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The interplay between technology, institutions, and culture: Pathways to sustainable palm oil practices in Indonesia

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Abstract

Background. Indonesia's palm oil industry plays an important role in the economy but faces sustainability challenges, with smallholders struggling to meet ISPO certification requirements.

Purpose. This study aims to analyze the factors influencing farmers' readiness to implement Indonesian Sustainable Palm Oil (ISPO).

Materials and methods. The factors influencing the level of farmers' readiness to implement ISPO are analyzed using the Structural Equation Modeling-Partial Least Square (SEM-PLS) method by testing the effect of exogenous latent variables (X) on endogenous latent variables (Y).

Results. The results show that farmers' readiness to implement ISPO is directly and significantly influenced by the perception of technology, institutional support, community culture, and access to information technology. The most significant influence is exerted by community culture, followed by access to information, then institutional support, and the smallest influence is exerted by the perception of technology.

Keywords: Palm oil; ISPO; sustainability; SEM PLS; Smallholder

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Introduction

Indonesia is one of the largest palm oil-producing countries in the world. Palm oil is a strategic commodity that contributes significantly to the national

economy, both through exports and the provision of employment [1]. However, despite its economic potential, the palm oil industry often receives negative attention related to environmental and social issues, such as deforestation, environmental damage, and labor rights violations [2].

In an effort to address these sustainability challenges, the Indonesian government has developed the Indonesian Sustainable Palm Oil (ISPO) certification system with a sustainability scheme that is mandatory for all palm oil plantation business actors, including smallholders [3]. ISPO aims to increase the competitiveness of Indonesian palm oil in the international market while encouraging palm oil plantation management practices that are more environmentally friendly, socially responsible, and in accordance with applicable regulations.

However, the implementation of ISPO at the smallholder level still faces various obstacles. Based on several studies, smallholders often have a low level of readiness to meet ISPO standards. This is due to various factors, such as farmers' limited knowledge and understanding of ISPO, access to funding, institutional support, land legality issues, and socio-cultural factors that influence the adoption of sustainable practices [4; 5].

The research also shows that smallholders' readiness to implement ISPO varies greatly depending on the region. As in Muara Kaman Ulu Village and Jonggon Village in Kutai Kartanegara District, East Kalimantan, smallholders face different levels of readiness and challenges. Farmers in Muara Kaman Ulu village who are involved in the inti-plasma scheme have a higher readiness index score compared to independent farmers in Jonggon village. Factors such as land legality and social structure also differ between the two villages, affecting their readiness to meet ISPO standards [6]. Therefore, it is important to identify factors that contribute to the level of readiness of farmers in ISPO implementation so that targeted interventions can be designed.

The Structural Equation Modeling-Partial Least Square (SEM-PLS) method is a relevant approach to analyzing the complex relationships among various factors that influence farmer readiness. SEM-PLS enables comprehensive analysis of latent variables that are difficult to measure directly, such as farmer attitudes, risk perceptions, and institutional support [7]. With this approach, the research is expected to provide a more in-depth picture of the farmer readiness model in ISPO implementation and the most influential factors.

This study aims to develop a strategy for smallholder readiness in ISPO implementation by identifying and analyzing the factors that influence it. Thus, the results of this study are expected to be the basis for policy makers, supporting

institutions, and stakeholders related to the preparation of strategies to improve the readiness and participation of oil palm smallholders in the ISPO scheme.

Materials and methods

The Structural Equation Modelling - Partial Least Squares (SEM-PLS) approach is one of the best methods for predicting results, especially in terms of forecasting and evaluating explanatory variables by considering the most potential variance. This method is widely used to analyze the relationship between variables in data analysis [8]. One of the advantages of SEM-PLS is its ability to produce better findings than other methods despite using a smaller sample size. SEM-PLS is also often applied to analyze complex path models [9]. The main attraction of this approach in management science is its various prospective benefits, including flexibility and efficiency [10]. The SEM-PLS approach allows for handling non-linear interactions in the model by using a two-stage analysis. In addition, PLS-based path modeling techniques have proven to be accurate and reliable in providing a precise assessment of structure. Before developing an internal model or evaluating the relationship between latent components, the convergent validity of the structural model must be evaluated to ensure a valid and consistent interpretation. With these characteristics, SEM-PLS is one of the effective approaches to analyzing complex data.

In this study, the SEM-PLS method was used to analyze the factors that influence the level of readiness of farmers in implementing ISPO by testing the effect of exogenous latent variables (X) on endogenous latent variables (Y). This analysis involves several exogenous latent variables, namely farmer characteristics (X1), perception of technology (X2), institutional support (X3), community culture (X4), and access to technological information (X5), with the endogenous latent variable being farmer readiness (Y1).

Path analysis was conducted using PLS to test the variables that influence the level of readiness of farmers in ISPO implementation. The first stage of the first-order analysis was carried out with Confirmatory Factor Analysis (CFA). The results of the measurement model of the PLS logarithm analysis can be seen in Figure 1, then excluded indicators that have a low loading factor value. The sub-variables are removed one by one based on the smallest loading factor value until the measurement model (outer model) is finally found. Indicators with low loading factors indicate poor convergent reliability, which in turn affects construct validity. Convergent reliability is measured using the loading factor value and composite reliability, so a low value indicates that the indicator is not strong enough to reflect the latent variable [11]. A feasible model has sub-variables with a loading factor value greater than 0.6 [7].

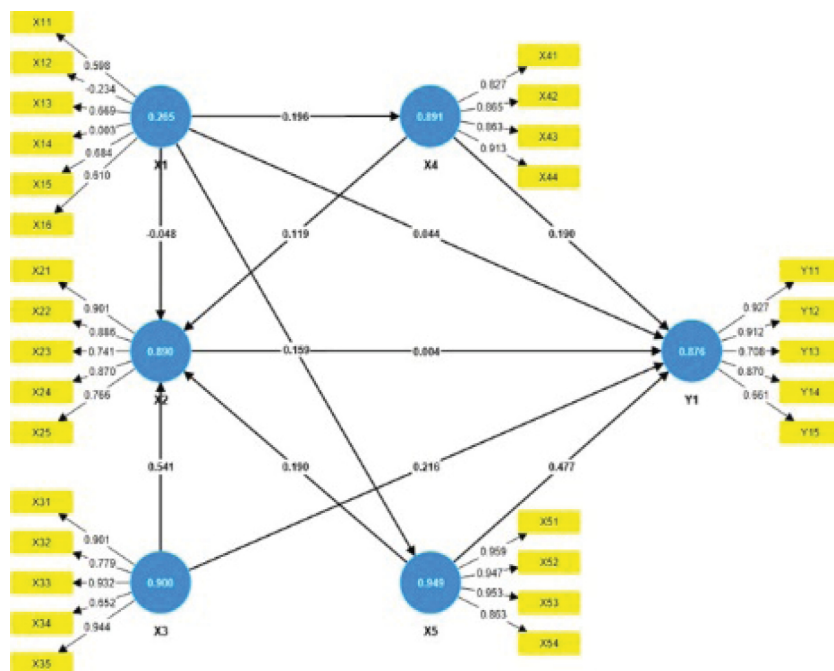


Fig. 1. Initial measurement model of farmer readiness for ISPO implementation

Therefore, at the initial stage of the measurement model analysis, indicators with loading factor values below 0.6, such as age, experience, and number of dependents, were excluded because they were not able to reflect the latent variables well [12].

Results and discussion

The Evaluation of Factors Affecting Farmers's Readiness to Implement the Indonesian Sustainable Palm Oil (Isipo) Certification

A Partial Least Square (PLS) analysis was conducted to test the variables affecting farmers' readiness for the implementation of ISPO. In the initial stage, the measurement model was generated from the PLS logarithm analysis (Figure 1); it was found that the results of the PLS algorithm iteration on the initial measurement model did not meet the Goodness of Fit (GoF) value standards, and therefore, the farmer characteristic variables with indicators that had the smallest loading factor value had to be removed from the model [13].

The characteristics eliminated included age (X1.1), experience (X1.2), and number of dependents (X1.4). The Goodness of Fit criteria presented in Table 1 indicate the minimum requirements that must be satisfied for the model to be declared fit for use. After the farmer characteristics variable (X1) was excluded, the test results indicated that the GoF level aligned with the standard. Consequently, it can be concluded that the model is suitable for use [14]. Following the elimination of the respondent characteristics variable (X1), it was also deemed necessary to eliminate the institutional support variable (X3), specifically the marketing institution indicator (X3.4), as well as the ISPO certificate readiness level variable (Y5), represented by the indicator for sustainable farming improvement (Y1.5). Both eliminated indicators exhibited red construct values despite being above 0.7. This elimination was undertaken to enhance the model's fit value and improve the constructed value of indicators within other variables [11].

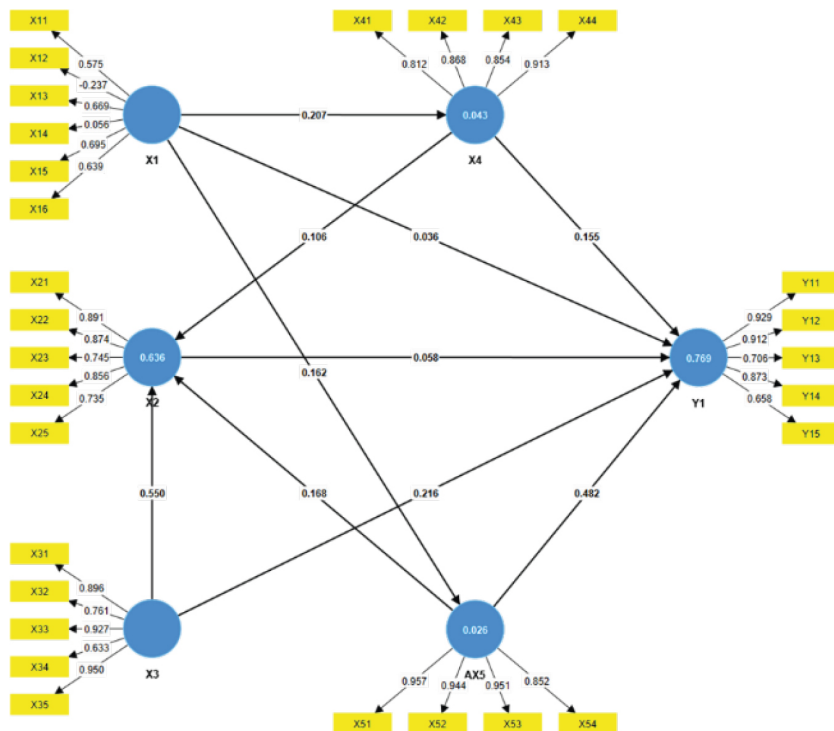


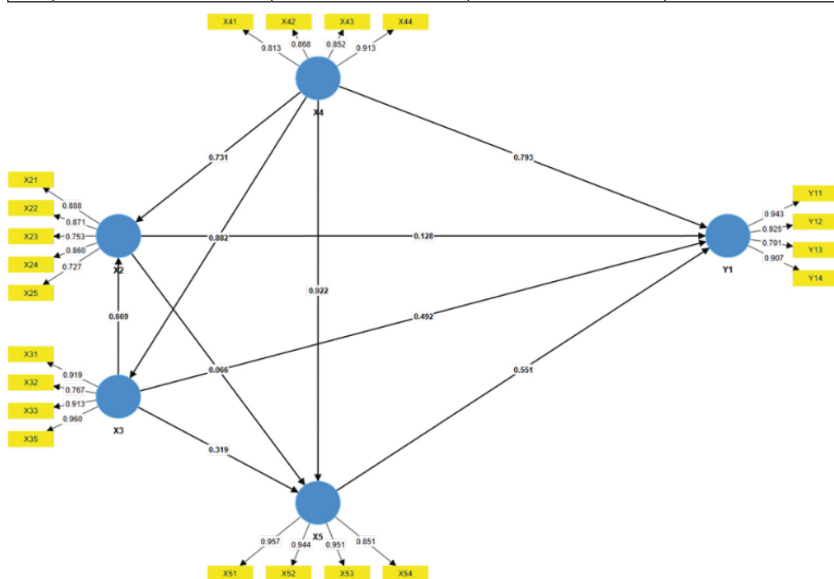
Fig. 2. Output of SEM-PLS analysis

Based on Figure 2, it is observed that the sub-variables included in farmer characteristics (X1) comprise age, education level, farming experience, land area, and total family income. From the data, the value of age (X1.1) is identified as 0.575; the level of education (X1.2) is -0.237; farming experience (X1.3) is 0.669; land area (X1.4) is 0.056; total family income (X1.5) is 0.695; and total income (X1.6) is 0.639. After the variables were eliminated, the test results indicated that the level of fit conformed to the standard. Therefore, it can be concluded that the model is appropriate for use. The criteria for model fit (Goodness of Fit) in Table 1 indicate the minimum requirements that must be satisfied for the constructed model to be considered suitable for use.

Table 1.

Goodness of Fit (GoF) test results on the model

No	GoF Measurements	Model Saturated	Model Estimation	Fit Level
1	SRMR	0,099	0,099	<i>Good Fit</i>
2	d_ ULS	2,688	2,688	<i>Good Fit</i>
3	d_ G	5,003	5,003	<i>Good Fit</i>
4	<i>Chi-square</i>	7266,217	7266,217	<i>Good Fit</i>
5	NFI	0,564	0,564	<i>Good Fit</i>

**Fig. 3. Measurement Model (outer model)**

Evaluation of Measurement Model (Outer Model)

The measurement model or Outer Model is evaluated to analyze the relationship between variables and their indicators. The evaluation conducted for the measurement model includes convergent validity (assessed based on the loading factor of each variable), discriminant validity, and composite reliability or Cronbach's Alpha output. Reliability and validity are used to assess the measurement model. Cronbach's Alpha is utilized to perform the reliability test.

Convergent Validity

The convergent validity of the measurement model using reflective indicators is evaluated based on the loading factor of the indicators that measure the construct. A minimum threshold of 0.5 is established for the loading factor. If the loading factor value exceeds 0.5, the construct validity is considered to be fulfilled. However, if the loading factor value is below 0.5, the construct is required to be excluded from the analysis [13]. The assessment of convergent validity using reflective indicators is conducted by analyzing the loading factor values of the indicators associated with the construct. Constructs with a loading factor above 0.5 are deemed to meet validity criteria, while constructs with a loading factor below 0.5 are removed from further analysis.

Table 2.

Loading Factor				
Variable	Indicator	Loading Factor	Re-estimation	Description
Perception of Technology (X2)	X2.1	0,891	0,888	Valid
	X2.2	0,874	0,871	Valid
	X2.3	0,745	0,753	Valid
	X2.4	0,856	0,860	Valid
	X2.5	0,735	0,727	Valid
Institutional Support (X3)	X3.1	0,896	0,919	Valid
	X3.2	0,761	0,767	Valid
	X3.3	0,927	0,913	Valid
	X3.5	0,950	0,960	Valid
Community Culture (X4)	X4.1	0,812	0,813	Valid
	X4.2	0,868	0,868	Valid
	X4.3	0,854	0,852	Valid
	X4.4	0,913	0,913	Valid

Variable	Indicator	Loading Factor	Re-estimation	Description
Information Technology Access (X5)	X5.1	0,957	0,957	Valid
	X5.2	0,944	0,944	Valid
	X5.3	0,951	0,951	Valid
	X5.4	0,852	0,851	Valid
ISPO Certification Readiness Level (Y1)	Y1.1	0,929	0,943	Valid
	Y1.2	0,912	0,925	Valid
	Y1.3	0,706	0,701	Valid
	Y1.4	0,873	0,907	Valid

Source: Processed primary data (2024)

Based on Table 2, no indicators were found to have a score of <0.5, as the indicators that did not meet the criteria had been eliminated. After the elimination of these indicators, re-estimation was conducted to ensure that all loading factor values exceeded 0.5 and were declared valid, meeting the required criteria. Following the determination of loading factor values for each research variable, the indicators that met the criteria were tested for validity and reliability to establish their connection to the latent variables in this study.

Composite Reliability and Cronbach’s Alpha

In addition to the construct validity test, a construct reliability test was performed, which was measured using composite reliability and Cronbach’s Alpha. The results of the composite reliability and Cronbach’s Alpha tests were generated using Smart PLS. A construct is considered to be reliable if the Average Variance Extracted (AVE) value exceeds 0.5, the composite reliability exceeds 0.7, and Cronbach’s Alpha exceeds the recommended threshold of 0.6 [15].

Table 3.

Reliability Test			
Variable	Cronbach’s Alpha	Composite Reliability	Average Variance Extracted (AVE)
Perception of Technology (X2)	0,879	0,912	0,677
Institutional Support (X3)	0,913	0,940	0,797
Community Culture (X4)	0,886	0,921	0,744
Information Technology Access (X5)	0,945	0,961	0,859
ISPO Certification Readiness Level (Y1)	0,894	0,928	0,764

Source: Processed primary data (2024)

Based on Table 3, the construct is considered reliable as it demonstrates a composite reliability value exceeding 0.70 and a Cronbach’s Alpha value exceeding 0.60. From the Smart PLS output, all constructs are shown to have composite reliability values above 0.70 and Cronbach’s Alpha values above 0.60. Therefore, it can be concluded that the constructs are reliable. Additionally, each variable is shown to have an Average Variance Extracted (AVE) value greater than 0.5. Consequently, all variables in this study are deemed valid and reliable, fulfilling the required reliability criteria [11].

Discriminant Validity

The discriminant validity test is conducted using two methods, namely cross-loading and the Fornell-Larcker criteria, to determine whether each indicator and variable exclusively measures its own variable or potentially measures other variables as well. In this study, the discriminant validity test is performed using the Fornell-Larcker criteria, as presented in Table 4.

Table 4.

Furnell-Lacker Criteria						
Variable	X2	X3	X4	X5	Y1	Description
X2	0,823					Valid
X3	0,793	0,893				Valid
X4	0,731	0,882	0,863			Valid
X5	0,746	0,884	0,922	0,927		Valid
Y1	0,700	0,809	0,793	0,839	0,874	Valid

Source: Processed primary data (2024)

According to the Furnell-Lacker criteria presented in Table 4, it is required that the square root value of the Average Variance Extracted (AVE) for each construct be greater than the correlation value between constructs in the model. This implies that the relationship between variables and other variables is considered more dominant than the size of the latent variable itself. The superiority of the latent construct in that block compared to other blocks is indicated. It can be concluded from this that the latent variable is well explained by the research instrument (valid).

Structural Model Testing (Inner Model)

The structural model in SEM-PLS is evaluated through the R2 of the dependent variable and the path coefficient values for the independent variables.

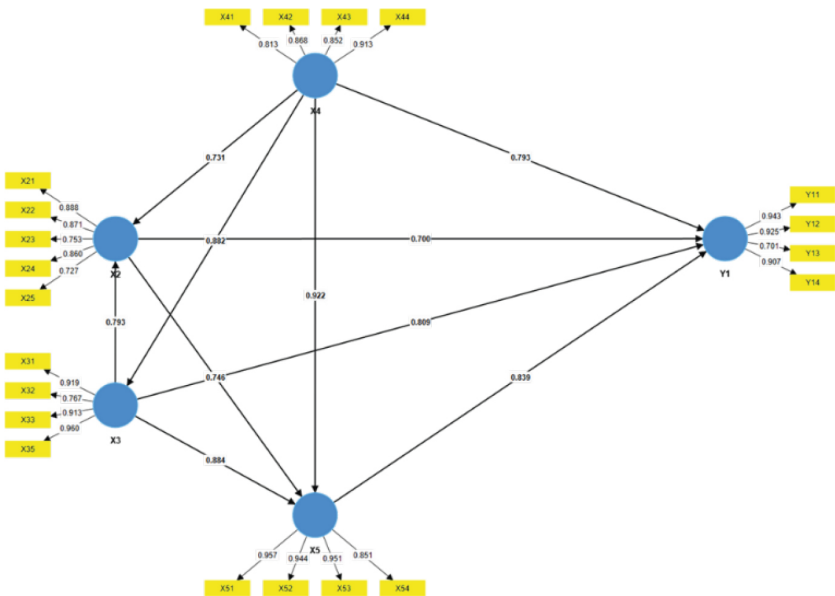


Fig. 4. Structural Model (inner model)

Variant Analysis (R-Square) or Determination Test

R^2 can be used to assess whether the effect of the independent latent variable on the dependent latent variable is substantive. The criteria for limiting the R^2 value are classified into three categories: 0.67, 0.33, and 0.19, with each classification indicating that the model is considered “good,” “moderate,” and “weak,” respectively [11].

Table 5.

R-Square Value (R^2)		
Variable	R-square	R-square Adjusted
ISPO Certification Readiness Level (Y1)	0,728	0,725

Source: Processed primary data (2024)

Based on the R^2 value in Table 5, it can be observed that the value of the ISPO Certification Readiness Level (Y1) construct is 0.728. This indicates that the Perception of Technology, Institutional Support, Community Culture, and access to information are able to explain 72.8% of the ISPO Certification Read-

iness Level construct variable, with the remaining 27.2% being explained by other variables outside the scope of this study. Other factors outside this study, such as government policies, socio-economic conditions, local political conditions, and regional geopolitics, could contribute to this. Therefore, it can be concluded that the Perception of Technology, Institutional Support, Community Culture, and access to information have a very strong influence on the ISPO Certification Readiness Level.

Path Coefficient Analysis Results

Path coefficient analysis is conducted to determine whether the hypothesis proposed in the study is accepted. Hypothesis testing is performed using the Bootstrapping function in SmartPLS 4.0. The hypothesis is accepted when the significance level of the P-value is <0.05 [16]. The table and final path diagram of the Path coefficient test results in this study are presented below. An equation is also formulated based on the model structure drawing, with the model structure being shown in Figure 4.

Table 6.

Path Coefficient Analysis Results

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistic (O/STDEV)	P-Value
Perception of Technology (X2) -> ISPO Certification Readiness Level (Y1)	0,128	0,129	0,043	2,984	0,003
Institutional Support (X3) -> ISPO Certification Readiness Level (Y1)	0,492	0,493	0,053	9,222	0,000
Community Culture (X4) -> ISPO Certification Readiness Level (Y1)	0,793	0,794	0,018	43,338	0,000
Akses Terhadap Informasi (X5) -> ISPO Certification Readiness Level (Y1)	0,551	0,551	0,074	7,430	0,000

Source: Processed primary data (2024)

Based on the structural model formed, the structural equation of the factors affecting the level of readiness of farmers in the implementation of ISPO is presented as follows:

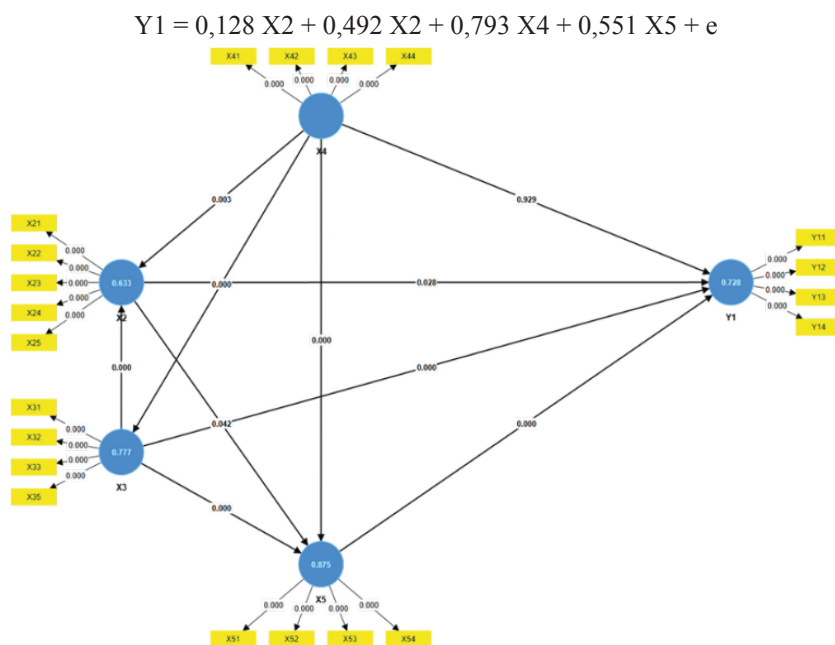


Fig. 5. PLS Bootstrapping

Variables that directly and significantly influence the readiness of farmers to implement ISPO include Perception of Technology, Institutional Support, Community Culture, and access to information technology. The R square value of 0.728 indicates that the factors tested in this study are able to explain 72.8% of the level of readiness of farmers, while the remaining 27.2% is explained by other factors outside the model.

Based on the results of statistical testing, the hypothesis is accepted if the significance value (sig) is <0.05 . Conversely, if the sig value is >0.05 , the hypothesis is rejected. An explanation of the influence of each variable is provided:

a. The coefficient value of Perception of Technology (X2) on ISPO Certification Readiness Level (Y1) is 0.128, indicating that a one percent increase in Perception of Technology results in a 12.8% increase in ISPO Certification Readiness Level. This influence is considered positive and significant, as the p-value is <0.05 .

b. The coefficient value of Institutional Support (X3) on the ISPO Certification Readiness Level is 0.492, indicating that a one percent increase in Institutional

Support results in a 49.2% increase in the ISPO Certification Readiness Level. This influence is considered positive and significant, as the p-value is <0.05 .

c. The coefficient value of Community Culture (X4) on the ISPO Certification Readiness Level is 0.793, indicating that a one percent increase in Community Culture results in a 79.3% increase in the ISPO Certification Readiness Level. This influence is considered positive and significant, as the p-value is <0.05 .

The coefficient value of Information Technology Access (X5) on the ISPO Certification Readiness Level is 0.551, indicating that a one percent increase in Information Technology Access results in a 55.1% increase in the ISPO Certification Readiness Level. This influence is considered positive and significant, as the p-value is <0.05 .

Discussion

It is revealed in this study that four main factors influence the readiness of farmers to implement ISPO certification: Perception of Technology, Institutional Support, Community Culture, and Information Technology Access. The importance of synergy between institutional, social, and technological aspects in facilitating the adoption of sustainability standards in the oil palm plantation sector, such as ISPO certification, is emphasized by these findings [17-19].

It is found that Perception of Technology contributes the least significantly to the readiness of farmers compared to other variables, with a coefficient of 0.128. This result is observed from the acquisition of a path coefficient value of 0.128, indicating that a 1% increase in the perception of technology among oil palm farmers results in a 12.8% increase in the ISPO Certification Readiness Level. This effect is also significant, although considered small, as it still meets the statistical requirements with a t-statistic of 2.984 and a p-value of 0.003. The Perception of Technology (X2) indicator consists of relative advantage (X2.1), compatibility (X2.2), triability (X2.3), complexity (X2.4), and observability (X2.5). All indicators in this variable are found to have values that pass the model evaluation test. The inner path analysis model shows that Perception of Technology (X2) has a significant effect on ISPO Certification Readiness Level (Y1). The perception of technology is recognized as playing a very important role in increasing the readiness for ISPO certification among oil palm farmers in the Aceh Tamiang district. Perception of Technology (X2) is still found to have a good loading factor value after re-estimation, above 0.7. Relative advantage is identified as the indicator with the highest coefficient of influence, with a value of 0.888. This indicates that oil palm farmers, whether ISPO farmers, PSR farmers, or independent farmers, who perceive significant benefits from adopting technology to meet ISPO standards are more likely to be ready and

encouraged to implement the technology. This aligns with Pasimura's research titled "Impact of Indonesian Sustainable Palm Oil (ISPO) Certification on the Environmental Behavior of Palm Oil Plantation Companies," which states that positive perceptions of technology facilitate the adoption of innovations that support environmental sustainability, with adaptation to new technology being an indicator of the successful implementation of ISPO [20]. Farmers' technological understanding and literacy are also found to contribute to their ability to fulfil certification requirements, such as document management and good agricultural practices (efficient irrigation or soil conservation methods).

Institutional Support has been proven to significantly contribute to the readiness of farmers, with a coefficient of 0.492. This indicates that every 1% increase in Institutional Support results in a 49.2% increase in readiness. This influence is positive and significant, with a t-statistic value of 9.222 and a p-value of 0.000. The significance demonstrates that institutional support plays an important role in ISPO certification readiness for farmers in the Aceh Tamiang district. Institutional Support (X3) is used as one of the indicators to measure the ISPO Certification Readiness Level (Y1) of oil palm farmers, including ISPO-certified oil palm farmers, independent farmers, and PSR farmers in the Aceh Tamiang district. In this study, Institutional Support (X3) consists of indicators of farmer group support (X3.1), government support (X3.2), company support (X3.3), marketing institution support (X3.4), and development partner institution support (X3.5). The marketing institution support indicator (X3.4) was the only one not passing the model evaluation test, as its value was found to be below 0.7, specifically 0.633. The effect of this indicator on the connected variables was also found to be low (red) during the analysis test. Consequently, the marketing institution support indicator (X3.4) was eliminated from the model to prevent distortion in the model estimation, which could reduce the overall quality and suitability of the model.

The elimination of invalid or low-loading indicators is an important step in improving model performance, enhancing internal consistency, and increasing model validity. This improvement is reflected in the increase in Goodness of Fit (GoF) values or other statistical indicators, such as Average Variance Extracted (AVE) and Composite Reliability. These findings align with Pasimura's research on the "Impact of Indonesian Sustainable Palm Oil (ISPO) Certification on the Environmental Behaviour of Palm Oil Plantation Companies," where institutions are shown to play a crucial role in the implementation of ISPO certification by influencing various aspects related to sustainability and environmental management practices in the oil palm plantation sector [20]. Pasimura emphasized that institutions significantly impact the implementation of ISPO certification through regulations, stakeholder

support, education, and monitoring and evaluation processes. Strengthening these institutional aspects is expected to increase the adoption of sustainability standards in the oil palm plantation sector, providing benefits to both the environment and society. Institutional support is also critical in helping farmers adopt technology [19], directly contributing to their readiness to implement ISPO certification by assisting them in accessing relevant technologies and training [18]. Research by Rahutomo on “Smallholders’ Land Productivity Improvement through Sustainable Palm Oil Certification in Indonesia” further emphasizes the importance of structured mentoring to improve smallholders’ understanding of ISPO and RSPO standards as a first step towards sustainable practices [21]. Additionally, palm oil companies are identified as playing a key role in providing material support, such as subsidized seeds and access to modern technology.

Community Culture is found to make the most significant contribution to the level of readiness of farmers, with a coefficient of 0.793. This indicates that every 1% increase in Community Culture (X4) results in a 79.3% increase in the ISPO Certification Readiness Level (Y1). The value of 79.3% is considered large, demonstrating that Community Culture (X4) has a very significant influence on the ISPO Certification Readiness Level (Y1) in Aceh Tamiang District. The influence of Community Culture is positive, with a t-statistic value of 43.338 and a p-value of 0.000. This value indicates a very strong and significant relationship between the Community Culture variable (X4) and the ISPO Certification Readiness Level (Y1), suggesting that the measured effect has near absolute certainty. The effect of Community Culture (X4) is assessed as one of the variables measuring the ISPO Certification Readiness Level (Y1) using four main indicators: social interaction (X4.1), social support (X4.2), problem-solving mechanisms (X4.3), and informal leadership (X4.4). The inner path analysis model confirms that Community Culture (X4) has a significant effect on the ISPO Certification Readiness Level (Y1).

This finding suggests that communities characterized by a collective culture and strong social interaction are more likely to adopt sustainability practices [18]. These findings are aligned with Denahusya’s research on “Overcoming Barriers to ISPO Certification: Analysing the Drivers of Sustainable Agricultural Adoption among Farmers,” which highlights the importance of considering local farmers’ beliefs, traditions, and social norms when promoting sustainable practices [18]. Local community support is identified as playing a crucial role in assisting farmers in implementing ISPO standards. A positive community culture is shown to facilitate the adoption of innovations, emphasizing the need to recognize and respect farmers’ cultural and social values while aligning them with sustainable practices in accordance with local beliefs, traditions, and social norms[22]. Increased adoption

of ISPO by farmers is also suggested to be achievable through effective communication by government policymakers and stakeholders. Such communication should align sustainability practices with the norms and values held by farmers [23; 24].

Information Technology Access is found to have the most dominant influence, with a coefficient of 0.551. This indicates that every 1% increase in Information Technology Access (X5) results in a 55.1% increase in the ISPO Certification Readiness Level (Y1). This effect is identified as positive, with a t-statistic value of 7.430 and a p-value of 0.000, signifying the crucial role played by Information Technology Access in influencing the ISPO Certification Readiness Level (Y1) for farmers. The influence of Information Technology Access (X5) on the ISPO Certification Readiness Level (Y1) is measured using indicators such as the intensity of media use (X5.1), the variety of types of information (X5.2), the diversity of information sources (X5.3), and the level of information utilization (X5.4). All indicators of Information Technology Access (X5) are found to impact the ISPO Certification Readiness Level (Y1). The coefficient values for these indicators are as follows: media use (X5.1) at 0.957, types of information (X5.2) at 0.944, information sources (X5.3) at 0.951, and information utilization at 0.852. The ability of farmers to access information through internet-based media is recognized as a key factor supporting their high access to information. Enhanced information access allows farmers to quickly understand the ISPO standards, facilitating a deeper comprehension of the required technology and its adoption to meet ISPO criteria [19]. The integration of communication tools with internet connectivity is shown to improve farmers' access to online information. Such accessibility enables farmers to receive technological information promptly, understand its application, and adopt the necessary technology for compliance with ISPO standards [25].

This access reduces the need for farmers to attend training or visit other locations to acquire knowledge, as they can easily learn new skills online. The findings of this study align with Nzonzo's research, "An Analysis Of Communication And Information Communication Technologies Adoption In Irrigated Rice Production in Kenya," which highlights the significant role of ICT adoption in increasing farmers' knowledge and skills in agricultural production and accessing market information [25]. The use of internet information is also found to enhance farmers' understanding of ISPO principles, implementation methods, and certification applications. Conversely, studies on tea plantation companies in Sri Lanka reveal that the age and experience of plantation managers influence ICT usage for information retrieval, with older and more experienced managers tending to rely more on printed materials [26]. Increased access to and utilization of information through the internet and mobile devices is observed to

improve both farmers' and plantation managers' understanding of sustainable agriculture standards, such as ISPO. From a technical perspective, the internet serves as a vital source of information on new technologies and plantation management practices, particularly in implementing Good Agricultural Practices (GAP), which are mandatory under the ISPO certification principles [4].

The implementation of ISPO is understood as a collective action, where the readiness of farmers to adopt ISPO practices is influenced by their social system, including the institutions they belong to, the prevailing community culture, and the information obtained from this system [6]. In this context, the role of supporting institutions is emphasized as being crucial in ensuring that changes in oil palm cultivation practices based on ISPO are encouraged and directed, enabling smallholders to address economic, environmental, and social challenges. Sustainable agricultural practices are thereby promoted, particularly with the planned implementation of the ISPO certification system in 2025 [18]. The need for strengthening access to information is highlighted to ensure that farmers can readily receive and comprehend technological information, thus facilitating accelerated change. It has been emphasized by Denayusha that approaches involving informal leadership, local community support, and the adaptation of practices to local culture are critical to enhancing farmers' readiness and participation in ISPO certification [18]. These strategies are identified as effective in overcoming barriers to the adoption of sustainable agricultural practices and in promoting the success of certification programs. In this regard, the social interactions of smallholders, the support provided by local communities in the implementation of ISPO, and the active role of communities in joint problem-solving are seen as pivotal in accelerating ISPO implementation among oil palm smallholders.

Conclusions

1. Farmers' readiness to implement ISPO is directly and significantly influenced by the Perception of Technology, Institutional Support, Community Culture, and access to information technology.
2. The most significant influence is exerted by Community Culture, followed by access to information, then Institutional Support, and the smallest influence is exerted by Perception of Technology.

Conflicts of interest information. The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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