoff (2024) showed that smallholder oil palm decisions are influenced by several household and farm-level attributes, including total farm area, risk attitude, non-oil palm income, and access to support mechanisms.

Farming experience has a positive but statistically insignificant effect on the percentage of converted land. The coefficient of 0.995 indicates that more experienced farmers tend to convert a larger proportion of their paddy fields, but the effect is not statistically significant. This suggests that farming experience alone does not determine the intensity of land conversion. Experienced farmers may have stronger knowledge of rice farming risks, including dependence on water availability, labor needs, pest attacks, and fluctuating farm-gate prices. However, experience may produce different responses: some farmers may remain attached to rice farming because of long-term familiarity, while others may use their experience to recognize the declining attractiveness of rice and shift toward oil palm.

The insignificant effect of farming experience also indicates that land conversion decisions may be shaped by factors beyond individual experience, such as market access, availability of oil palm buyers, social influence, land inheritance patterns, household labor availability, and local infrastructure conditions. Githinji et al. (2024) emphasized that farmers' land-use decisions are not only shaped by sociodemographic, economic, and ecological factors, but also by social relations and reference groups. This is relevant in explaining why land conversion may spread within a village when farmers observe neighbors or relatives obtaining better economic outcomes from oil palm.

Overall, the Tobit regression results show that production cost is the only variable that significantly influences the percentage of paddy field conversion into oil palm plantations. Meanwhile, rice farming income and farming experience do not have significant effects. These findings suggest that the intensity of land conversion in Tinokkah Village is not determined solely by income level or length of farming experience, but is more closely related to the economic structure of rice farming and farmers' willingness or ability to continue investing in paddy

cultivation. The high number of farmers who converted 100 percent of their paddy fields also indicates a strong shift in land-use orientation from food crop farming to plantation-based farming.

From a broader policy perspective, these findings indicate a trade-off between household economic rationality and local food sustainability. For individual farmers, converting paddy fields into oil palm plantations may be perceived as a rational strategy to secure long-term income and reduce labor-intensive rice farming activities. However, at the regional level, the conversion of paddy fields may reduce the local rice production base and create pressure on food crop sustainability. Ngadi & Nagata (2022) argued that oil palm land-use change can place pressure on rice sustainability, particularly in areas that previously served as rice production centers. Therefore, maintaining paddy fields requires not only regulatory control over land conversion, but also economic incentives that make rice farming viable for smallholders.

CONCLUSION

This study examined the factors influencing the percentage of paddy field conversion into oil palm plantations in Tinokkah Village. Descriptively, conversion was highly intensive, averaging 80.67% of land with many farmers converting all of their paddy fields, and became concentrated after 2022, coinciding with the period of high global palm oil prices. The Tobit regression shows that rice production cost before conversion is the only variable with a statistically significant (negative) effect on the percentage of converted land, while rice farming income and farming experience are not significant. This indicates that the intensity of land conversion is shaped more by the economic structure of rice farming than by income level or farming experience alone. The findings imply a trade-off between household economic rationality and local food security: while conversion is rational for individual households, it gradually erodes the local rice production base. Maintaining paddy fields therefore requires not only regulatory control over land conversion but also economic incentives that keep rice farming viable for smallholders. Future research is encouraged to incorporate price variables and a larger, multi-village sample to strengthen causal inference.

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