AGRISOCIONOMICS
Jurnal Sosial Ekonomi dan Kebijakan Pertanian

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Smallholder Oil Palm Farming Based on ISPO Certification: Sustainable or Not?

Mirawati Yanita*, Gina Fauzia, Dompak Napitupulu, Rozaina Ningsih, Karina Rahmah, Ulidesi Siadari, Zulkifli Alamsyah
Department of Agribusiness, Faculty of Agriculture, University of Jambi, Jambi, Indonesia
*Correspondence Email: mirawatiyanita@unja.ac.id

Submitted 15 December 2025; Approved 17 June 2026

ABSTRACT

Oil Palm farming has a substantial positive impact on job creation and the socio-economic conditions of communities, particularly in rural areas. However, a major challenge faced by smallholder Oil Palm farmers, especially those operating on a small scale, is the sustainability of their farming practices. These barriers often hinder the implementation of sustainable agricultural practices that align with certification standards, particularly the Indonesian Sustainable Oil Palm (ISPO) standards. This study aims to describe the social and economic characteristics of ISPO-certified smallholder Oil Palm farmers, analyze management practices based on farm performance, and assess the sustainability model of smallholder Oil Palm farming in Merangin Regency, as reflected in ISPO certification. The research was conducted in Nalo Tantan District, which has varying levels of Oil Palm productivity and ISPO-certified smallholder farmers. The study used observational methods, fdirect interviews, and secondary data analysis from relevant institutions and scientific literature. A sample of 60 respondents was selected for the study. The results showed an average Oil Palm production of 84.43 tons/ha/year with an average selling price of IDR 2,682/kg. The average land area used by farmers was 3.40 ha, with fertiliser use of 840 kg/ha/year and pesticide use of 7.1 liters/ha/year. The sustainability analysis showed that ISPO-certified smallholder Oil Palm farming in Nalo Tantan has a relatively good sustainability status, with a sustainability index of 66.99. The economic dimension was highly sustainable with a score of 77.85, while the social and ecological dimensions were moderately sustainable, scoring 57.76 and 67.22, respectively. It is crucial to strengthen certification implementation, improve social and environmental management, and support economic sustainability by enhancing resource management and expanding market access.

Keywords: *Certification, ISPO, Oil Palm Smallholders, Sustainability*

BACKGROUND

One of the most reliable subsectors within the agricultural sector is the plantation subsector. The role of plantations in supporting and driving the national economy is highly significant. Based on constant 2021 prices, the agricultural sector contributed 12.62% to the Gross Domestic Product (GDP), with the plantation crop subsector as the largest contributor at 30.28%. The area of smallholder oil palm plantations in Indonesia expanded by 418.02% between 2000 and 2020 (Statistics Indonesia, 2021). The rapid increase in oil palm production has raised concerns that sustainability principles may be overlooked, potentially leading to the loss of forest cover and forest area, declines in biodiversity, disruption of ecosystem balance, increased greenhouse gas emissions, and social conflicts with communities surrounding plantation areas. This situation arises because both large-scale companies and smallholder plantations often neglect sustainability principles in pursuit of land expansion (Rizal et al., 2019).

Concerns have been raised about a lack of commitment small scale palm oil plantation farmers to sustainability principles following the inauguration of Minister of Agriculture Regulation No.19/OT.140/3/2011 on Indonesian Sustainable Palm Oil, which was later upgraded by Ministerial Regulation No.11/OT.140/3/2015; this regulation is expected to boost the economy while also ensuring environmental protection and sustainable palm oil production ISPO (Indonesian Sustainable Palm Oil) certification is viewed as a solution that enables the assessment and management of oil palm plantations, addressing environmental risks and the ongoing issue of low confidence in production in the international market, particularly affecting small oil palm farms (Dharmawan et al., 2019). The objectives of establishing ISPO include positioning palm oil development as an integral part of Indonesia's economic development, strengthening Indonesians' basic attitudes toward sustainable palm oil production, and supporting Indonesia's commitment to the conservation of natural resources and environmental functions (Suwanda et al., 2020).

The Perkasa Nalo Tantan Cooperative was founded in 2017, initially comprising 70 members and covering 350 hectares. In 2019, the Perkasa Nalo Tantan Cooperative acquired an ISPO certification. PT Agrindo Indah Persada facilitated the acquisition of this ISPO accreditation. In 2018, Nalo Tantan, Chairman of the Perkasa Cooperative, announced that the organization conducted an audit by including stakeholders to provide guidance on the cultivation, management, and supply of Fresh Fruit Bunches (FFB) to the company. The cooperative's partnership with the company has enabled it to attain ISPO accreditation and has supported enterprises without a primary plantation. In 2025, the Perkasa Nalo Tantan Cooperative consisted of 25 agricultural associations. Fifteen agricultural collectives secured ISPO accreditation, with 532 members and covering 2,497.22 hectares.

Farmers must get a Plantation Business Registration Certificate for Cultivation (STDB) issued by the Department of Plantations to achieve ISPO accreditation. In practice, several aspects remain unsatisfactory, particularly in the social dimension. Subcontract-based partnership schemes tend to benefit cooperatives more than independent smallholders with limited landholdings. Moreover, decisions regarding ISPO implementation have not yet fully involved all farmers. From an ecological perspective, outcomes are also not entirely satisfactory, as the application of environmentally friendly cultivation practices has been inconsistent. Some farmers have not yet fully complied with the cultivation practices required under the ISPO standards. Following the initial observation of the unsatisfactory implementation of ISPO, the sustainability concept of ISPO within the Perkasa Nalo Tantan Cooperative underwent further scrutiny. This study examines autonomous oil palm plantations from a sustainability perspective, highlighting ecological, economic, and social dimensions. The assessment indicators for this study are based on ISPO's (Indonesian Sustainable Palm Oil) sustainability principles and criteria. The Perkasa Nalo Tantan Cooperative was established in 2017 with 70 members and spans 350 hectares. In 2019, the cooperative obtained ISPO (Indonesian Sustainable Palm Oil) certification, aided by PT Agrindo Indah Persada.

Following an initial evaluation that revealed inadequate adherence to ISPO principles, an extensive inquiry was conducted to examine the Perkasa Nalo Tantan Cooperative's sustainability practices thoroughly. This analysis focuses on independent oil palm plantations, with a particular

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

emphasis on sustainability status, and examines the ecological, economic, and social dimensions of the Perkasa Nalo Tantan Cooperative.

RESEARCH METHODS

This study was conducted in the Nalo Tantan sub-district of Merangin Regency, intentionally chosen because the Perkasa Nalo Tantan Cooperative was the inaugural ISPO beneficiary cooperative in the region. The study participants were 60 ISPO-certified independent oil palm growers from the Perkasa Nalo Tantan Cooperative. This study was conducted from October 2024 to January 2025. This research aims to assess the sustainability of ISPO accreditation. This study employs descriptive and quantitative analysis approaches. Descriptive analysis converts raw data sets into comprehensible formats and refines information into more succinct representations. The depiction of the observational outcomes is a hallmark of descriptive analysis. The sustainability status of smallholder oil palm plantations certified under ISPO is evaluated using the Rap-palmoil ordination technique via Multidimensional Scaling (MDS), which assesses the sustainability index and identifies critical attributes influencing it in each dimension through leverage analysis. This study demonstrates the sustainability of smallholder oil palm plantations certified under ISPO through three approaches: economic, social, and environmental. Every dimension comprises six features, developed from the ISPO principles for smallholders.

The analysis of Rap-oilpalm ordination is conducted in several phases(Saragih et al., 2020), such as, (1) Identify attributes based on prior research and evaluate the sustainability of independent oil palm plantations according to ISPO principles and criteria; (2) Evaluate each attribute on an ordinal scale (scoring) based on the sustainability criteria for each dimension; (3) Perform Rap-oilpalm analysis utilizing the MDS method; (4) Assess the index and sustainability status of the independent oil palm plantations examined at both the multidimensional level and for each individuals dimension. (5) Utilise analysis to identify sensitive parameters influencing the sustainability of independent oil palm plantations; (6) Employ Monte Carlo analysis to account for uncertainty factors. The MDS analysis is leveraged to identify sensitive qualities and necessary adjustments or enhancements.

Sensitive qualities are identified by leverage analysis, indicated by the variation in the Root Mean Square (RMS) of ordination along the X-axis. Monte Carlo analysis is employed to assess the impact of error on the 95% confidence interval. The Monte Carlo index is compared to the MDS index (Anwar et al., 2022). Rapfish's analysis commences with an examination of the attributes and a definition of the content to be analyzed, and thereafter assigns a score according to the criteria established by Rapfish. Next, Rapfish conducts MDS to determine the placement of favorable and unfavorable elements. The locations of sustainability indicators can be shown on the horizontal and vertical axes, with sustainability index values ranging from 0 (poor) to 100 (excellent) (Hasibuan, 2020). Table 1 provides an evaluation of the index category and the sustainability status.

The attributes analyzed in this study comprise the economic, social, and ecological dimensions. The attributes used to measure the sustainability status of the economic dimension include certified seeds, palm oil productivity, implementation of price transparency, access to fresh fruit bunch (FFB) sales, transportation, and minimum wage. The social dimension includes

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

institutional or group activity, education level, land dispute conflicts, frequency of counseling, extension frequency, and farmer loyalty. The ecological dimension attributes consist of environmental permits in accordance with the Environmental Management and Monitoring Statement (SPPL), oil palm maintenance records, standard operating procedures (SOPs) for land clearing without burning, peatland use, conservation measures, and integrated pest management techniques. The Rap-Oilpalm (Rapid Appraisal for Oil Palm) method, based on Multidimensional Scaling (MDS) in this study, is a rapid analytical approach used to assess the sustainability level of oil palm farming by converting various attributes (ecological, economic, and social) into a sustainability index within a multidimensional space. Through MDS, qualitative and quantitative data are scored and mapped in an ordination plot, after which the stress value and coefficient of determination (R^2) are calculated to evaluate model fit and to generate an index ranging from 0 to 100 that indicates sustainability status (from unsustainable to highly sustainable). In practice, leverage analysis is employed to identify the most sensitive attributes influencing the index, thereby providing a basis for policy recommendations or interventions. Monte Carlo analysis is subsequently applied to assess the uncertainty and stability of the MDS results by performing repeated simulations with random variations in attribute scores or weights; if the Monte Carlo results closely match the initial MDS results, the model is considered robust and not substantially affected by input errors or assessor subjectivity. The combination of Rap-Oilpalm MDS and Monte Carlo analysis enables researchers to comprehensively, rapidly, and reliably evaluate the sustainability of oil palm systems, while ensuring the resulting conclusions have an adequate level of confidence.

Table 1. Categories of Index and Sustainability Status of Independent Oil Palm Plantations at the Perkasa Nalo Tantan Cooperative

Index value	Category status
0,00 - 25,00	Bad; Unsustainable
25,01 – 50,00	Less; less sustainable
50,01 – 75,00	Enough; Quite sustainable
75,01 – 100,00	Good; Highly sustainable

Source: Primary Data Processed, 2019

The sustainability of smallholder oil palm plantations is closely linked to global challenges that encompass environmental, economic, and social dimensions. ISPO certification serves as a strategic tool for Indonesia to guarantee that oil palm cultivation practices adhere to both national and international sustainability standards. Prior studies indicate that applying ISPO principles enhances farm efficiency, bolsters environmental governance, and promotes farmer engagement in a more transparent supply chain (Syahza et al., 2018). Implementing ISPO at the independent smallholder level faces both technical and non-technical challenges, including restricted access to information, inadequate managerial capacity, and limited understanding of environmentally sustainable cultivation technologies (Budiarti & Manuhutu, 2019). Consequently, employing a multidimensional approach in sustainability studies is essential for assessing the current status and determining intervention priorities to enhance the sustainability performance of independent oil palm plantations. (Priyanto et al., 2017; Saragih et al., 2020; Situmorang & Andriani, 2019).

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

RESULT AND DISCUSSION

Overview of Independent Smallholder Oil Palm Farming

Farmer Identity

The sample farmers in this study are independent oil palm farmers operating ISPO (*Indonesian Sustainable Palm Oil*)- certified plantations within the Perkasa Nalo Tantan Cooperative. The identity of the sample farmer can be seen in several aspects, namely age, education level, number of dependent family members, farming experience, land area, and farming type.

Farmer Age

The age of farmers is one factor that can affect their ability to carry out oil palm farming physically and mentally, including in decision-making. The sample in this study ranged in age from 26 to 67 years and was grouped into six age groups. Table 2 shows the distribution of sample farmers by age group in the study area.

Table 2. Sample Farmer Distribution Based on Age Group in the Research Area

Age (Years)	Frequency (People)	Percentage (%)
26–32	6	10,00
33–39	9	15,00
40–46	19	31,67
47–53	12	20,00
54–60	9	15,00
61–67	5	8,33
Total	60	100,00

Source: Primary Data Processed, 2025

The study found that the sample farmers had an average age of 40-46 years, with 31.67% (19 farmers) in this age range. (Mantra, 2004) stated that, economically, the productive age is divided into three classifications: the age group 0–14 years, which is not productive; the age group 15–64 years, which is productive; and the age group 65+, which is no longer productive. Based on Table 2, the majority of oil palm farmers in the Perkasa Nalo Tantan Cooperative are in the productive age group. As many as 91.67 percent of farmers are classified as in the productive age, while the remaining 8.33 percent are in an almost unproductive age. The relationship between farmers' age and ISPO certification in Koperasi Nalo Tantan is generally associated with the level of adoption of sustainable practices, administrative compliance, and readiness to follow certification standards. Farmers in the productive age range (approximately 30–55 years) tend to be more receptive to innovation, more active in attending training, and better able to adjust their cultivation practices to meet ISPO principles and criteria, thereby increasing their likelihood of participating in the certification process.

In contrast, older farmers often possess extensive farming experience but, in some cases, face constraints in fulfilling administrative requirements, maintaining farm records, adopting technology, and participating in extension activities, all of which are essential components of the certification

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

process. Nevertheless, institutional support from the cooperative, technical assistance, and training programs can mediate the influence of age, enabling farmers from different age groups to have equal opportunities to comply with ISPO standards. Therefore, farmers' age is not a single determining factor; rather, it interacts with education level, access to information, and the intensity of assistance in influencing the success of ISPO certification in cooperative Nalo Tantan.

This shows that most farmers are still physically able to carry out agricultural activities optimally. (Hasibuan, 2020) emphasized that age will affect work productivity and output results. Farmers of productive age generally have greater adaptability to cultivation innovations and technological applications, thereby supporting increased productivity in oil palm farming businesses.

Education Level

Education can help foster maturity in decision-making, understanding, and knowledge absoIDRtion (Hasibuan, 2020). Education can affect a person's creativity and abilities, as in the case of a farmer. More details are shown in Table 3.

Table 3. Distribution of Sample Farmers Based on Education Level at the Perkasa Nalo Tantan Cooperative

Education Level	Frequency (People)	Percentage (%)
SD	2	3,33
SMP	1	1,67
SMA	26	43,33
SMK	2	3,33
Diploma	2	3,33
Sarjana	27	45,00
Total	60	100,00

Source: Primary Data Processed, 2025

Based on Table 3, the level of education of farmers in the research area ranges from elementary to undergraduate. The results of the study show that the majority of farmers have a high level of secondary education, with 45.00 percent (27 farmers) having received education up to the bachelor's level.

In addition, 28 farmers with secondary education backgrounds (high school and vocational school) accounted for 46.66 percent of the total respondents. Meanwhile, the rest consisted of farmers who graduated from elementary and junior high schools, with relatively small percentages of 3.33% and 1.67%, respectively.

Furthermore, according to Zhang et al. (2023), farmers with higher levels of education tend to be more efficient in managing natural resources, which affects their resource allocation decisions. Furthermore Oli et al., (2025) state that higher levels of education are associated with a more positive attitude toward learning among farmers, which, in turn, increases the likelihood of promptly and effectively adopting agricultural innovations.

This relatively high level of education reflects that most farmers in the Perkasa Nalo Tantan Cooperative have strong potential to receive and apply new knowledge related to oil palm cultivation and business management. Higher education generally encourages farmers to be more open to

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

adopting modern agribusiness technologies and practices, thereby supporting increased efficiency and productivity in their farming.

Number of Family Members

The number of family members can affect household needs—the more family members, the greater the household needs, and vice versa. According to Meilianni, (2020), the number of family members is the total number of family members who live and eat from a single kitchen. In addition, the number of family members illustrates the economic burden the family bears to support its members. The number of family members refers to the number of dependents living in one family home, as shown in Table 4.

Table 4. Distribution of Sample Farmers Based on the Number of Family Members in the Perkasa Nalo Tantan Cooperative

Number of Family Members	Frequency (People)	Percentage (%)
2–3	34	56,67
4–5	26	43,33
Total	60	100,00

Source: Primary Data Processed, 2025

Table 4 shows that the number of family members among the sample farmers in the Perkasa Nalo Tantan Cooperative varies, ranging from 2 to 5. Most farmers have a family of 2-3 people, totaling 34 people, or 56.67 percent of the total respondents. Meanwhile, 26 farmers, or 43.33 percent, have family members of 4-5 people. The relationship between the number of family members and ISPO certification in Koperasi Nalo Tantan is associated with the availability of family labor, the ability to meet administrative requirements, and the economic burden of the farmer's household. Farmers with larger family sizes generally have more internal labor that can assist with cultivation activities, plantation maintenance, farm record-keeping, and the implementation of sustainable practices in accordance with ISPO standards, thereby facilitating compliance with certification principles and criteria. However, a greater number of dependents can also increase household economic needs, which in some cases may limit farmers' capacity to finance plantation improvements, training, or certification documentation. Conversely, farmers with fewer family members may face labor shortages and thus rely more on hired labor. Still, their lighter economic burden may make it easier to allocate funds to meet certification requirements. Therefore, family size does not function as a single determining factor; rather, it interacts with income level, access to cooperative assistance, and support from certification programs in influencing farmers' success in obtaining ISPO certification in Koperasi Nalo Tantan.

According to (Supriatna et al., 2024) the sustainability status of independent smallholder oil palm plantations in several Indonesian provinces, including the social dimension related to the number of family members, influences sustainable practices. This is the case, according to (Gutierrez Al-Khudhairy, 2023)**,** who states that the impact of sustainable management practices on oil palm fruit production in small plantations in Sabah, Malaysia, is influenced by social factors such as family size.

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

This relatively small number of family members suggests that most farmers in the study area have few household dependents. According to (Hernanto, 1991), the number of family dependents affects the economic activities of farmers' households, including the use of family labor in farming and the allocation of household income. The larger the family, the greater the economic needs, which can ultimately affect the intensity of family members' involvement in farming activities.

Farming Experience

Farming experience is one of the factors that support success in farming. Deductively, if farmers have had sufficient experience in agriculture, they will be skilled at managing their farms (Hernanto, 1991). The longer the farmer's experience in farming, the higher the success rate is expected to be. The farming experience of the sample farmers in the study area was measured from the first time each farmer farmed oil palm, as declared in the year. The distribution of sample smallholders by oil palm farming experience is shown in Table 5.

Table 5. Farmer Contribution Sample Based on Farming Experience at the Perkasa Nalo Tantan Cooperative

Farming Experience (Years)	Frequency (People)	Percentage (%)
6–7	7	11,67
8–9	16	26,67
10–11	24	40,00
12–13	2	3,33
14–15	6	10,00
16–17	5	8,33
Total	60	100,00

Source: Primary Data Processed, 2025

Based on Table 5, the farming experience of sample farmers in the Perkasa Nalo Tantan Cooperative is dominated by those with 10-11 years of experience, totaling 24 people (40.00 percent of the total sample). This range of experience shows that most farmers have been managing oil palm plantations for quite some time, which, in theory, will affect their ability to allocate production factors efficiently and productively.

According to (Akbar et al., 2024), Farming experience shows the importance of increasing technology literacy and access to resources that support sustainable farming practices. Furthermore, (Siregar & Siregar, 2024) stated that oil palm farmers' experiences in Percut Sei Tuan District indicate that social relationships between farmers and large oil palm companies strongly influence the sustainability of agricultural practices.

The length of experience in farming is an important capital for farmers in understanding the dynamics of oil palm farming, both from a technical and managerial perspective. However, the study's results show that, even with sufficient experience, the application of the principles of Indonesia Sustainable Palm Oil (ISPO) remains suboptimal, especially in the ecological dimension. Several aspects, such as maintenance records, plant age, land area, fertilizer and pesticide use, and agricultural equipment management and production records, are still not carried out systematically by most farmers.

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Age of Oil Palm Plants

Plant productivity is affected by a plant's lifespan. The older the plant, the less production will be. This is, of course, also influenced by seeds, maintenance activities, and harvesting methods.

The distribution of sample farmers by plant age in the Perkasa Nalo Tantan cooperative is shown in Table 6.

Table 6. Distribution of Sample Farmers Based on Plant Age in the Research Area

Plant Age (Years)	Number of Farmers	Percentage (%)
7–9	26	43,33
10–12	12	20,00
13–15	15	25,00
16–18	3	5,00
19–21	4	6,67
Total	60	100,00

Source: Primary Data Processed, 2025

Based on Table 6, most of the oil palm plants in the study area were 7–9 years old, accounting for 43.33 percent. This age falls within the young-to-juvenile range, with plants still in the productive phase. The economic lifespan of oil palm plants generally reaches 25 years, with the classification of young (3–8 years), adolescents (9–13 years), adults (14–20 years), and old age (>20 years). The results showed that most oil palm plants in the study area were still in their productive phase and had not yet entered the old phase.

Production Factor

The production factor is the use of resources or inputs needed in the production process to produce products or outputs (Soekartawi, 2022). The production factors used in oil palm farming in the Perkasa Nalo Tantan cooperative consist of land use, fertilizers, pesticides, labor, and agricultural tools.

Land

In oil palm farming, land is a medium for planting; therefore, it is an important production factor. The land area referred to in this study is the area of land cultivated by farmers in oil palm farming activities. The land-use regions of the sample farmers are shown in Table 7.

Table 7. Distribution of Sample Farmers Based on Land Area in the Research Area

plantation area (ha)	number of people	Percentage (%)
1–2	29	48,33
3–4	19	31,67
5–6	4	6,67
7–8	6	10,00
9–10	2	3,33
Total	60	100,00

Source: Primary Data Processed, 2025

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Based on the results of the study presented in Table 7, most of the sample smallholders have an oil palm farming area of 1-2 hectares, with 29 people (48.33%). Meanwhile, farmers with the largest landholdings of 9-10 hectares account for only 2 people, or 3.33 percent.

Fertilizer

The use of fertilizers can support plant needs; therefore, fertilizers play an important role in production factors. Applying fertilizers with the right composition can lead to high yields. In addition to providing nutrients, fertilization can also improve soil acidity. The fertilizers used by farmers in the study area include Urea, KCL, NPK, and SP36, as shown in Table 8.

Table 8. Use of Fertilizers in Oil Palm Farming in the Research Area

Description	Average (kg/ha/year)	Standarts of Department of Plantations (kg/ha/year)
Urea	261	340
KCL	245	306
NPK	309	204
SP36	25	272

Source: Primary Data Processed, 2019

Fertilization in the research area is carried out 2-3 times a year, in accordance with the Directorate General of Plantations' recommendation. The fertilizer doses used by farmers in the research area were Urea, a minimum of 2.5 kg/stem; KCL, 3 kg/stick; NPK, up to 3 kg/rod; and SP36, up to 3 kg/rod.

Pesticides

The use of pesticides aims to eradicate weeds that interfere with oil palm growth, as well as those that hinder fertilization and harvesting. Pesticides are sprayed at the gates, pikul markets, and harvest collection places (TPH). Pesticide spraying in the research area is carried out twice a year. This is in accordance with the Directorate General of Plantations' recommendation to spray with a 3-month rotation on the pikul road and a 6-month rotation on the goal.

The types of drugs used in oil palm farming in the research area are Gramaxone, Round Up, and Naraxone. Based on the study's results, several farmers do not use drugs in oil palm farming. The average use of pesticides in the research area is shown in Table 9.

Table 9. Use of Pesticides in Oil Palm Farming in Research Areas

Description	Average (kg/ha/year)	Standarts of Department of Plantations (kg/ha/year)
Gramaxone	6,3	10
Round Up	0,6	10
Naraxone	0,2	10

Source: Primary Data Processed, 2019

Workforce

Labor is the amount of effort put into the production process. Labor used in oil palm farming comes from domestic and non-family labor. The family labor force consists of husbands, wives, and children. In contrast, the labor force outside the family comes from the area around the farmer's

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

residence, measured according to the agreed-upon size between the farmer and the laborer. Labor is used in fertilization, spraying, finishing, and harvesting activities.

Work agreements established between farmers and workers in the research area for labor wages in fertilization and spraying activities are calculated at an average salary of IDR 150,000/day. In comparison, for an average harvesting of IDR 150,000/day, harvesting and transportation are calculated based on the amount of FFB harvested, with an average wage of IDR 200,000/ton. The use of labor for each oil palm farming activity in the study area varies in Table 10.

Table 10. Labor Use (HOK) of Oil Palm Farming in Research Areas

Farming Activities	Average (Hok/ha/year)
Fertilization	0,95
Spraying	1,2
Completion	1,52
Harvesting	16,87
Total	20,54

Source: Primary Data Processed, 2025

Based on the data in Table 10, the labor use (HOK) in the research area is 20.54 HOK/ha/year. Harvesting labor is the farming activity that requires the most labor, at 16.87 HOK/ha/year.

Farm Tools

Agricultural tools are the equipment used in farming. Based on the results of the research, the tools used in oil palm farming in the research area include hoes, tojok, egrek, dodos, gancu, angkong, grass machines, spray keps, and machetes.

Price of Fresh Fruit Bunches (FFB)

The average price of palm oil in the research area in 2024 was IDR 2,220/kg, with a low of IDR 1,120/kg and a high of IDR 3,402/kg. FFB prices fluctuate due to changes in export prices. The price of FFB in ISPO-certified oil palm plantations is determined by the plantation service, so that companies cannot buy FFB below the price set by the plantation service. The cooperative's price to farmers will increase by IDR 30/ton. The following are the details of FFB prices in the research area, as shown in Table 11.

Table 11. Average Price of Fresh Fruit Bunches January-December

Month	Jambi Disbun Price (IDR)	Cooperative Pricing (IDR)	Disbun Difference
January	3.341	3.290	51
February	3.494	3.390	104
March	3.909	3.852	57
April	3.769	3.642	127
May	2.808	2.720	88
June	2.471	2.329	142

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Month	Jambi Disbun Price (IDR)	Cooperative Pricing (IDR)	Disbun Difference
July	1.527	1.439	88
August	2.016	1.915	101
September	2.363	2.242	121
October	2.259	2.205	54
November	2.700	2.570	130
Desember	2.714	2.592	122

Source: Primary Data Processed, 2025

Production

Production results are the final outputs of an oil palm farming process. Palm oil production by farmers greatly affects income: the higher the production, the higher the income. Distribution of sample smallholders based on oil palm production in Table 12.

Table 12. Distribution of Sample Farmers Based on the Production of Fresh Fruit Bunches in the Research Area

Production (ton/year)	Number of Farmers	Percentage (%)
36–62	26	43,33
63–89	16	26,67
90–116	6	10,00
117–143	3	5,00
144–170	3	5,00
171–197	3	5,00
198–224	1	1,67
225–251	2	3,33
Total	60	100,00

Source: Primary Data Processed, 2025

Based on Table 12, the distribution of samples by production results over one year shows that most farmers are in the 36-62ton production interval, with 26 people (43.33%). Meanwhile, farmers with the highest production, above 225 tons per year, account for only 2 people, or 3.33 percent.

The Perkasa Nalo Tantan Cooperative was formed in 2017, received ISPO certification in 2019, and had 532 members; the Perkasa Cooperative became the first cooperative in Merangin Regency to receive ISPO certification.

According to (Gunawan & Wirawan, 2020)**,** an overview of independent oil palm farming is important to understand the challenges and opportunities faced by independent smallholders in improving welfare while maintaining environmental sustainability. A brief recapitulation of the overview of oil palm farming in the research area is presented in Table 13.

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Table 13. Recapitulation of the Overview of Oil Palm Cultivation in the Research Area

No	Description	Average	Norm
1	Age of Oil Palm Plants	10,39	
2	Land Area (ha)	3,40	
3	Fertilizer (kg/ha/year)		
	- Urea	261	204
	- KCL	245	272
	- NPK	309	340
	- SP36	25	306
4	Pesticides (L/ha/year)		
	- Gramaxone	6,3	10
	- Round Up	0,6	10
	- Naraxone	0,2	10
5	Workforce (HOK/ha/year)	20,54	
6	Agricultural Equipment (units/ha/year)	9	
7	Price of Fresh Fruit Bunches (IDR)	2.682	2.781
8	Production (Tons)	24,86	

Source: Primary Data Processed, 2025

Based on Table 13, the average age of oil palm trees in the study area is 10.39 years, and the average oil palm land area per farmer is 3.40 hectares. Based on the Regulation of the Minister of Agriculture No. 18/Permentan/KB.330/5/2016 concerning Guidelines for Oil Palm Replanting, farmers who own land areas of less than 4 hectares are classified as smallholder farmers.

The use of fertilizers and pesticides has applied the correct fertilizer element and dose, as shown in Table 13, where the average fertilizer use is still relatively close to the norm recommended by the Directorate General of Agriculture. The average labor absorption in the research area is 20.54 HOK/ha/year. Agricultural tools used in farming include hoes, tojok, egrek, dodos, gancu, angkong, lawn mowers, spray kets, and machetes. The difference between the cooperative FFB price and the Plantation Department's cost is IDR 99. FFB production averaged 24.86 tons/ha/year.

Sustainability Status of the Economic Dimension

The economic dimension is the ability of oil palm plantations to meet and sustainably address farmers' needs—measured by independent smallholders using Rap-Palmoil analysis. The attributes used to measure the sustainability status of the financial dimension are certified seeds, palm oil productivity, implementation of price transparency, access to FFB sales, transportation, and minimum wage. The sustainability analysis of the economic dimension for the ISPO-certified independent oil palm plantation in the Perkasa Cooperative yielded a score of 77.85, placing it in the very sustainable category. The leverage analysis was conducted to determine the sensitivity of each attribute to the sustainability of ISPO-certified independent oil palm plantation farming within mighty cooperatives in the economic dimension. The analysts' results show that an attribute sensitive to the sustainability index's value, namely palm oil productivity, is evident in Figure 1.

AGRISOCIONOMICS
Jurnal Sosial Ekonomi dan Kebijakan Pertanian
ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

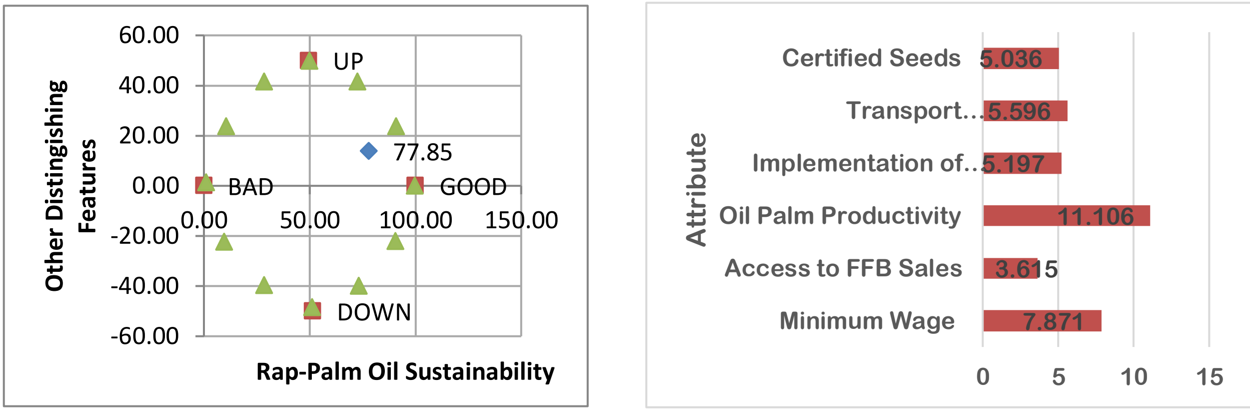


Figure 1. Sustainability Index and Sensitive Indicators of Economic Dimensions
Source: Primary Data Processed, 2025

The results of the laverage analysis showed that the most sensitive attribute was palm oil productivity, with an RMS of 11,106. PPKS (2013) and Sukarno (2009) stated that productivity is high when 24 tons of FFB are produced per hectare per year. Under the eight conditions, the average ISPO-certified farmer in the Perkasa cooperative has a productivity of more than 24 tons/ha/year. The use of the minimum wage attribute of labor is an absolute attribute from ISPO in plantation companies, as indicated. There is evidence that it has implemented minimum-wage regulations for workers. The minimum wage standards for labor in this study are based on the daily wage at the research location. The average daily wage in the workforce is IDR 150,000. Based on field conditions, farmers who use hired labor to earn wages have followed the average wage standards in the field. Research results (Oktaviana et al., 2022) showed that the minimum wage negatively affects labor absorption: as the minimum wage increases, the number of workers decreases, thereby affecting regional economies.

Sustainability Status of the Social Dimension

The social dimension comprises six attributes compiled from the ISPO principles on the social factors that affect the sustainability of independent smallholder oil palm farming. Based on the results of the analysis of MDS ordination on six attributes that affect the level of progress in the social dimension, namely, institutional or group activity, education level, land dispute conflicts, extension frequency, and farmer loyalty.

Figure 2. Sustainability Index and Social-Dimension Sensitive Indicators
Source: Primary Data Processed, 2025

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Based on the analyzed data, the activities of ISPO-certified independent oil palm plantations in Perkasa cooperative in the social dimension have an index value of 57.76, indicating that oil palm plantation farming is considered quite sustainable. Based on the leverage analysis, the key indicator most affecting the progress of ISPO-certified oil palm plantations in the Perkasa cooperative is the frequency of extensions.

The figure above shows that the green triangular visualization indicates that each unit of analysis falls within the moderately sustainable to sustainable category. The green color denotes an index value greater than 50% (moderately sustainable), with an overall attribute index of 57.76, indicating a moderately sustainable status. In the figure, this position lies within the quadrant labeled "GOOD." The relatively stable and non-extreme shape of the triangle suggests that the main attributes/dimensions are comparatively balanced and not disproportionately distributed, and that there is no significant pressure distorting the ordination. This implies that the implementation of ISPO among independent smallholders has established a fairly sound, relatively stable foundation for sustainability across the assessed attributes/dimensions.

The Rapish analysis based on Multidimensional Scaling (MDS) demonstrates that the green triangle and the red quadrilateral overlap. This overlap indicates a close ordination position and a high degree of similarity in sustainability characteristics across dimensions. It also serves as a visual indicator of the direction of improvement or decline in sustainability levels within the multidimensional space.

Overall, within the social dimension, it can be concluded that the implementation of ISPO certification among independent smallholders has progressed in a relatively balanced manner across dimensions. Nevertheless, further strengthening is required for sensitive attributes with the lowest scores—particularly the attribute related to land tenure conflict—to enhance the overall stability of the system.

The frequency of counseling was the most sensitive attribute in the social dimension, with an RMS of 5.593. ISPO-certified farmers, on average, participate in counseling less than 3 times a year under field conditions, while the mighty cooperative can hold counseling approximately 6 times a year. Smallholders who have other jobs contribute to this condition, making it challenging for them to attend counseling sessions consistently. Counseling at Perkasa cooperatives is held by cooperative partner companies, namely PT Agrindo Indah Persada. The ISPO principle aims to enhance business sustainability by improving performance and formulating strategies that foster sustainable expansion of palm oil production. To achieve this, farmers who directly manage and care for oil palm plantations must have sufficient knowledge to care properly for them, ensuring sustainable farming.

Ecological Dimension Sustainability Status

The ecological sustainability of oil palm plantations benefits environmental sustainability. The sustainability of the ecological dimension is measured using six attributes compiled from the sustainability study of independent oil palm plantations based on ISPO principles. These attributes include an environmental permit in accordance with SPPL, oil palm maintenance records, SOPs for land clearing without burning, peatland use, conservation measures, and integrated pest control techniques. The sustainability status of the ecological dimension in ISPO-certified independent oil palm plantation farming in the Perkasa Cooperative is 67.22. Based on the results of leverage analysis,

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

it can be seen that the key indicator that most affects the progress of ISPO-certified oil palm plantations in the Perkasa cooperative is the record of oil palm maintenance, as shown in Figure 3.

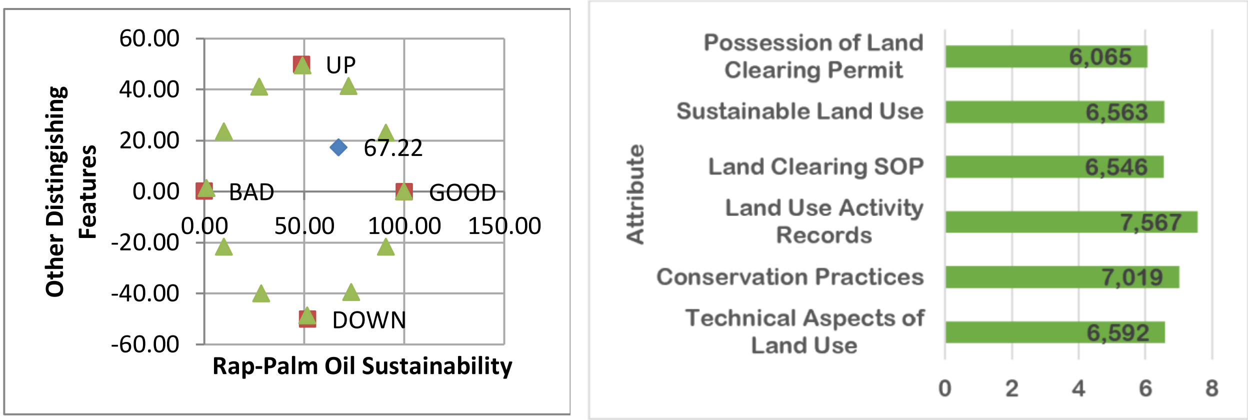


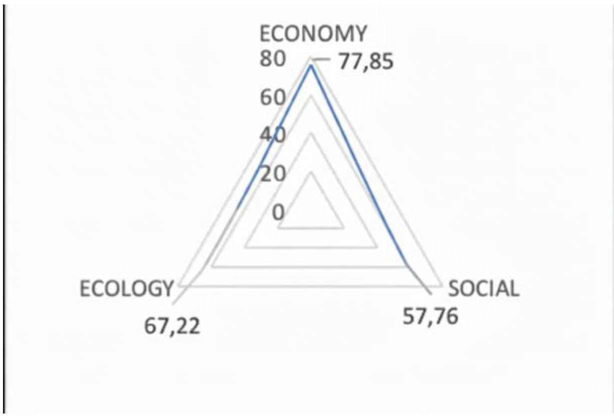
Figure 3. Sustainability Index and Ecological Dimension Sensitive Indicators
Source: Primary Data Processed, 2025

Similar to the social dimension, the Rapfish analysis for the ecological dimension indicates that all attributes fall within the moderately sustainable category, with an index value of 67.22. This condition is represented by a blue diamond symbol located in the quadrant facing the GOOD direction. The green triangles indicate that each attribute demonstrates a level of sustainability categorized as moderately sustainable. Meanwhile, the presence of two overlapping geometric shapes serves as a visual marker indicating the direction of improvement or decline in sustainability within a multidimensional space. Overall, within the ecological dimension, the implementation of ISPO certification among independent smallholders is relatively balanced across several attributes and is classified as moderately sustainable.

Based on the results of the laverage analysis on the economic dimension, the most sensitive attribute is the record of palm oil maintenance with an RMS of 7.567. According to ISPO standards, farmers who already have ISPO certification are required to maintain their crops; of course, this can support oil palm productivity, and the maintenance of these crops must be recorded. Palm oil maintenance records include fertilization schedules, spraying, and FFB sales. This record is useful for evaluating sustainable oil palm farming. Conditions in the field for FFB sales are recorded directly by the cooperative, but for fertilization schedules and others, the cooperative submits them to farmers. The next sensitive attribute is conservation measures with an RMS of 7.019. The 3rd principle of ISPO is the management of the environment, natural resources, and biodiversity, namely, knowing and having records of these resources. In the field conditions, the area where farmers carry out oil palm farming is not a national park or conservation area, so farmers do not have records about it.

Multidimensional Sustainability Status

A multidimensional analysis of the sustainability status of ISPO-certified oil palm plantation farming in the Perkasa Nalo Tantan cooperative showed a sustainability index value of 66.99 based on the standard sustainability index for ISPO-certified smallholders, showing that the status of oil palm plantation farming was quite sustainable because it was between 50.01-75.00.



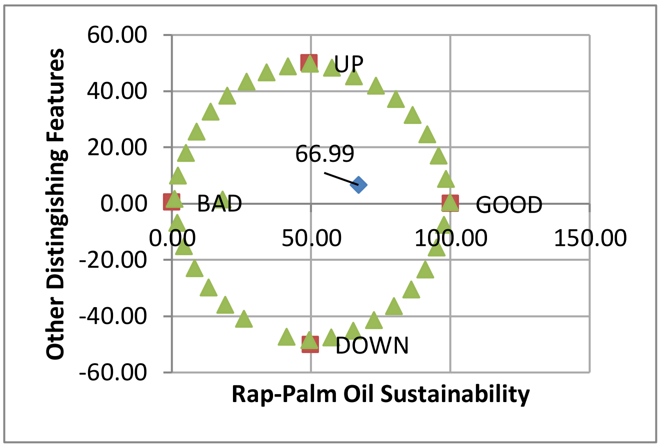


Figure 4. Multidimensional Sustainability Index and Flyover Diagram
Source: Primary Data Processed, 2025

Based on the analysis, the sustainability index was calculated from the assessment of 18 sustainability attributes across three dimensions. In another study on the sustainability of multidimensional palm oil (Najmi et al., 2019), the sustainability of people's core plantations in South Aceh Regency was rated 47.66 and considered less sustainable. The sustainability index value for each dimension is 77.85 (very sustainable) for the economic dimension, 57.76 (quite sustainable) for the social dimension, and 67.22 (quite sustainable) for the ecological dimension, as shown in the flyover diagram. The value of the sustainability dimension on the hover chart can be inteIDRreted as follows: the farther the sustainability point is from the midpoint, the greater the sustainability value.

Based on the overall dimensional analysis, each attribute within each dimension is represented by a green triangle, which signifies sustainability, along with its respective percentage value. Meanwhile, the overall index is positioned in the quadrant approaching the “Good” category, with a score of 66.99. It can therefore be concluded that the implementation of ISPO by independent smallholders is moderately sustainable, falling within the 50–75 score range and indicated by a light green classification.

Stress Value and Coefficient of Determination

The R2 (determination coefficient) and stress values are used to determine whether additional attributes are needed to reflect the dimension better. Stress is a measure of the mismatch between the data and the MDS measurement. R2 is the square of the correlation coefficient that shows the proportion and optimization of the measurement of the value of the data. The following are the R2 and stress values shown in Table 14.

Table 14. Stress Values and Determination Coefficients in Rap-Palm Oil Independent Oil Farming with ISPO Certification

Dimension	Sustainability Index Value	Stress	R2
Economics	77,85	0,14	0,94
Social	57,76	0,15	0,93
Ekologi	67,22	0,15	0,94
Multi-size	66,99	0,13	0,95

Source: Primary Data Processed, 2025

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

Based on research (Hasibuan, 2020), the R2 value will be higher when the value obtained is larger, approaching 1 or 100%. A stress value that is smaller than the stipulation that the stress value in the analysis using the MDS method is sufficient if it is obtained less than 0.25 or 25%. The results of the study show that all attributes used in the sustainability analysis of ISPO-certified independent oil palm farming in the Perkasa cooperative are quite good and can represent these three dimensions.

The successful application of the Multi-Dimensional Scaling (MDS) method to analyze the sustainability status of independent oil palm plantations demonstrates that integrating economic, social, and ecological factors provides a comprehensive picture of on-the-ground conditions. Previous research has confirmed that the sustainability of independent oil palm farming depends not only on production efficiency but also on smallholders' institutional capacity, access to technological information, and consistent policy support (Daryanto et al., 2018; Hidayati, 2020). ISPO certification has proven effective in improving farmer management discipline across both technical and administrative aspects, although intensive assistance is still needed to ensure sustainability principles are thoroughly internalized (Wulandari & Raharja, 2020). On the other hand, the synergy between cooperatives and coIDRorate partners plays a key role in providing environmentally friendly cultivation practices while increasing farmers' bargaining power in the global market (Astuti et al., 2020).

Monte Carlo

The final stage in analyzing the behavior is to conduct a Monte Carlo analysis. This analysis examines the extent of error in the study, including differences among respondents' assessments of attributes, data entry errors, and incomplete or missing data (Hasibuan, 2020). The following is the value of the prosperity index from a Monte Carlo analysis of the economic, social, and ecological dimensions shown in Table 15.

Table 15. Monte Carlo Analysis for Rap-Palm Oil Value at 95 Percent Confidence Interval

Dimension	Sustainability Index %		Margin (MDS-Monte Carlo)
	MDS	Monte Carlo	
Economics	77,85	76,69	1,16
Social	57,76	57,63	0,13
Ekologi	67,22	66,71	0,51

Source: Primary Data Processed, 2025

The difference between the index value and the Monte Carlo analysis value for each dimension can be said to have a relatively small error (random error) if it is not more than 5%. This shows that there are errors in scoring and data management, and demonstrates that their influence can be avoided during data processing (Harjono, 2012). The results of the analysis showed a difference of less than 5%, with the analysis error relatively small.

Validation of sustainability analysis results using the Monte Carlo method is an important step to ensure data reliability and minimize bias in the assessment process. Accuracy in determining attributes, scoring, and inteIDRreting results significantly affects the accuracy of measuring the sustainability status of independent oil palm plantations (Astuti et al., 2020). Several studies have shown that applying Monte Carlo analysis to assess plantation sustainability can identify potential systematic errors that often arise from the subjectivity of the assessor or the imperfections of the

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

instrument (Sari & Nurrochmat, 2018). In addition, the consistency of results between MDS and Monte Carlo simulations indicates that the model is quite robust in reflecting real field conditions (Susanto & Arifin, 2019). Therefore, integrating quantitative approaches with Monte Carlo validation is increasingly recommended in sustainability studies to obtain more accurate and representative results (Utami et al., 2020).

CONCLUSION AND SUGGESTION

The overview of oil palm farming in the study area is that the average oil palm production is 84.43 tons/ha/year with an average selling price of IDR 2,682/kg. The average land use for oil palm farming is 3.40 ha/farmer, fertilizer 840 kg/ha/year, pesticides 7.1 liters/ha year, and labor 20.54 HOK/ha. The sustainability status of ISPO-certified independent oil palm farming in the Perkasa Nalo Tantan cooperative is multidimensionally quite sustainable, with an index value of 66.99. The sustainability status of the economic dimension is 77.85 (very sustainable), the social dimension is 57.76 (quite sustainable), and the ecological dimension is 67.22 (quite sustainable).

These findings confirm the need to strengthen the application of ISPO principles at the independent smallholder level, especially in the use of production inputs in accordance with technical norms and the recording of sustainable farming activities. Efforts to assist and build the capacity of smallholders through cooperatives are expected to strengthen the implementation of sustainable agricultural practices that are more consistent, efficient, and environmentally friendly, thereby supporting the sustainability of the smallholder oil palm farming system in the future.

REFERENCES

Akbar, M. F., Napitupulu, D. M. T., & Yanita, M. (2024). Analisis keberlanjutan perkebunan kelapa sawit rakyat di Kecamatan Sekernan, Kabupaten Muaro Jambi. *Jurnal Sosial Ekonomi Pertanian Dan Agribisnis*, *21*(2), 183–194.

Anwar, A., Galib, M., & Amran, F. D. (2022). Analysis of Cocoa (Theobroma cacao L) Sustainability Status in Bantaeng District. *Jurnal Tanah Dan Sumberdaya Lahan*, *9*(1), 121–130. https://doi.org/10.21776/ub.jtsl.2022.009.1.13

Astuti, D. F., Yulianingsih, Y., & Firdaus, M. (2020). Kemitraan Koperasi dan Perusahaan dalam Mendukung Sertifikasi ISPO: Studi Kasus di Kalimantan Barat. *Jurnal Agribisnis Indonesia*, *8*(1), 12–22.

Badan Pusat Statistik. (2021). *Pedapatan Domestik Bruto (PDB) Seri 2010*.

Budiarti, A., & Manuhutu, T. (2019). Tantangan Implementasi ISPO bagi Petani Swadaya: Studi Kasus di Kabupaten Seruyan, Kalimantan Tengah. *Jurnal Ilmu Lingkungan*, *17*(2), 121–130.

Daryanto, A., Lubis, H., & Siregar, I. (2018). Penguatan Kelembagaan Petani Swadaya dalam Mendukung Implementasi ISPO. *Jurnal Manajemen Agribisnis*, *5*(2), 105–114.

Dharmawan, A. H., Nasdian, F. T., Barus, B., Kinseng, R. A., Indaryanti, Y., Indriana, H., Mardianingsih, D. I., Rahmadian, F., Hidayati, H. N., & Roslinawati, A. M. (2019). Kesiapan Petani Kelapa Sawit Swadaya dalam Implementasi ISPO: Persoalan Lingkungan Hidup, Legalitas dan Keberlanjutan. *Jurnal Ilmu Lingkungan*, *17*(2), 304. https://doi.org/10.14710/jil.17.2.304-315

Gunawan, I., & Wirawan, D. (2020). Kesiapan petani swadaya dalam penerapan sertifikasi ISPO di Indonesia. *Jurnal Agribisnis Dan Kebijakan Pertanian*, *8*(1), 12–24.

Gutierrez Al-Khudhairy, S. (2023). Sustainable management practices do not reduce oil palm fruit production on smallholder farms in Sabah, Malaysia. *Journal of Oil Palm Research*, *35*(1), 1–

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

10.

Harjono, D. K. (2012). *Hukum Penanaman Modal: Tinjauan Terhadap Pemberlakuan Undang-Undang No. 25 Tahun 2007 tentang Penanaman Modal*. Pusat Pengembangan Hukum dan Bisnis Indonesia.

Hasibuan, N. R. (2020). *Analisis keberlanjutan usaha perkebunan kelapa sawit rakyat di kabupaten padang lawas*.

Hernanto, F. (1991). *Ilmu Usahatani*. Penebar Swadaya. Jakarta.

Hidayati, E. (2020). Aplikasi Rapfish dalam Menilai Keberlanjutan Perkebunan Kelapa Sawit di Sumatera Selatan. *Jurnal Ekonomi Pertanian Dan Agribisnis*, *4*(3), 201–210.

Kementerian Pertanian Republik Indonesia. 2016. *Peraturan Menteri Pertanian No. 18/Permentan/KB.330/5/2016 tentang Pedoman Peremajaan Perkebunan Kelapa Sawit.* Jakarta: Kementerian Pertanian RI.

Mantra, I. B. (2004). *Struktur umur penduduk dan klasifikasi kelompok umur berdasarkan produktivitas ekonomi*. Pustaka Baru Press.

Meilianni, R. (2020). Alokasi Tenaga Kerja Dan Pendapatan Petani Kelapa Sawit Di Kabupaten Musibanyuasin , Sumatera Selatan. *Jurnal Ketenagakerjaan*, *15*(1), 1–13.

Najmi, N. L., Al Jaktsa, A. J., Suharno, S., & Fariyanti, A. (2019). Status Keberlanjutan Pengelolaan Perkebunan Inti Rakyat Kelapa Sawit Berkelanjutan Di Trumon, Kabupaten Aceh Selatan. *Forum Agribisnis*, *9*(1), 53–68. https://doi.org/10.29244/fagb.9.1.53-68

Nuryanti, S., Hutabarat, S., & Yusri, J. (2019). Analysis On Sustainability Of Oil Palm Independent Smallholder (A Case Study of Oil Palm Independent Smallholder Kelompok Tani Petani Makmur at Lubuk Ogong Village, Bandar Sei Kijang Sub District, Pelalawan District). *Jurnal Sungkai*, *7*(1), 61–78.

Oktaviana, N., Safrida, & Ginting, L. N. (2022). Dampak Kebijakan Upah Minimum Terhadap Penyerapan Tenaga Kerja Sektor Pertanian Di Provinsi Aceh. *Jurnal Agrisep*, *23*(1), 35–42.

Oli, D., Gyawali, B., Acharya, S., & Oshikoya, S. (2025). Factors influencing learning attitude of farmers regarding adoption of farming technologies in farms of Kentucky, USA. *Smart Agric. Technol.*, *10*(100801), 100801. https://doi.org/10.1016/j.atech.2025.100801

Priyanto, H., Prakoso, A., & Yulianingsih, T. (2017). Validasi Data Keberlanjutan Perkebunan Kelapa Sawit Menggunakan Metode Monte Carlo. *Jurnal Teknologi Lingkungan*, *18*(2), 145–152.

Rizal, A., Hamidah, S., & Wuryani, S. (2019). Analisis Penerapan Sertifikasi Indonesian Sustainable Palm Oil (Ispo) Dalam Usaha Kelapa Sawit (Studi Kasus Di Kebun Baru Ptpn I dan …. *Seminar Nasional Inovasi Pangan Lokal Untuk Mendukung Ketahanan Pangan*, *April*, 22–28.

Saragih, S., Syah, R., & Putri, N. (2020). Pengukuran Keberlanjutan Perkebunan Kelapa Sawit Rakyat Menggunakan Metode MDS. *Jurnal Penelitian Sosial Dan Ekonomi Kehutanan*, *17*(1), 45–56.

Sari, L., & Nurrochmat, D. (2018). Penerapan Monte Carlo dalam Analisis Keberlanjutan Usaha Tani Kelapa Sawit. *Jurnal Ilmu-Ilmu Pertanian Indonesia*, *20*(1), 37–46.

Siregar, A. P., & Siregar, A. P. (2024). Analisis faktor sosial yang mempengaruhi pendapatan usahatani kelapa sawit di Kecamatan Percut Sei Tuan, Kabupaten Deli Serdang. *Agrisentrum: Jurnal Ilmiah Agribisnis Dan Agronomi*, *17*(2), 123–134.

Situmorang, P. S., & Andriani, E. (2019). Analisis Faktor-Faktor yang Mempengaruhi Keberlanjutan Usahatani Kelapa Sawit di Sumatera Utara. *Jurnal Ekonomi Dan Kebijakan Pertanian*, *7*(1), 45–54.

Soekartawi. (2022). Basic Principles of Agricultural Economics Theory and Application. *Raja Grafindo Persada. Jakarta*.

Supriatna, J., Djumarno, D., Saluy, A. B., & Kurniawan, D. (2024). Sustainability analysis of smallholder oil palm plantations in several provinces in Indonesia. *Sustainability*, *16*(11), 4383.

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 10 (2): 542-562, June 2026

https://doi.org/10.3390/su16114383

Susanto, M., & Arifin, P. (2019). Evaluasi Model Multi Dimensional Scaling dengan Monte Carlo pada Penilaian Keberlanjutan Perkebunan Rakyat. *Jurnal Sistem Informasi Pertanian*, *14*(3), 205–214.

Suwanda, M. H., Puspitasari, P., Soetopo, D., & Talib, C. (2020). *Analisis Keberlanjutan Usaha Tani Kelapa Kelapa Sawit Di Lahan Gambut: Studi Kasus Di Kampar, Riau.*

Syahza, A., Nasrul, R., & Bakce, R. (2018). Model Pemberdayaan Petani Kelapa Sawit Melalui Penguatan Kelembagaan di Riau. *Jurnal Agribisnis Indonesia*, *6*(1), 23–32.

Utami, D. H., Iskandar, S., & Pramono, R. (2020). Monte Carlo Simulation for Reducing Data Uncertainty in Sustainable Palm Oil Assessment. *Jurnal Agro Ekonomi*, *38*(2), 183–193.

Wulandari, R., & Raharja, S. (2020). Tantangan Implementasi Sertifikasi ISPO pada Petani Swadaya di Riau: Perspektif Pembangunan Berkelanjutan. *Jurnal Ilmu Sosial Indonesia*, *21*(3), 232–241.

Zhang, M., Qin, J., & Tan, H. (2023). Education level of farmers, market-oriented reforms, and agricultural water resource utilization efficiency. *Journal of Environmental Management*, *317*, 115380. https://doi.org/10.1016/j.jenvman.2022.115380