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A Structural Equation Model to Assess the Impact of the Economic and Environmental Benefits to the Indonesian Sustainable Palm Oil (ISPO) Adoption

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***Abstract*—Indonesian Sustainable Palm Oil (ISPO) was established initially to protect the national interest. However, the implementation level of ISPO still needs to be improved, mainly by smallholders. The low interest of smallholders is closely related to rational reasons such as economic and environmental benefits. Therefore, this study fills the gap by analyzing the economic and environmental benefits of adopting ISPO certifications using 300 respondents (150 ISPO and 150 non-ISPO) from four regencies (Batanghari, Muaro Jambi, Tebo, and Tanjung Jabung Barat) in Jambi Province, Indonesia. The study employed a closed-ended questionnaire to collect the farmers' perspective data and utilized the Structural Equation Model (SEM) to address the research question. SEM can capture the perceptions of respondents and describe the impact of economic and environmental benefits to the ISPO adoption. The results found that the intention to adopt ISPO directly impacted the adoption rate. The intention to adopt by smallholders can be influenced by two variables, namely economic benefits and controlling behavior. The impact of the environmental advantages on the adoption intention was found to be insignificant. In addition, economic benefits have a dominant influence on all latent variables that compose intentions to adopt, such as subjective norms, attitudes toward sustainable management, and perceived control behavior. The study recommends that stakeholders pursue measures to disseminate the economic benefits of ISPO implementation to smallholders through various channels, including governmental and private extension. The government should also carry out a policy to create a supporting ecosystem to boost farmers' participation in adopting ISPO certification.**

***Keywords*—Economic benefit; environmental benefit; ISPO; SEM; smallholders.**

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I. INTRODUCTION

One of Indonesia's ruling plantation commodities is palm oil. The palm oil industry is crucial in improving and expanding the country's economy, especially as a source of foreign exchange, employment absorber, and contributor to GDP. Besides being used for cooking oil, Globally, CPO is the most commonly used vegetable oil, and it is also projected as a promising biodiesel source [1]. Indonesia is the largest global producer and exporter of crude palm oil, with export value reaching US$ 15.57 billion [2]. This makes palm oil the second most valuable exported commodity after oil and gas.

This prominent role encourages the increase of land areas designated for cultivating palm oil. Over the last five years (2018-2022), the area of oil plantations in Indonesia has steadily increased at 2% per year. According to [3], [4] the land area dedicated to oil palm plantations is growing yearly, encouraging production growth. In 2022, the area of oil palm plantations reached 15,380,981 acres. Those areas are owned by large privately owned companies (54.63%), smallholders (41.48%), and large state companies 3.89%) [5].

However, expanding land for oil palm cultivation is open to various environmental problems. Palm oil plantations are claimed to cause environmental damage [6]. [7] stated that

palm oil production has caused significant damage to the natural environment. Furthermore, oil palm plantations are accused of causing land and forest fires, especially in the Sumatra and Kalimantan islands [8], [9], which causes poor air quality.

Some studies [10], [11] reported that 52% of the total forest fires in 2015 occurred in peatlands rich in carbon, making Indonesia one of the most significant contributors to global warming. These various negative impacts have the potential to become threats, especially to habitat loss of critically endangered species in rainforest ecosystems and ecosystem sustainability.

The consequences of environmental impacts have encouraged importing countries, especially the European Union, to impose non-tariff import barriers. This obstacle is reflected in the implementation of the RED II policy by the European Union, where oil palm plantations are seen as incompatible with the EU's progressive, sustainable development vision [12]. The EU Commission has categorized palm oil as the only high-risk feedstock for indirect land use change, with over 40% expansion on high carbon stock land (compared to 8% for soybean) based on available data [13]. It will reduce the European Union's demand for palm oil. If this happens, it will also greatly damage Indonesian palm oil exports.

To maintain the national palm oil competitiveness through sustainable development, the government issued the sustainable farming approach called the Indonesian Sustainable Palm Oil (ISPO) certification [14], [15]. The Indonesian government aims to promote sustainable palm oil plantations in response to global market pressures while increasing the competitiveness of Indonesian palm oil [16]. The ISPO certificate is enforced mandatory by the government, which means that all stakeholders must implement ISPO certification without exception.

However, until 2020, less than one-third of the smallholder plantations were ISPO certified. Several problems faced by oil palm farmers are institutions [17], [18], land legality [19], [20], [21], weak regulatory capacity [22], seeds legality, and the implementation of good agricultural practices in their businesses. However, these various factors are mainly caused by farmers' perceptions regarding their unpreparedness to implement the principles of ISPO certification [23], [24]. The low attractiveness of farmers is closely related to rational reasons such as economic and environmental benefits.

However, only a few studies have assessed the economic and environmental impacts of implementing sustainable palm oil certification. Most previous research evaluated the impact of adopting Roundtable Sustainable Palm Oil (RSPO). These studies focused on the impact of certification on the prices received by farmers [25], better performance, including planting material and fertilizer use [26], better performance in terms of environmental and economic criteria [27], and achieving sustainable development goals [28]. Meanwhile, studies focusing on ISPO are still lacking as the scheme was only established in 2011. The RSPO still maintains relatively better legitimacy in the global market since its establishment in 2004 [29]. The existence of two sustainability certification standards (RSPO and ISPO) means that producers, especially smallholders, need help determining which to adopt. The confusion is also apparent in the global market. European markets prioritize certified products, while traditional Indonesian markets (China and India) do not. Inconsistencies also arise along the palm oil value chain. Farmers are the most affected actors as the parties with the weakest bargaining position. Finally, farmers want to know, particularly, the economic and environmental impact on their farming business after implementing these certifications. Farmers may adopt ISPO based on their perceptions of economic and environmental factors. Therefore, it is crucial to conduct this study to fill the current research gap on the effect of the economic and environmental advantage perception towards the intention of implementing ISPO certifications.

II. Materials and Methods

A. Research Location

A Survey was carried out in four regencies in Jambi provinces, including Batanghari, Tanjung Jabung Barat, Tebo, and Muaro Jambi Regency. These four locations were purposively chosen, considering that Jambi province is one of the most significant contributors to the Indonesian palm oil industry. This study determined two regencies for ISPO representatives, namely Mutiara Bumi Cooperative in Batanghari Regency and Catur Manunggal Farmer Group in Tanjung Jabung Barat Regency. Tebo and Muaro Jambi regencies were chosen to represent farmer respondents who had not implemented ISPO certification.

B. Sampling Technique

The sampling of farmers in this study used the multistage disproportionate purposive sampling method. Sample selection was carried out in stages, starting with a province (Jambi Province) and then selecting sample districts, namely four districts. After that, the researchers determined the sample by choosing 75 farmers in each district to obtain a sample of 300 respondents. Of the 300 samples, each was divided into 150 oil palm farmers who had implemented ISPO certification and 150 oil palm farmers who still needed to implement ISPO certification. The sample of farmers was obtained using the incidental method, and smallholder farmers were selected. The SEM analysis was conducted using LISREL software to analyze the collected data.

C. Variable and Measurement

The study utilized latent variables as part of its analysis. Table 1 presents the indicators used to measure the latent variables indirectly. Data for measuring the variables was collected using closed questionnaires. Likert scales were used to measure the variables in which the assessment range is between 1 and 5, with options ranging from strongly disagree to strongly agree.

TABLE I
THE LATENT AND MANIFEST VARIABLES

Latent Variable	Manifest Variable
Economic benefits	1. Farmer group
	2. Productivity
	3. Profit
	4. Cooperation
	5. Free from land conflict
Environmental benefits	1. Land and water conservation
	2. Biodiversity
	3. Environmental damage

Latent Variable	Manifest Variable
	4. Integrated pest control
Subjective Norm	1. Surrounding environment
	2. Organizational support
	3. External motivation
	4. Mental maturity
	5. Community figures
Attitude toward sustainable management	1. Experience
	2. Knowledge
	3. Media
	4. Intervention
Perceived behavioral control	1. FFB competitiveness
	2. Environmental awareness
	3. Company Collaboration
	4. Land legality
	5. GAP implementation
Intention to adopt ISPO	1. Usefulness
	2. Ignorance
	3. Need correlation
	4. Efforts to promote needs
ISPO adoption	Adoption decision

This study used a six-stage process to estimate SEM, including 1) specification, 2) identification, 3) estimation, 4) validity and reliability test, 5) fit test, and 6) re-specification [30], [31], [32].

D. Testing for Validity and Reliability

This study used the estimated t-value to evaluate the measurement model's validity. If a manifest variable has a t-value < 1.96, then the manifest variable can be removed from the model. The reliability of the measurement model was assessed using construct reliability (CR) and variance extracted (VE). Good CR and VE values indicate that the indicators used in the research are consistent.

E. Model Fit Testing

The goodness of fit (GOF) test was used to evaluate how well a model fits the data. It measures the model's overall fit and helps determine if the model is a good representation of the data. The model suitability test with SEM cannot be determined by just one suitability criterion. The RMSEA test results indicate the suitability of the structural equation model in determining the average difference for each degree of freedom expected to occur in the population. Close fit is indicated by RMSEA ≤ 0.05, while good fit is indicated by 0.05 < RMSEA ≤ 0.08 [33], and an RMSEA value ranging from 0.08 to 0.10 indicates marginal fit.

The Goodness of Fit Index (GFI) value is a measure that shows how much the model can explain the diversity of data. The RMR test result value is the average between the observed matrix and the estimated results. The AGFI value is an expansion of the GFI. It is adjusted to the ratio between the degree of freedom of the independence model and the degree of freedom of the estimated model [34].

F. Hypothesis

This study hypothesizes that the Indonesian Sustainable Palm Oil (ISPO) certification has a significant positive impact on the economic well-being of palm oil farmers and the quality of the natural environment. The proposed hypothesis is that by adhering to ISPO standards, palm oil farmers can achieve more significant economic benefits. These benefits are attributed to access to broader and premium markets, which tend to pay higher prices for sustainably produced products. Additionally, the certification is expected to promote production efficiency and reduce operational costs by adopting advanced agricultural technologies and better land management practices.

From an environmental perspective, this hypothesis also posits that ISPO certification will contribute to forest conservation and biodiversity. With stringent standards, farmers are required to manage their land responsibly, which can reduce deforestation and greenhouse gas emissions. Implementing these sustainable practices is expected to preserve local ecosystems and mitigate adverse environmental impacts. Therefore, this study aims to test whether ISPO certification truly offers dual benefits for farmers' economies and environmental sustainability.

III. Result and Discussion

A. Result

1) Respondent Characteristics: Based on gender, most respondents were male (94%). Male domination condition is because oil palm farming requires more energy, especially at the planting and harvesting stages. [35], [36] states that male workers still dominate work on oil palm plantations. Meanwhile, four types of women work in the oil palm plantation sector daily, including women who have the status of smallholder farmers, casual daily workers, family camp women, and permanent employees of palm oil companies. The role of women is mainly involved in the fertilization and maintenance processes, which do not require too much energy. Women spend less time farming and more time on household chores and leisure compared to those in traditional crop households [36].

Based on age, the majority (75.67%) of respondents were over 40 years old. Only a small number of respondents were relatively young. This condition is common, where the younger generation is not interested in working in the agricultural sector. In line with age, farmers have relatively long experience, with an average of over ten years (84%). In terms of education, the majority of farmers have only completed primary education (35.33%). This fact illustrates that the respondent's education level is in the low category. A low level of education can describe a relatively low level of progress and human resource capabilities. Finally, a low level of education will also correlate with the level of competence in a skill. In addition, 98% of respondents were involved in farmer group membership. This high proportion also shows that farmers know the importance of institutions in pursuing their life goals. Another fact shows that the majority, or more than 95% of farmers, rely on income from their oil palm plantations.

2) Validity and Reliability: Testing the suitability of the measurement model in SEM uses validity and reliability tests, where the validity test determines whether a variable measures its intended construct. A variable is considered to have good validity for its construct if it satisfies two conditions. Firstly, its loading factors' t-value must be greater than the critical value (≥ 1.96). Secondly, its standardized loading factors should equal or exceed 0.7, or the minimum standardized indicator variable coefficient (lambda) value

should be 0.5 [34].The measurement model analysis reveals that all indicator variables have a t-value greater than 1.96. Furthermore, the value obtained for the standardized loading factors is more significant than 0.7. In other words, all the proposed manifest indicator variables can represent this research's desired manifest/indicator variables.

Based on the reliability testing of the measurement model (Table 2), all latent variables have CR and VE values that support good reliability. Good CR and VE values show that the indicators used in the research are consistent. If the study is repeated at a different time, smallholder farmers in Jambi Province will give reliable/consistent answers.

TABLE II
THE RELIABILITY TEST OF A MEASUREMENT MODEL

Latent variable	CR	Reliability	VE	Reliability
Economic benefit (EKO)	0.9528 ≥ 0,70	Good	0.8020 ≥ 0,50	Good
Environment benefit (LING)	0.9429 ≥ 0,70	Good	0.8054 ≥ 0,50	Good
Subjective Norm (SUBNORM)	0.9416 ≥ 0,70	Good	0.7636 ≥ 0,50	Good
Attitude (SKP)	0.9552 ≥ 0,70	Good	0.7531 ≥ 0,50	Good
Control behavior (CNTRL)	0.9576 ≥ 0,70	Good	0.8496 ≥ 0,50	Good
Intention to adopt ISPO (INTNT)	0.9594 ≥ 0,70	Good	0.8552 ≥ 0,50	Good
ISPO Adoption (ADOPT)	1.00 ≥ 0,70	Good	1.00 ≥ 0,50	Good

3) Model Fit Test: In the SEM model, not only one test tool is used, but there are three groups of test tools: parsimony fit measures, absolute fit measures, and relative fit measures [37]The absolute goodness-of-fit test determines the degree to which the overall model predicts the correlation and covariance matrices. Table 3 illustrates the outcomes of analyzing the model's overall fit. The Absolute fit measure determines how well the overall model (structural and measurement models) predicts the correlation and covariance matrices using RMSEA and GFI.

RMSEA measures deviations in parameter values using the population covariance matrix [33], so RMSEA is a highly informative indicator for assessing the suitability of a measurement model. After analyzing the outcomes, the RMSEA value of the model tested is 0.0136 with a GFI value of 0.99, so overall, it can be concluded that the tested model closely fits the absolute model test criteria at a good level.

TABLE III
OVERALL MODEL FIT TEST RESULTS

Overall Model Fit Measure	Result	Condition	Conclusion
RMSEA	0.005	≤ 0.08	
GFI	0.99		
CFI	0.99		
NFI	0.96		
NNFI	0.99	≥ 0.90	Good
IFI	0.99		
RFI	0.95		
AGFI	0.96		
PGFI	0.70	≥ 0.50	

The measure of model suitability involves comparing the proposed incremental fit model with a basic model, which is frequently referred to as the null model or independence model, consists of several test tools for suitability, including (a) CFI, (b) NFI, (c) NNFI, (d) IFI, (e) RFI. Based on Table 2, those measurements indicate that the model meets good testing criteria.

The parsimonious fit model measure corresponds to the proposed model with the base model. Following the principle of parsimony, it means obtaining the highest possible degree of fit for each degree of freedom, consisting of several test equipment for suitability, including (a) AGFI and (b) PGFI. Based on the research results, the Adjusted Goodness of Fit Index (AGFI) is 0.96, and the Parsimonious Goodness of Fit Index (PGFI) is 0.70. The model is considered close to good because it meets the established test criteria.

4) The Impact of Economic and Environmental Benefits on the Adoption of ISPO: SEM analysis in this study was conducted using a one-step approach (full/hybrid SEM model) by combining the measurement and structural models. The two models were then estimated simultaneously in a single analysis. This condition aligns with the research objectives. The measurement model shows the relationship between latent and indicator variables when measuring each latent variable. The structural model shows the effect of exogenous on endogenous latent variables. The relationship is explained by the loading factor value to calculate the closeness of the relationship between latent variables in the SEM model with the estimated standardized solution. Table 4 summarizes the loading factor value based on the standardized solution estimation results and the value based on the t-value estimation results.

TABLE IV
OVERALL MODEL FIT TEST RESULTS

Relationship between latent variable		Standardized Loading Factor Coefficient	T-value
(EKO)	(SUBNORM)	0.55	27.61
(LING)	(SUBNORM)	0.54	27.37
(EKO)	(SKP)	0.32	8.35
(LING)	(SKP)	0.42	10.02
(SUBNORM)	(SKP)	0.27	5.09
(EKO)	(CTRL)	0.25	4.39
(LING)	(CTRL)	0.26	4.58
(SKP)	(CTRL)	0.50	7.54
(EKO)	(INTNT)	0.28	5.88
(LING)	(INTNT)	0.02	0.58
(CTRL)	(INTNT)	0.55	7.37
(INTNT)	(ADOPT)	0.68	8.01

The estimation results of the SEM model show the intention to adopt the ISPO variable affects the ISPO adoption variable. Meanwhile, the intention of smallholders to adopt ISPO is positively influenced by control behavior and economic benefits. Environmental benefits do not influence farmers' intention to adopt the ISPO. The variable of attitude towards sustainable management, economic benefits, and environmental benefits positively influences perceived control behavior. Subjective norm variables and environmental and economic benefits are proven to significantly affect the variable attitude toward sustainable management. The economic and environmental benefits

variables also positively influence the subjective norm variable.

The results of the relationship between latent variables show that the economic benefits variable have a positive influence on all latent variables. In addition, the economic benefits variable has a higher loading factor value than the environmental benefits, except for attitudes toward sustainable management. Economic benefit is one of the most substantial factors driving farmers' intention to adopt Indonesian sustainable palm oil certification.

The most significant contributor to the latent variable of economic benefits is the manifest variable of productivity. The level of productivity in this study is seen from the highest perception of respondents on the statement that a farmer who applies to environmentally friendly farming can support productivity and provide economic benefits. The manifest variables of environmental benefits all significantly affect the latent variables of environmental benefits. The most significant contributor to the latent variable of environmental benefits is the manifest variable of biodiversity preservation.

The biggest contributor that significantly affects the subjective norm latent variable is the manifest variable of group effort. Group effort in this study is seen from the highest perception of respondents on the statement of the characteristics of a farmer who manages oil palm plantations that can run effectively and efficiently (saving) if done together with a farmer group organization. This condition is illustrated by the difference in profit management between respondent farmers in districts that apply ISPO and those that do not apply ISPO.

The manifest variable of attitude towards sustainable management significantly influences the latent variable of attitude towards sustainable management. This variable captures farmers' attitudes toward applying economic, social, and environmental principles. The largest contributor that significantly affects the latent variable of sustainable management attitude is the manifest variable of environmentally friendly behavior. The desire to apply in this study is seen from the highest perception of respondents to the statement that respondents will use environmentally friendly behavior in the management of oil palm plantations.

The most significant contributor that significantly affects the latent variable of perceived control behavior is the manifest variable of the availability of supporting parties. The availability of supporting parties in this study is seen from the respondents' highest perception that implementing sustainable oil palm plantation management is relatively easy because many parties support it. This aligns with the field conditions, where many parties support farmers in implementing sustainable palm oil management. These parties include the government, private sector, and universities.

The manifest variable of interest is the largest contributor and significantly affects the latent variable of intention to adopt ISPO. Interest in this study is based on respondents' highest perception of the statement that farmers are interested in implementing ISPO even though they still need to understand it fully.

B. Discussion

Presidential Regulation No. 2020 on Indonesia's Sustainable Palm Oil Plantation Certification System marks the beginning of the history of sustainable palm oil plantations. A prominent change in this regulation is the mandatory implementation of ISPO for all plantation business actors, including smallholders. This expansion is believed to increase traceability along the global palm oil value chain. However, this effort still needs to be improved, primarily due to the low ISPO certification obtained by smallholders. [38], [39] added that the average performance of smallholders' ISPO implementation could be much higher. Until 2017, there were only ten cooperatives that had been ISPO certified. This low level of adoption is mainly influenced by the need for more knowledge of the economic and environmental benefits of smallholder farmers, as shown in the SEM model.

Based on economic benefits, farmers in ISPO-certified locations are more knowledgeable about the economic benefits of ISPO certification than farmers in non-ISPO locations. Non-ISPO farmers believe that obtaining ISPO certification is economically costly. However, both groups of farmers (ISPO and non-ISPO) know the economic benefits of ISPO certification. The economic benefits of ISPO smallholders include forming and organizing smallholder groups, increased oil palm productivity, increased product marketability and income, increased cooperation between smallholder groups, and business legality that protects against conflict.

ISPO certification requires smallholder management and institutional organization that provides a learning platform for smallholders with various partners. Farmers' obligation to join a smallholder group opens access to various insights and opportunities, especially related to marketing and the provision of production facilities. Therefore, it is important for farmer groups to regularly conduct training to improve their members' knowledge, thus creating a good group ecosystem, which in turn will increase the competitiveness and efficiency of farmers' businesses.

The second economic benefit is increasing oil palm productivity. The results of [40]'s research show that the average productivity of ISPO-certified oil palm planters is 18.32 tons of FFB per ha, compared to the national average productivity of conventional oil palm planters of 12.82 tons per hectare in 2023. This figure shows that ISPO certification increases oil palm productivity, which in turn will have implications for increasing farmers' income. This increase in productivity is due to the implementation of Good Agricultural Practices (GAP) by ISPO-certified farmers, increasing farmers' income. Therefore, ISPO certification and the application of GAP need to be immediately adopted by oil palm farmers, with government support through financial assistance and technical assistance to smallholder groups.

ISPO-certified palm oil products have higher marketability, with higher prices of IDR 100 - IDR 200 per kg of FFB compared to uncertified products. Although the price difference is still relatively small, the government needs to encourage the acceleration of ISPO through a certified palm oil price adjustment policy. In addition, ISPO certification requires smallholders to have a legal business entity, which provides more benefits when selling products and opens access to exports abroad. Another problem is the frequent occurrence of land disputes over oil palm plantations. Through ISPO certification, the social and economic impacts arising from oil palm plantations on local communities are

more controlled because farmers' oil palm plantations must be legal and certified. This legality also helps reduce land disputes and social conflicts among small-scale farmers. The government is expected to mediate in land disputes and provide assistance for the legality of business plantations so that farmers can obtain ISPO certification.

The low adoption rate of farmers is mainly because their only source of income is from oil palm plantations. Diversification of income sources by smallholders can be an effort to survive and provide fiscal flexibility for families to intervene to improve their welfare [41], [42]. [43] Added that with a diversified income source structure, the dominance of the head of palm oil determines the encouragement of farmers to engage in certification. This condition is reflected in the higher proportion of farmers with other sources of income in ISPO farmers compared to non-ISPO farmers. In addition, the average land ownership of ISPO farmers is higher (4.76 Ha) than non-ISPO farmers (2.5 Ha). This difference is the main economic motive in encouraging farmers to have the intention to adopt ISPO.

The fiscal constraints have made farmers think twice about adopting ISPO certification. Moreover, the complexity of the process and the number of principles and criteria that must be met have discouraged farmers. For example, in the legality principle, land legality requirements must be fulfilled in the form of land certificates. It is not straightforward for farmers to obtain land ownership certificates, especially for farmers who have already expanded into the Forestry Cultivation Area (KBK) or Protected Forest [44], [45], [46], [47], [48]. On the principle of seed legality, farmers mainly buy oil palm seedlings that are not certified or use the results of seedlings independently by farmers. On the principle of cultivation, farmers generally do not apply cultivation based on Good Agriculture Practice (GAP). As for the institutional principle, all farmers already have an institution that can coordinate their farming activities.

These factors make farmers unwilling to adopt ISPO. There is potential for increased productivity and income due to ISPO certification [49]. This potential increase can be realized through improving the cultivation system according to GAP standards. Smallholder farmers still need to implement GAP to manage their plantation businesses. This condition is reflected in the low level of productivity of smallholders compared to large private companies and large state companies. In addition, implementing ISPO is proven to increase financial efficiency over the costs incurred [16]. [50] stated that smallholders generally had yet to be informed about farm management according to GAP standards, where they ignore the condition of oil palm plantations that have begun to be unproductive, and their production has decreased. Through ISPO certification, smallholder farmers are encouraged to conduct a good cultivation system to increase production. In addition, ISPO certification can also improve market acceptance, as currently, most processing companies are more interested in receiving FFB from ISPO-certified farmers [51], [52]. This condition is confirmed in the field: ISPO farmers have easier access to the market than non-ISPO farmers. ISPO smallholders have bargaining power over pricing, and, companies will invite organization farmers with ISPO certificates to enter into purchase contracts. This contract agreement ensures that ISPO farmers receive relatively more stable prices than non-ISPO farmers.

Based on environmental benefits, the SEM model shows that environmental benefits do not affect farmers' intention to adopt ISPO. In other words, environmental factors are not a reason for farmers to adopt ISPO. Farmers at the research location do not completely understand the environmental impacts of adopting ISPO. , Smallholders do not currently view environmental impact as the primary reason for adopting ISPO.. Most non-ISPO farmers do not have the environmental permit requirements in the form of Environmental Management and Monitoring Letters. Most organization members need access to the environmental documents stipulated by the regional government.

Purnomo et al [53] depict farmers' ignorance of the many forest fires that still occur due to mismanagement in oil palm plantations. Another study revealed that smallholders need to be educated on the principles of natural resource conservation, especially respect for biodiversity [54], to ensure sustainability. In addition, expanding protected forest areas is evidence that farmers still need to be fully aware of agrarian law. The penetration of oil palm plantations into forest areas is a significant challenge for the issue of sustainability of oil palm production, mainly related to deforestation activities [55], [56], [57] and land conversion and changes in the ecological landscape of the area [58];[59] which are alarming. The study conducted by [53] revealed that local communities expand their land using the unsustainable method of fires to clear the peat land. They also claim that fire is their ancient way of land clearing.

Findings from the study indicate that one of the factors that need to be encouraged to increase ISPO adoption at the smallholder level is economic benefits. The variable related to economic benefits has been shown to directly and indirectly influence farmers' intentions to adopt ISPO.[2] stated that farmers knowledge of the benefits they will get is in the moderate category, while farmers' perception of ISPO simplicity is low. Once Farmers recognize the economic benefits of adopting ISPO, it also ensures that environmental requirements for ISPO certification are indirectly met. The perception of farmers regarding their economic potential will encourage long-term adoption.

The potential economic benefits are confirmed by most companies implementing ISPO or RSPO in Jambi Province. Companies today often collaborate with farmer groups that have received sustainability certification. Companies also offer higher prices compared to farmers who do not have sustainability certification. The higher price will also incentivize farmers to engage in sustainable farming practices. Regarding human resources, increasing farmer adoption of economic benefits can be achieved by mainstreaming ISPO-related information to farmers in various regions nationwide. This effort can be done through agricultural extension activities that link technology sources and principal actors, as well as various information channels owned by the government and the private sector. In addition, the high cost of ISPO certification can also be overcome by facilitating stakeholders, including government, academics, companies, and NGOs, to implement ISPO sustainability principles. The facilitation can be done through capacity building and institutional programs, assistance with

production facilities, access to capital, guarantee of fair prices, and assistance with the certification process.

The government and NGOs have carried out various facilitations to assist farmer organizations in obtaining ISPO certification, and this role must be increased to provide regulatory certainty for the implementation of ISPO, which is currently mandatory for farmers. Meanwhile, the support expected from companies is prioritized on providing market guarantees for ISPO-certified production. Finally, the outcome of a supportive ecosystem will increase ISPO adoption among smallholders.

The implications of the sustainable palm oil industry in Indonesia are as follows:

a. The study suggests that governmental intervention is crucial in creating a supportive ecosystem for smallholders to participate in ISPO certification. Policymakers should consider implementing policies that incentivize and facilitate the adoption process. This could involve offering financial incentives, providing technical assistance, or streamlining bureaucratic procedures related to certification.
b. To increase smallholders' willingness to adopt sustainable practices, it is essential to establish robust extension services that effectively communicate the economic benefits of ISPO certification. By utilizing workshops and disseminating information through both governmental and private channels, these initiatives can play a pivotal role in influencing smallholders' intentions towards embracing ISPO certification and ultimately contribute to the sustainability of the palm oil industry.
c. The findings suggest that efforts to enhance smallholders' control behavior—likely related to their confidence and capacity to adhere to certification requirements—could further facilitate adoption. Capacity-building programs focused on providing technical assistance, training, and resources to smallholders can play a crucial role.
d. While the study found that the impact of environmental benefits on adoption intention was insignificant, it doesn't imply neglecting environmental sustainability. Instead, it suggests the need for better integrating environmental concerns into communication strategies and policy frameworks. Efforts should be made to raise awareness about the environmental benefits of ISPO certification and to incentivize environmentally friendly practices within industry.
e. The research highlights the ongoing need for improvement in implementing ISPO, particularly in engaging smallholders. Industry stakeholders should view this as an opportunity for continuous improvement and innovation. This could involve refining certification standards, enhancing support services for smallholders, and adopting technology-driven solutions to streamline the certification process.
f. The study suggests stakeholders, including governmental bodies, private sector actors, and NGOs, must collaborate closely to promote ISPO adoption. This collaboration could involve joint initiatives to educate, incentivize, and support smallholders in obtaining and maintaining certification.
g. As ISPO adoption continues to evolve, ongoing monitoring and evaluation of its impacts on smallholders, communities, and the environment will be essential. This data can inform adaptive management strategies, ensuring that the certification scheme remains effective in achieving its sustainability goals while addressing the needs and concerns of all stakeholders involved.

IV. Conclusion

This paper revealed that farmers with intentions can be encouraged to adopt Indonesian sustainable palm oil certification. The intention of farmers to adopt ISPO can then be directly affected by two variables, namely control behavior and economic benefits. Meanwhile, the environmental benefit variable does not influence farmers' desire to adopt. Economic benefits are a latent variable that influences all latent variables that form intentions to adopt, such as subjective norms, attitudes toward sustainable management, and perceived control behavior. It illustrates that economic encouragement is one of the most vital factors in encouraging farmers to adopt Indonesian sustainable palm oil certification. The study recommends that all actors (government, NGO, private, and higher education) ensure the dissemination of economic benefits from implementing ISPO certification can reach independent farmers in various regions. The government should also implement a policy to create a supporting ecosystem that will enhance the reduction of farmers' misperceptions about ISPO by providing facilitation support for ISPO training and capital access, assisting along the certification process.

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References

[1] M. Arsyad, A. Amiruddin, Suharno, and S. Jahroh, "Competitiveness of palm oil products in international trade: An analysis between Indonesia and Malaysia," *Caraka Tani: J. Sustain. Agric.*, vol. 35, no. 2, pp. 157–167, Oct. 2020, doi: 10.20961/carakatani.v35i2.41091.

[2] H. Hasnah, R. Hariance, and M. Hendri, "Analysis of the implementation of Indonesian Sustainable Palm Oil-ISPO certification at farmer level in West Pasaman Regency," in *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 741, p. 012072, May 2021, doi: 10.1088/1755-1315/741/1/012072.

[3] J. F. D. Tapia, S. S. Doliente, and S. Samsatli, "How much land is available for sustainable palm oil?," *Land Use Policy*, vol. 102, p. 105187, Mar. 2021, doi: 10.1016/j.landusepol.2020.105187.

[4] J. F. D. Tapia, S. S. Doliente, and S. Samsatli, "How much land is available for sustainable palm oil?," *Land Use Policy*, vol. 102, p. 105187, Mar. 2021, doi: 10.1016/j.landusepol.2020.105187.

[5] Kementerian Pertanian, *Statistical of National Leading Estate Crops Commodity 2020-2022*. Jakarta, Dec. 2021.

[6] K. G. Austin, A. Mosnier, J. Pirker, I. McCallum, S. Fritz, and P. S. Kasibhatla, "Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitments," *Land Use Policy*, vol. 69, pp. 41–48, Dec. 2017, doi:10.1016/j.landusepol.2017.08.036.

[7] L. M. Ayompe, M. Schaafsma, and B. N. Egoh, "Towards sustainable palm oil production: The positive and negative impacts on ecosystem

services and human wellbeing," *J. Clean. Prod.*, vol. 278, p. 123914, Jan. 2021, doi: 10.1016/j.jclepro.2020.123914.
[8] M. Eilenberg, "The last enclosure: Smoke, fire, and crisis on the Indonesian forest frontier," *J. Peasant Stud.*, vol. 49, no. 5, pp. 969–998, Jul. 2022, doi: 10.1080/03066150.2021.1907355.
[9] R. Astuti, "Governing the ungovernable: The politics of disciplining pulpwood and palm oil plantations in Indonesia's tropical peatland," *Geoforum*, vol. 124, pp. 381–391, Aug. 2021, doi:10.1016/j.geoforum.2021.03.004.
[10] I. Lestari, D. Murdiyarso, and M. Taufik, "Rewetting tropical peatlands reduced net greenhouse gas emissions in Riau Province, Indonesia," *Forests*, vol. 13, no. 4, p. 505, Mar. 2022, doi:10.3390/f13040505.
[11] K. Ribeiro et al., "Tropical peatlands and their contribution to the global carbon cycle and climate change," *Glob. Change Biol.*, vol. 27, no. 3, pp. 489–505, Feb. 2021, doi: 10.1111/gcb.15408.
[12] S. Mayr, B. Hollaus, and V. Madner, "Palm oil, the RED II, and WTO law: EU sustainable biofuel policy tangled up in green?," *Rev. Eur. Comp. Int. Environ. Law*, vol. 30, no. 2, pp. 233–248, Jul. 2021, doi:10.1111/reel.12386.
[13] P. Dusser, "The European energy policy for 2020–2030 RED II: What future for vegetable oil as a source of bioenergy?," *OCL*, vol. 26, p. 51, 2019, doi: 10.1051/ocl/2019040.
[14] A. H. Dharmawan et al., "The agrarian, structural, and cultural constraints of smallholders' readiness for sustainability standards implementation: The case of Indonesian Sustainable Palm Oil in East Kalimantan," *Sustainability*, vol. 13, no. 5, pp. 1–20, Mar. 2021, doi:10.3390/su13052611.
[15] F. Hariyanti, A. Syahza, Zulkarnain, and Nofrizal, "Sustainability of the palm oil industry: An empirical study of the development of sustainable oil palm in Bengkalis Regency, Indonesia," *Int. J. Sustain. Dev. Plan.*, vol. 17, no. 1, pp. 109–118, Feb. 2022, doi:10.18280/ijsdp.170110.
[16] Rodhiah, I. Ifdal, I. W. Syarfi, and H. Hasnah, "The impact of ISPO certification on economic, social, and environmental aspects in the palm oil plantation," in *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 336, p. 012013, Oct. 2019, doi: 10.1088/1755-1315/336/1/012013.
[17] S. A. B. Choiruzzad, A. Tyson, and H. Varkkey, "The ambiguities of Indonesian Sustainable Palm Oil certification: Internal incoherence, governance rescaling, and state transformation," *Asia Eur. J.*, vol. 19, no. 2, pp. 189–208, Jun. 2021, doi: 10.1007/s10308-020-00593-0.
[18] L. R. Wibowo et al., "Accelerating certification of oil palm smallholders through institutionalization of various incentives," *For. Soc.*, vol. 7, no. 2, pp. 263–294, Nov. 2023, doi:10.24259/fs.v7i2.24679.
[19] N. Yuslaini, U. Suwaryo, N. A. Deliarnoor, and D. Sri Kartini, "Palm oil industry and investment development in Dumai City, Indonesia: A focus on local economy development and sustainability," *Cogent Soc. Sci.*, vol. 9, no. 1, 2023, doi: 10.1080/23311886.2023.2235780.
[20] G. Mulyasari, I. N. Djarot, N. A. Sasongko, and A. S. Putra, "Social-life cycle assessment of oil palm plantation smallholders in Bengkulu province, Indonesia," *Heliyon*, vol. 9, no. 8, Aug. 2023, doi:10.1016/j.heliyon.2023.e19123.
[21] E. P. Pramudya et al., "Incentives for palm oil smallholders in mandatory certification in Indonesia," *Land*, vol. 11, no. 4, Apr. 2022, doi: 10.3390/land11040576.
[22] P. Pacheco, G. Schoneveld, A. Dermawan, H. Komarudin, and M. Djama, "Governing sustainable palm oil supply: Disconnects, complementarities, and antagonisms between state regulations and private standards," *Regul. Gov.*, vol. 14, no. 3, pp. 1–20, Jul. 2020, doi:10.1111/rego.12220.
[23] N. Saadun et al., "Socio-ecological perspectives of engaging smallholders in environmental-friendly palm oil certification schemes," *Land Use Policy*, vol. 72, pp. 333–340, Mar. 2018, doi: 10.1016/j.landusepol.2017.12.057.
[24] M. Apriyanto, Partini, H. Mardesci, G. Syahrantau, and Yulianti, "The role of farmers readiness in the sustainable palm oil industry," in *J. Phys.: Conf. Ser.*, vol. 1764, p. 012211, Feb. 2021, doi: 10.1088/1742-6596/1764/1/012211.
[25] E. Oliphant and A. C. Simon, "The cost of sustainable palm oil: Should an Indonesian smallholder pursue RSPO certification?," *World Dev. Perspect.*, vol. 26, Jun. 2022, doi: 10.1016/j.wdp.2022.100432.
[26] R. E. De Vos, A. Suwarno, M. Slingerland, P. J. Van Der Meer, and J. M. Lucey, "Independent oil palm smallholder management practices and yields: Can RSPO certification make a difference?," *Environ. Res. Lett.*, vol. 16, no. 6, Jun. 2021, doi: 10.1088/1748-9326/ac018d.
[27] Y. S. Tey, M. Brindal, A. H. I. A. Hadi, and S. Darham, "Financial costs and benefits of the Roundtable on Sustainable Palm Oil certification among independent smallholders: A probabilistic view of the Monte Carlo approach," *Sustain. Prod. Consum.*, vol. 30, pp. 377–386, Mar. 2022, doi: 10.1016/j.spc.2021.12.020.
[28] N. A. Majid, Z. Ramli, S. M. Sum, and A. H. Awang, "Sustainable palm oil certification scheme frameworks and impacts: A systematic literature review," *Sustainability*, vol. 13, no. 6, p. 3263, Mar. 2021, doi: 10.3390/su13063263.
[29] S. A. B. Choiruzzad, A. Tyson, and H. Varkkey, "The ambiguities of Indonesian Sustainable Palm Oil certification: Internal incoherence, governance rescaling, and state transformation," *Asia Eur. J.*, vol. 19, no. 2, pp. 189–208, Jun. 2021, doi: 10.1007/s10308-020-00593-0.
[30] K. K. Naji, M. Gunduz, and A. F. Naser, "The effect of change-order management factors on construction project success: A structural equation modeling approach," *J. Constr. Eng. Manag.*, vol. 148, no. 9, Sep. 2022, doi: 10.1061/(asce)co.1943-7862.0002350.
[31] J. E. Villalva A. , "Sustainability assessment in the steel industry using partial least squares - Structural equation model," *World Dev. Sustain.*, vol. 2, p. 100054, Jun. 2023, doi: 10.1016/j.wds.2023.100054.
[32] M. S. Malek and V. Bhatt, "Examine the comparison of CSFs for public and private sector's stakeholders: A SEM approach towards PPP in Indian road sector," *Int. J. Constr. Manag.*, vol. 23, no. 13, pp. 2239–2248, Oct. 2023, doi: 10.1080/15623599.2022.2049490.
[33] M. W. Browne and R. Cudeck, "Alternative ways of assessing model fit," *Sociol. Methods Res.*, vol. 21, no. 2, pp. 230–258, Nov. 1992, doi:10.1177/0049124192021002005.
[34] K. G. Jöreskog and D. Sörbom, *LISREL 8*. Chicago: Scientific Software, 2001.
[35] D. Chrisendo, H. Siregar, and M. Qaim, "Oil palm and structural transformation of agriculture in Indonesia," *Agric. Econ.*, vol. 52, no. 5, pp. 849–862, Sep. 2021, doi: 10.1111/agec.12658.
[36] N. Mehraban, B. L. Debela, U. Kalsum, and M. Qaim, "What about her? Oil palm cultivation and intra-household gender roles," *Food Policy*, vol. 110, p. 102276, Jul. 2022, doi:10.1016/j.foodpol.2022.102276.
[37] J. F. Hair, W. C. Black, B. J. Babin, R. E. Anderson, and R. L. Tatham, *Multivariate Data Analysis*, 6th ed. Prentice Hall, 2006.
[38] A. H. Dharmawan et al., "The agrarian, structural, and cultural constraints of smallholders' readiness for sustainability standards implementation: The case of Indonesian Sustainable Palm Oil in East Kalimantan," *Sustainability*, vol. 13, no. 5, p. 2611, Mar. 2021, doi:10.3390/su13052611.
[39] N. Dewi, S. Hadi, N. A. Rosnita, and Y. Kusumawaty, "Improving performance of independent smallholders towards the principles of Indonesian Sustainable Palm Oil certification in Riau Province: Prospective scenario approach," *Int. J. Environ. Waste Manag.*, vol. 31, no. 4, pp. 534–553, 2023, doi: 10.1504/ijewm.2023.131152.
[40] A. B. Rahutomo, M. Karuniasa, and E. Frimawaty, "Peningkatan produktivitas lahan pekebun melalui sertifikasi kelapa sawit berkelanjutan di Indonesia," *Anal. Kebijakan Pertan.*, vol. 21, no. 1, pp. 43–55, 2023, doi: 10.21082/akp.v21n1.2023.43-55.
[41] M. Adem and F. Tesafa, "Intensity of income diversification among small-holder farmers in Asayita Woreda, Afar Region, Ethiopia," *Cogent Econ. Finance*, vol. 8, no. 1, 2020, doi:10.1080/23322039.2020.1759394.
[42] G. Danso-Abbeam, G. Dagunga, and D. S. Ehiakpor, "Rural non-farm income diversification: Implications on smallholder farmers' welfare and agricultural technology adoption in Ghana," *Heliyon*, vol. 6, no. 11, Nov. 2020, doi: 10.1016/j.heliyon.2020.e05393.
[43] E. I. K. Putri et al., "The oil palm governance: Challenges of sustainability policy in Indonesia," *Sustainability*, vol. 14, no. 3, Feb. 2022, doi: 10.3390/su14031820.
[44] J. D. Watts et al., "Challenges faced by smallholders in achieving sustainable palm oil certification in Indonesia," *World Dev.*, vol. 146, p. 105565, Oct. 2021, doi: 10.1016/j.worlddev.2021.105565.
[45] F. Isharyadi, U. Ayuningtyas, B. D. Tampubolon, D. R. Wahono, and N. Aliyah, "The challenges of sustainable palm oil product development in Indonesia against consumer demand," *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 828, no. 1, 2021, doi: 10.1088/1755-1315/828/1/012055.
[46] E. Meijaard et al., "The environmental impacts of palm oil in context," *Nat. Plants*, vol. 6, no. 12, pp. 1418–1426, Dec. 2020, doi:10.1038/s41477-020-00813-w.
[47] M. Sofiyuddin, S. Suyanto, S. Kadir, and S. Dewi, "Sustainable land preparation for farmer-managed lowland agriculture in

Indonesia," *For. Policy Econ.*, vol. 130, p. 102534, Sep. 2021, doi:10.1016/j.forpol.2021.102534.

[48] R. E. de Vos, A. Suwarno, M. Slingerland, P. J. van der Meer, and J. M. Lucey, "Pre-certification conditions of independent oil palm smallholders in Indonesia: Assessing prospects for RSPO certification," *Land Use Policy*, vol. 130, p. 106660, Jul. 2023, doi:10.1016/j.landusepol.2023.106660.

[49] M. A. Agustira, R. F. Ranola, A. J. U. Sajise, and L. M. Florece, "Economic impacts of smallholder oil palm (*Elaeis guineensis* Jacq.) plantations on peatlands in Indonesia," *J. Econ. Manag. Agric. Dev.*, vol. 1, no. 2, pp. 105–123, 2015.

[50] E. P. Pramudya et al., "Incentives for palm oil smallholders in mandatory certification in Indonesia," *Land*, vol. 11, no. 4, Apr. 2022, doi: 10.3390/land11040576.

[51] A. Syahza and M. Irianti, "Formulation of control strategy on the environmental impact potential as a result of the development of palm oil plantation," *J. Sci. Technol. Policy Manag.*, vol. 12, no. 1, pp. 106–116, Apr. 2021, doi: 10.1108/JSTPM-06-2019-0059.

[52] Y. B. Kadarusman and A. G. Herabadi, "Improving sustainable development within Indonesian palm oil: The importance of the reward system," *Sustain. Dev.*, vol. 26, no. 4, pp. 422–434, Jul. 2018, doi: 10.1002/sd.1715.

[53] E. P. Purnomo, R. Ramdani, Agustiyara, Q. P. V. Tomaro, and G. S. Samidjo, "Land ownership transformation before and after forest fires in Indonesian palm oil plantation areas," *J. Land Use Sci.*, vol. 14, no. 1, pp. 37–51, Jan. 2019, doi: 10.1080/1747423X.2019.1614686.

[54] N. Saadun et al., "Socio-ecological perspectives of engaging smallholders in environmental-friendly palm oil certification schemes," *Land Use Policy*, vol. 72, pp. 333–340, Mar. 2018, doi:10.1016/j.landusepol.2017.12.057.

[55] G. Schouten and P. Glasbergen, "Creating legitimacy in global private governance: The case of the Roundtable on Sustainable Palm Oil," *Ecol. Econ.*, vol. 70, no. 11, pp. 1891–1899, Sep. 2011, doi:10.1016/j.ecolecon.2011.03.012.

[56] B. Wicke, R. Sikkema, V. Dornburg, and A. Faaij, "Exploring land use changes and the role of palm oil production in Indonesia and Malaysia," *Land Use Policy*, vol. 28, no. 1, pp. 193–206, Jan. 2011, doi: 10.1016/j.landusepol.2010.06.001.

[57] S. B. Hansen, R. Padfield, K. Syayuti, S. Evers, Z. Zakariah, and S. Mastura, "Trends in global palm oil sustainability research," *J. Clean. Prod.*, vol. 100, pp. 140–149, Aug. 2015, doi:10.1016/j.jclepro.2015.03.051.

[58] M. Gatto, M. Wollni, and M. Qaim, "Oil palm boom and land-use dynamics in Indonesia: The role of policies and socioeconomic factors," *Land Use Policy*, vol. 46, pp. 292–303, Jun. 2015, doi:10.1016/j.landusepol.2015.03.001.

[59] M. Euler, V. Krishna, S. Schwarze, H. Siregar, and M. Qaim, "Oil palm adoption, household welfare, and nutrition among smallholder farmers in Indonesia," *World Dev.*, vol. 93, pp. 219–235, May 2017, doi: 10.1016/j.worlddev.2016.12.019.