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Does RSPO Certification Increase Smallholder Oil Palm Income? Evidence from Batanghari, Indonesia

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Abstract. This study analyzes income differentials between independent oil palm smallholders certified by the Roundtable on Sustainable Palm Oil (RSPO) and non-certified farmers in Maro Sebo Ilir District, Batanghari Regency, Indonesia. Although certification is promoted as a mechanism to enhance smallholder welfare, empirical evidence remains inconclusive and rarely examines net income differences disaggregated by plant age under uniform price conditions. Primary data were collected from September 2022 to August 2023 from 60 farmers (30 RSPO-certified and 30 non-certified), categorized into two plant age groups: 11–18 years and 19–26 years. Farm income was calculated as total revenue minus total cost and analyzed using independent-samples t-tests. The results indicate that RSPO-certified farmers achieved higher productivity and income despite incurring higher input costs. Average annual incomes among certified farmers reached IDR 25,600,675 and IDR 25,785,872 per hectare for the 11–18 and 19–26-year groups, respectively, compared with IDR 20,144,977 and IDR 20,766,920 among non-certified farmers. Income differences of approximately 27.1% and 24.2% were statistically significant ($p < 0.05$). The findings suggest that income gains are primarily associated with improved technical efficiency, intensified input use, and institutional support rather than price premiums, and remain contingent upon local market and institutional conditions.

Keywords: certification_impact; farm_productivity; rural_economy; smallholder_certification; sustainable_agriculture

1. Introduction

Oil palm (*Elaeis guineensis Jacq.*) is one of the most economically valuable plantation crops in Indonesia. The development of oil palm plantations began in the 1970s and experienced rapid expansion during the 1980s. In 1980, the total plantation area was only 294,560 hectares, but it grew significantly to 15,380,981 hectares by 2022 (Direktorat Jenderal Perkebunan, 2025). The area of oil palm plantations in Batanghari in 2022 was 201.10 thousand hectares (around 201,100 ha), then increased in 2023 to 204,621 ha (Badan Pusat Statistik, 2025). This expansion has been accompanied by various negative environmental impacts. The expansion of oil palm into tropical forests has contributed to substantial forest biomass loss, with significant implications for ecosystem degradation and increased global carbon emissions through deforestation (Xu, Y., Yu, L., Ciais, P., *et al.* 2022).

To address the environmental challenges associated with oil palm expansion, the concept of sustainable and environmentally friendly palm oil production emerged. This approach focuses not only on economic benefits but also on ecological preservation and social well-being. Certification systems, such as the Roundtable on Sustainable Palm Oil (RSPO), have been introduced in Indonesia to promote sustainable practices while ensuring that domestic producers can maintain access to global markets. (Ayompe et al., 2021).

One example is the Cahaya Putra Harapan Association (ACPH), an independent smallholder group established in 2017 in the Maro Sebo Ilir District. ACPH obtained RSPO certification in 2018 and currently has 406 members across three villages—Tidar Kuranji, Karya Mukti, and Bukit Sari—with a total certified area of 431.8 hectares. RSPO-certified farmers benefit from legal land status, certified planting materials, and improved knowledge of environmental management and biodiversity protection. These advantages, supported by

RSPO's principles and criteria, lead to the production of Fresh Fruit Bunches (FFB) with superior quality and yield (Muharani et al., 2020).

In theory, RSPO certification should provide certified smallholders with better market access, stable prices, and higher income compared to non-certified farmers. In practice, within the research area, RSPO certification is implemented through farmer institutions organized under the Cahaya Putra Harapan Association (ACPH). Certified farmers regularly receive training, technical assistance, and monitoring through annual audits. They apply the RSPO principles and criteria, including the use of certified planting materials, more precise fertilization practices, shorter harvesting intervals (10 days), and more systematic farm record-keeping. In addition, institutional support is provided through premium sharing and limited input assistance. In this context, income differences are closely associated with more intensive farm management and strengthened technical capacity facilitated by the farmers' organization.

Compared with findings from other regions of Indonesia reported in the literature, the economic effects of certification are not uniformly observed. In several areas, price differentials are minimal, and economic benefits depend largely on institutional strength, market access, and the continuity of technical support. Therefore, the characteristics of Maro Sebo Ilir—particularly its relatively homogeneous market conditions and active farmer organization—represent a specific contextual setting that distinguishes it from other regions. This comparison sharpens the research gap by demonstrating that the economic implications of certification are not universal but highly context-dependent, shaped by local institutional and technical support structures. RSPO certification does not always ensure fair treatment or favorable pricing for smallholders, as price premiums are often insufficient to cover certification costs and market access remains uncertain (Richartz, C, 2025).

This study explicitly formulates the question of whether there are differences in farm characteristics, production levels, cost structures, and income between independent oil palm smallholders certified by the Roundtable on Sustainable Palm Oil (RSPO) and their non-certified counterparts, and whether these differences remain statistically significant when analyzed across plant age groups of 11–18 years and 19–26 years. The hypotheses tested are: (H_0) there is no difference in average income between RSPO and non-RSPO farmers within each plant age group; and (H_1) there is a difference in average income between the two groups, with the directional expectation that RSPO-certified farmers earn higher incomes. Empirically, this study addresses an important gap in the literature, as prior research has generally examined the impact of certification in aggregate terms without disaggregating results by plant age, and has tended to emphasize premium prices and market access rather than providing a detailed analysis of net income per hectare under conditions of uniform selling prices.

The novel contribution of this study lies in its age-disaggregated income comparison approach, which enables a more precise identification of certification effects across different phases of the oil palm production cycle. Furthermore, the study offers a micro-level analysis of cost structures and the intensity of cultivation practices as mechanisms explaining income differentials. Maro Sebo Ilir holds analytical significance because RSPO-certified and non-certified farmers coexist within a relatively homogeneous market environment in terms of pricing and mill access, thereby allowing greater control over external factors and ensuring that observed differences more accurately reflect managerial practices and institutional effects associated with certification. As a representative ex-transmigration smallholder oil palm area, the site was selected not merely for data availability but also for its relevance to elucidating the economic dynamics of sustainability certification's impacts on smallholder livelihoods.

Based on these conditions, this study aims to: (1) describe the characteristics of RSPO-certified and non-RSPO-certified independent oil palm farming; (2) analyze the respective

incomes of these two groups; and (3) compare income differences between them. The research was conducted in Tidar Kuranji Village, Maro Sebo Ilir District, using a purposive sampling method to select respondents. The focus is on assessing whether RSPO certification provides measurable economic benefits to independent smallholders while also supporting sustainable palm oil production practices.

2. Materials and Methods

This research was conducted in Tidar Kuranji Village, which was purposively selected as the study location because it has independent oil palm farmers who have obtained RSPO certification. Farmer sampling in this study used a judgmental sampling method, with 60 respondents: 30 RSPO-certified and 30 non-RSPO-certified oil palm farmers. Statistically, the sample size of 30 respondents per group meets the conventional threshold for applying parametric tests based on the Central Limit Theorem, which supports the normal distribution approach to the sample mean (Triola, M. F., 2018). The classification comprised 21 farmers with oil palm trees aged 11–18 years and nine farmers with trees aged 19–26 years in each group. This sample distribution was determined on the basis that the number of observations was considered adequate to represent the population of both RSPO-certified and non-RSPO-certified farmers. The use of judgmental (purposive) sampling techniques was based on clear criteria, namely certification status and tree maturity group, ensuring comparability between RSPO and non-RSPO smallholders within the same geographic and market environment. Both groups operate in the same village, sell their crops to the same mill, and face similar selling prices and transportation costs. This design helps control for external variables that could affect income, thereby reducing structural bias in the comparison. However, it is acknowledged that the use of judgmental sampling limits external validity, so the study's results cannot be generalized broadly without caution.

The income of RSPO-certified and non-RSPO-certified independent oil palm farming was calculated using the formula proposed by (Soekartawi, 2002):

$$\pi = TR - TC$$

Where:
π = farm income (IDR ha^{-1} $year^{-1}$)
TR = total revenue (IDR ha^{-1} $year^{-1}$)
TC = total cost (IDR ha^{-1} $year^{-1}$)

To analyze the income differences between RSPO-certified and non-RSPO-certified independent oil palm farming, an independent sample t-test was used. The independent-samples t-test requires several assumptions: independence of observations, normality of income variables within each group, and homogeneity of variance across groups. In this study, the independence assumption holds because each respondent represents a distinct farming household. The normality assumption can be tested statistically using the Shapiro–Wilk test or by examining skewness and kurtosis values, especially since each subgroup consists of 30 observations, which increases robustness based on the Central Limit Theorem. Homogeneity of variance needs to be tested using Levene's test before interpreting the t-value; if the variance is not homogeneous, then the t-test adjustment (Welch's correction) is used. Explicit testing and reporting of these assumptions will strengthen the validity of the income comparison results. The t-test is applied to compare two means to determine whether the difference between them is statistically significant and not due to chance, using the following formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s1^2}{n_1} - \frac{s2^2}{n_2}}}$$

Keterangan :

$\overline{x_1}$ = Mean income of RSPO-certified independent oil palm farming
$\overline{x_2}$ = Mean income of non-RSPO-certified independent oil palm farming
n_1 = Number of RSPO-certified farmer samples
n_2 = Number of non-RSPO-certified farmer samples
s_1^2 = Variance of income for RSPO-certified farmers
s_2^2 = Variance of income for non-RSPO-certified farmers

With hypotheses:

$$H_0 = \bar{x}_1 = \bar{x}_2$$
$$H_1 = \bar{x}_1 \geq \bar{x}_2$$

Decision-making rules:
$t_{hit} < t_{tab}$ $\alpha = 5\%$, then accept H0 minus H1
$t_{hit} > t_{tab}$ $\alpha = 5\%$, then accept H0 minus H1

3. Results and Discussion

Respondents' Socio-Economic Characteristics

Table 1. Socio-Economic Characteristics of Respondents in the Research Area

Information	RSPO		Non RSPO	
	Plant Age 11-18 Years	Plant Age 19-26 Years	Plant Age 11-18 Years	Plant Age 19-26 Years
Age	45-53	45-62	27-35	27-35
Education Level	Senior High School	Elementary School, Junior High School	Senior High School	Senior High School
Number of Family Members	3	3	3	3
Farming Experience	17-23	24-30	10-16	17-23

Most RSPO-certified smallholders with oil palm plantations aged 11–18 years were in the 45–53 age range, while those with plantations aged 19–26 years were in the 45–62 age range. For non-RSPO-certified smallholders, both the 11–18 and 19–26 age groups were predominantly in the 27–35 age range, as presented in Table 1. According to United Nations (2022), the productive age for humans is between 15 and 64 years. This indicates that most farmers in the study area are within the productive age range, possessing good physical ability to work optimally in managing their farms. In addition, farmers who are within the productive age range generally demonstrate stronger analytical abilities and a higher propensity to embrace and implement new agricultural innovations (Rizzo et al., 2024).

The educational level of respondent farmers varied, ranging from no formal education to senior high school. Most respondents were senior high school graduates or equivalent. A relatively adequate level of formal education may enhance farmers' quality of decision-making and strengthen their ability to absorb and apply innovations in oil palm farm management practices (Abubakar et al., 2023)

Regarding household size, most RSPO-certified and non-RSPO-certified farmers had three household members. A larger household size, particularly with productive-age members, can contribute to agricultural activities and reduce the need for hired labor, thereby lowering

production costs (Kubitza et al., 2022).

The farming experience of RSPO-certified farmers in the study area was predominantly between 17–30 years, whereas for non-RSPO-certified farmers, it was mostly between 10–16 years. This difference can be attributed to historical land ownership patterns, where land originally owned by ex-transmigrant settlers has been partially sold or inherited. According to (Suardi et al., 2025), longer farming experience can improve farmers' decision-making, skills, and abilities in managing oil palm farms, which is consistent with findings from similar studies on oil palm farmers in Indonesia (Hasnah et al., 2026).

Overview of Oil Palm Farming in the Research Area

Oil palm plantations in the study area are considered to be in a relatively productive stage, supported by maintenance practices carried out by farmers in accordance with the principles and criteria of the Roundtable on Sustainable Palm Oil (RSPO). These practices aim to ensure sustainable and environmentally friendly oil palm farming, while also enhancing competitiveness in international markets. In the study area, oil palm cultivation serves as the primary source of livelihood for most residents. Oil palm plantations in the study area are considered to be at a relatively productive stage, supported by maintenance practices carried out by farmers in accordance with the principles and criteria of the Roundtable on Sustainable Palm Oil (RSPO). These practices aim to ensure sustainable, environmentally friendly oil palm farming while increasing competitiveness in the international market. In the study area, oil palm cultivation is the primary source of livelihood for the majority of the population. Consequently, farmers are committed to maintaining and managing their plantations to secure income to meet their daily household needs (Herdiansyah et al., 2025). An aggressive strategy to increase farmers' understanding of environmental costs is an aggressive approach (Nainggolan, 2023).

Consequently, farmers are committed to maintaining and managing their plantations to secure income for fulfilling their daily household needs (Herdiansyah et al., 2025).

Table 2. Plant Age, Number of Trees, and Types of Oil Palm Seedlings RSPO and Non RSPO in Research Areas

Description	RSPO		Non RSPO	
Plant Age (Years)	11-18	19-26	11-18	19-26
Number of Trees (Trunk/Ha)	127	118	131	167
Planting Distance	8.87 x 8.87	9.2 x 9.2	8.5 x 9	8.5 x 7
Types of Seeds	Marihat and Topaz	Marihat	Marihat and Topaz	Marihat

RSPO-certified and non-RSPO oil palm plantations in the study area are divided into two age groups. Within each age group, differences in oil palm tree density per hectare are presented in Table 2. Similar to RSPO-certified independent smallholder plantations, non-RSPO plantations also show variations in plant density per hectare across age groups. This variation is primarily due to the removal of unproductive or stunted trees and the presence of agricultural land traversed by waterways. Despite these differences, the same variety of planting material—Marihat oil palm seedlings—is used across both groups (Nurchalidah & Priwiratama, 2019). These variations in plant population and plantation characteristics form the basis for further comparison of RSPO and non-RSPO smallholder farming practices as presented in Table 3.

Table 3. Overview of RSPO and Non-RSPO Certified Oil Palm Farming in the Research Area.

Description	RSPO		Non RSPO	
	Plant Age 11-18	Plant Age 19-26	Plant Age 11-18	Plant Age 19-26

Land (Ha)	1.46	0.56	2.22	0.94
Number of Trees (Trunks Ha^{-1})	127	118	131	167
Production (kg ha^{-1}year^{-1})	21,485.23	24,873.02	16,302.74	16,269.38
Harvest Rotation (Days)	10	10	15	15

The characteristics of independent small-scale oil palm farms with RSPO certification in the study area differ from those without RSPO certification in terms of plant age, number of trees, production, and crop rotation, as presented in Table 3. It is also evident that maintenance activities in RSPO-certified farms are far more intensive compared to non-RSPO farms, as reflected in the greater amount of fertilizer applied. Proper maintenance significantly influences the production yield of oil palm plantations (Abubakar et al., 2023).

According to (Linuo et al., 2024), longer harvest rotations reduce fruit bunch density percentages over time, leading to lower production volumes and potentially affecting fruit quality. RSPO-certified farmers conduct shorter harvest rotations to maintain both the quality and quantity of harvested fruits. This approach is reflected in the higher production levels achieved by RSPO farmers compared to their non-RSPO counterparts.

From an experience perspective, farmers with oil palm aged 19–26 years are generally more experienced than those managing plantations aged 11–18 years. This is because younger plantations are often inherited or granted by parents, and the recipients may lack the skills and experience to manage them effectively. Nevertheless, RSPO farmers, regardless of experience level, receive regular training sessions and guidance to share knowledge and updates on best practices in oil palm cultivation. Additionally, RSPO farms undergo annual audits, requiring farmers to maintain intensive and consistent care following proper agronomic standards (Comyns & D'Antone. 2025).

Income of Oil Palm Farming Pattern Self-Help Pattern RSPO and Non-RSPO Certified

Table 4. Analysis of Income of Independent Oil Palm Farming Patterns RSPO and Non-RSPO Certified in Research Areas September 2022 - August 2023

Description	RSPO (IDR Ha^{-1}Year^{-1})		Non RSPO (IDR Ha^{-1}Year^{-1})	
	Plant Age 11-18	Plant Age 19-26	Plant Age 11-18	Plant Age 19-26
Income				
1. Production (IDR Ha^{-1}Year^{-1})	21,485.23	24,873.02	16,302.74	16,269.38
2. Proce (IDR Kg^{-1}Year^{-1})	2,338.33	2,338.33	2,338.33	2,338.33
Total Revenue (TR)	50,239,558	58,161,329	38,121,209	38,043,179
B. Variable Cost				
1. Fertilization (IDR Ha^{-1}Year^{-1})	16,851,340	21,884,920	12,137,710	10,884,163
MOP (KCl)	11,585,846	15,238,096	6,658,086	7,565,013
ZA	2,837,574	3,214,286	1,415,702	638,298
RP	1,119,374	1,285,714	0	0
Dolomite	584,476	861,110	717,718	695,037
Borate	724,070	1,285,714	0	0
Urea	0	0	3,346,204	1,985,815
Total Fertilization Cost (IDR Ha^{-1} Year^{-1})	16,851,340	21,884,920	12,137,710	10,884,163
2. Medications (IDR Ha^{-1}Year^{-1})	206,458	232,142	736,702	543,736
Round-Up	206,458	232,142	127,412	111,702

Gramaxon	0	0	24,776	136,526
Garlon	0	0	584,514	295,508
3. T.K.L.K	4,619,268	6,773,306	2,890,541	3,450,694
4. Other Cost	2,900,505	3,357,857	2,153,943	2,256,975
Total Variable Costs (TVC) (Rp/Ha/Year)	24,577,571	32,248,225	17,918,896	17,135,568
C. Fixed Cost (FC)				
1. Tool shrinkage. (IDR $Ha^{-1}Year^{-1}$)	89,518	71,250	57,336	140,691
D. Total Cost (TC=VC+FC)	24,638,883	32,375,457	17,976,232	17,276,259
Income (IDR $Ha^{-1}Year^{-1}$) (π=TR-TC)	25,600,675	25,785,872	20,144,977	20,766,920

Source : Primary Data Processing Results

Table 4 shows that the income from RSPO-certified independent smallholder oil palm farming is higher than that of non-RSPO independent smallholder farms (RSPO, 2024). The income disparity between RSPO and non-RSPO farmers occurs due to differences in production yields as well as variations in the total costs incurred. Based on the results presented in Table 4, the total production costs incurred by RSPO-certified farmers are indeed higher than those of non-RSPO farmers. This difference is primarily attributable to greater fertilization intensity, more comprehensive input use, and higher harvesting frequency. However, these additional costs are offset by a substantial increase in output. Given that the selling price of fresh fruit bunches (FFB) is relatively similar across both groups, differences in farm income are mainly driven by higher production volumes. Thus, the cost structure of RSPO farmers reflects an input-intensification strategy that enhances productivity more than the associated increase in costs, ultimately resulting in higher net income.

This finding suggests that certification operates through mechanisms of improved technical efficiency and enhanced farm management practices rather than through price premiums. Empirical data indicate that RSPO farmers with plantation ages of 11–18 years earn IDR 25,600,675 per hectare per year, compared to IDR 20,144,977 for non-RSPO farmers, implying that RSPO farmers' income is approximately 27.1% higher. In the 19–26-year age group, RSPO farmers earn IDR 25,785,872 per hectare per year, while non-RSPO farmers earn IDR 20,766,920, representing a difference of approximately 24.2%.

Expressing these differences in percentage terms is essential, as it provides a more substantive assessment of the economic magnitude of certification impacts beyond nominal comparisons (Hutabarat, 2022). The higher income observed among RSPO farmers in Maro Sebo Ilir is not due to price differentials but rather to increased productivity resulting from more intensive cultivation practices, regular training, and annual audits. Accordingly, these findings contribute to the literature by demonstrating that the effects of certification are highly contextual and depend substantially on the institutional strength of farmer groups, the availability of continuous training support, and the consistency with which agronomic standards are implemented.

In marketing their produce, both RSPO and non-RSPO farmers sell their harvested fresh fruit bunches to palm oil mills through farmer groups, which charge a transportation fee of IDR 160 per kilogram. This marketing arrangement, often coordinated through farmer organizations, can influence price negotiations and overall farm profitability (Oliphant & Simon, 2022).

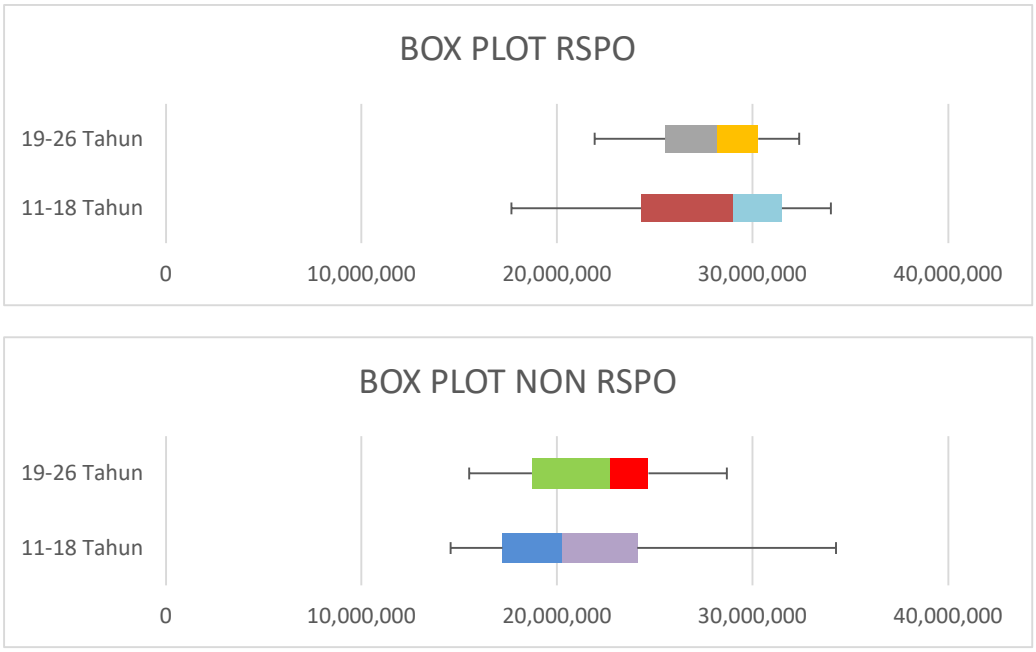

Figure 1. Box Plot Test Results

Distribution of annual income per hectare between independent oil palm smallholders certified by the Roundtable on Sustainable Palm Oil (RSPO) and non-RSPO smallholders across two age groups, namely 11–18 years and 19–26 years. Overall, the boxplots show that the median income of RSPO-certified smallholders across both age groups is consistently higher than that of non-RSPO smallholders, as presented in Figure 1. In the 11–18 year age group, the median income of RSPO farmers is approximately IDR 29–30 million per hectare per year, whereas non-RSPO farmers earn around IDR 20–22 million per hectare per year. This pattern is consistent with the results presented in Table 5, which show that the mean income of RSPO farmers (IDR 25,600,675/ha/year) exceeds that of non-RSPO farmers (IDR 20,144,977/ha/year), representing a difference of approximately 27.1%.

Similarly, in the 19–26 years age group, the median income of RSPO farmers remains higher, ranging from approximately IDR 28–30 million per hectare per year, compared to IDR 21–23 million per hectare per year among non-RSPO farmers. This finding aligns with the data in Table 5, where the mean income of RSPO farmers (IDR 25,785,872/ha/year) surpasses that of non-RSPO farmers (IDR 20,766,920/ha/year), indicating an income differential of about 24.2% in favor of RSPO-certified farmers.

In terms of dispersion, the interquartile range (IQR) of the RSPO group appears more compact, suggesting relatively stable income variability. In contrast, the non-RSPO group shows a wider spread, particularly in the 11–18-year age category, indicating greater income variability. No prominent extreme outliers are observed in either group. Therefore, the differences in medians and distribution patterns support the independent-samples t-test results, which confirm a statistically significant difference in income between RSPO-certified and non-RSPO independent oil palm farmers across both plant age groups.

The implementation of the RSPO oil palm cultivation standards and their principles and criteria in the study area have been effective, as farmers holding RSPO certification regularly receive training and extension services on sustainable and best management practices. These initiatives aim to ensure that farmers consistently adhere to the cultivation rules and standards required in their farming activities. Through the Cahaya Putra Harapan Association (ACPH), farmers also regularly receive various forms of assistance, including non-cash aid, personal protective equipment (PPE) for use during farming operations, and the distribution of premium

sharing derived from the sale of RSPO credit. Regular capacity-building and incentives, such as premium sharing, have been shown to strengthen farmers' commitment to sustainability standards and improve farm performance. (Veriasa et al., 2024)

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Comparative Analysis of Oil Palm Farming Income in RSPO and Non-RSPO Certified Self-Help Patterns

To determine whether there is a significant difference between the two average farm incomes, a T-test was conducted using SPSS at a 95% confidence level ("t-table 5%"). In this study, the comparison focused on the average income of RSPO-certified and non-RSPO oil palm smallholdings. The independent sample T-test was applied to compare the incomes of RSPO and non-RSPO oil palm farms using SPSS. The results of the statistical analysis can be seen in Table 5. The independent sample T-test is widely used in agricultural economics research to assess income differences between groups, providing a robust method for comparing means when the data meet the required assumptions (Tampubolon et al., 2025)

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Table 5. Comparative Analysis of Income Comparison of Oil Palm Farming Patterns of RSPO and Non-RSPO Certified Self-Help Patterns in Research Areas

No	Description	RSPO	Non RSPO
	Plant Age 11-18 Year		
1	Average Farming Income (IDR Ha^{-1} $Year^{-1}$)	25,600,675	20,144,977
2	Sig. (2 tailed)	.000	.000
3	T value calculated	4.316	
	Table T values	2.021	
	Plant Age 19-26 Years		
1	Average Farming Income (IDR Ha^{-1} $Year^{-1}$)	25,785,872	20,766,920
2	Sig. (2 tailed)	.019	.019
3	T value calculated	2.597	
	Table T values	2.120	

The results of the independent sample T-test comparing the average income of RSPO-certified and non-RSPO small-scale oil palm plantations show that the significance value (2-tailed) is 0.000 <α = 5% (0.05) for the 11–18 age group, and 0.019 <α = 5% (0.05) for the 19–26 age group. Furthermore, the calculated T value (T-count) and critical T value (T-table) for both age groups show that for the 11–18 age group, 4.316 > 2.021, and for the 19–26 age group, 2.597 > 2.120. The data are presented in Table 5. Therefore, the decision is to reject H_0 and accept H_1. This means that there is a statistically significant difference between the average income of RSPO-certified small-scale oil palm plantations and non-RSPO independent small-scale oil palm plantations. These findings align with previous research by (Renner et al., 2024), who also reported higher incomes among RSPO-certified smallholders compared to non-certified counterparts due to better agricultural practices and improved access to premium markets.

From a policy perspective, this study's findings indicate that certification can enhance smallholder farmers' incomes when accompanied by effective improvements in technical and institutional capacities. This suggests that policy interventions should not focus solely on expanding the number of certified farmers, but also on strengthening training programs, providing sustained technical assistance, and improving the governance of farmer organizations. Active government oversight in monitoring certification processes is critically

important to support and strengthen farmers' prosperity (Hutagalung & Adhi, 2024).

Nevertheless, these results are context-specific, as the study was conducted in a region characterized by relatively homogeneous market conditions, factory access, and price structures. Consequently, generalizing these policy implications to other regions should account for variations in market access, institutional capacity, and agronomic conditions.

To strengthen causal inference, future research could employ panel (longitudinal) data to compare farmers' income conditions before and after certification. In addition, quasi-experimental approaches, such as propensity score matching, may be applied to mitigate selection bias arising from farmers' self-selection into certification schemes. Further studies may also integrate technical efficiency analysis (e.g., stochastic frontier analysis) to estimate the contribution of farming practices to productivity more precisely. Such approaches would enable a more robust evaluation of certification impacts and enhance the external validity of the findings.

4. Limitations and Future Directions

Discussion of the validity of these findings is limited by methodological weaknesses, particularly the use of purposive sampling of 60 respondents, which limits the generalizability of the results to the broader national population of independent smallholder farmers. The limited sample size and focus on a single association (ACPH) pose a risk of selection bias, where economic gains may be more influenced by the intrinsic characteristics of "early adopters" or established social capital groups than by the direct effects of certification. Furthermore, the cross-sectional study design provides only a snapshot of a specific period. It therefore cannot definitively establish temporal causality, proving that certification was the sole driver of the income increases.

Other limitations include the measurement instrument's heavy reliance on self-reports through interviews, which are susceptible to recall and social desirability biases due to the lack of a standardized farm recording system at the farmer level. To address this, future research should use panel (longitudinal) data and quasi-experimental methods, such as Propensity Score Matching (PSM), to mitigate selection bias and more accurately track income trajectories before and after certification. Integration of objective verification tools, such as satellite imagery, and the RSPO digital infrastructure "Prisma" is also highly recommended to reduce reliance on smallholder recall data and improve the reliability of operational data in the field.

Finally, future research directions should broaden the scope to include broader social and ecological dimensions, such as the welfare of contract labor, gender inclusion in household resource allocation, and the impact of certification on biodiversity at the landscape level. Evaluating the effectiveness of the new RSPO Independent Smallholder Standard (ISH) 2024 and smallholders' readiness for international trade regulations, such as the EUDR, is crucial to ensuring the inclusion of smallholders in global supply chains. By integrating research agendas on market transformation and ecosystem management, future studies can provide more holistic strategic guidance for the ecological ecosystem and ecology of independent oil palm smallholders.

5. Conclusion

This study confirms that RSPO certification significantly increases the net income of independent oil palm smallholders in Batanghari Regency, with the identified income gap ranging from 24.2% to 27.1% across various crop maturity groups. Through a disaggregation approach based on crop maturity and a detailed analysis of micro-level cost structures, this study contributes to the development of agricultural economic studies that go beyond previous aggregative approaches, which tend to ignore the biological cycle of oil palm. Empirical

findings indicate that price premiums do not solely drive the increased economic benefits of certification, but rather that these benefits are driven by increased technical efficiency, the implementation of Good Agricultural Practices (GAP), and strengthened institutional support. The practical implications of these results point to the importance of formulating policies that focus on strengthening farmer institutional governance and enhancing agronomic capacity as key strategies for promoting the welfare of rural communities, particularly in transmigration areas.

However, this study has limitations that require attention, particularly the use of a cross-sectional design and a purposive sampling technique with a relatively small sample size, which limit the ability to draw direct causal inferences and generalize the results to broader contexts. Therefore, further research is recommended to utilize longitudinal panel data and apply the Propensity Score Matching (PSM) method to reduce potential selection bias and enable analysis of long-term income dynamics post-certification. Furthermore, the use of objective verification instruments, such as multispectral satellite imagery and integration with the RSPO Prisma digital infrastructure, is recommended to minimize recall bias in smallholder self-reporting. Future studies should also consider alternative theoretical approaches, such as the Capability-Opportunity-Motivation (COM-B) model, and include additional variables covering gender, labor welfare, and ecological impacts at the landscape scale, to produce a more comprehensive evaluation of sustainability standards.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

In compiling this work, the author used ChatGPT for proofreading. Following use of the tool, the author reviewed and made necessary corrections and takes full responsibility for the entire contents of the publication.

Authorship Contribution Statement

Mirawati Yanita 1st : The first author served as the principal investigator, designing the concept and methodology, and leading the field investigation of 60 respondents. His contributions included formal data analysis and statistical validation using software, data curation management, drafting the original manuscript, and visualizing all research findings; Ira Wahyuni 2nd: Contributed to the formulation of research ideas, development of objectives, and design of methodology to analyze income differences between RSPO and non-RSPO smallholders. Critically reviewed draft manuscripts prepared by the lead author and contributed to the editing process to improve the structure and quality of the scientific argument before publication; Dompak MT Napitupulu 3rd: The author is responsible for developing the methodology, validating the findings, and conducting formal data analysis. Their role also includes direct involvement in the research investigation and conducting a critical review and editing of the manuscript to ensure the article's scientific accuracy and quality; Gina Fauzia 4th : The author contributed to formal data validation and analysis to ensure the accuracy of the research findings. He was also directly involved in the field investigation process and contributed to the critical review and editing of the manuscript to improve the scientific quality of the article; Karina Rahmah 5th: The author contributed to formal data validation and analysis to ensure the accuracy of the research findings. He was also directly involved in the field investigation process and contributed to the critical review and editing of the manuscript to improve the scientific quality of the article; Ulidesi Siadari 6th: The author contributed to formal data validation and analysis to ensure the accuracy of the research findings. He was also directly involved in the field investigation process and contributed to the critical review and editing of the manuscript to improve the scientific quality of the article.

Declaration of Competing Interest

None of the authors in this study has any apparent financial interests. The researchers cooperated in every aspect of this research.

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