Using the structural equation modeling approach to determine the factors affecting the adoption of the Indonesian sustainable palm oil production system by smallholder farmers

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Abstract. The palm oil industry plays a vital role in the Indonesian economy. This industry can support sustainable development, since it is based on renewable natural resources. The contribution to sustainable development is hampered if the oil palm production system, especially of smallholder farmers, is not sustainable. Since almost half of the oil palm plantations in Indonesia are run by smallholder farmers, the sustainability of the oil palm farming of smallholder farmers may significantly influence the overall sustainability. The adoption of the Indonesian Sustainable Palm Oil production system by smallholder farmers may improve the sustainability of oil palm farming in Indonesia. This study aimed to determine the factors influencing the adoption of the Indonesian Sustainable Oil Palm production system by smallholder farmers. Overall, respondents were 313 conventional smallholder farmers and 167 smallholder farmers implementing the Indonesian Sustainable Palm Oil production system. A structured-questionnaire was used to gather the data, while a data analysis was conducted using Structural Equation Modelling. The results reveal that the intention to directly adopt the Indonesian Sustainable Palm Oil production system influenced the adoption of Indonesian sustainable palm oil production. At the same time, the intention to adopt it was influenced by the perceived control behavior, perceived environment, and economic benefit. The influence of the perceived environmental benefit of the intention to adopt Indonesian sustainable palm oil was higher than that of the perceived economic benefit. The social-economic conditions of the farmers influenced the perceived environment and economic benefit.
Key Words: sustainable oil palm, smallholder, ISPO, adoption, economic benefit, environment benefit.

Introduction. The oil palm industry contributes significantly to the Indonesian economy, as smallholder oil palm plantations are the primary income source of over 3 million Indonesian farmers. This role will become increasingly more important as the palm oil industry relies on renewable natural resources that have the potential to support Indonesia's economic development over the long term.

For Indonesia, oil palm plantation development is not only an essential part of the economic growth of the agricultural sector, it also assists in rural development and the alleviation of poverty (Susila 2004; Sandker et al 2007). This vital role of oil palm plantations occurs because oil palm plantations are developing new economic growth centers, creating jobs in rural areas and increasing people's incomes (PASPI 2014). However, oil palm plantation development is not all good news, as it causes social and environmental problems.

Social issues of oil palm plantations include land conflicts (Nupearachchi 2014) resulting from the small bargaining power of the people (Rist et al 2010). Environmental issues facing oil palm plantations include the effect of greenhouse gas emissions, due to the opening of new plantation land (Fargione et al 2008), as well as the degradation of wildlife habitat (i.e., endangered orangutans), loss of diversity (Fitzherbert et al 2008;

Koh & Wilcove 2008; Teuscher et al 2015) and chemical fertilizer pollution (McCarthy & Zen 2010).

Oil palms have become the backbone of the farmers' household economy in the Bengkulu Province, where most of the oil palm plantations are community plantations (68%), involving 380 thousand farmers (BPS 2016; Daemeter Consulting 2015). According to Sukiyono et al (2017), the economy of smallholder oil palm plantations is highly vulnerable to the falling prices of fresh fruit bunches (FFB). This is because oil palm commodities are the main pillars of the household economy. This is especially the case if the FFB price changes are declining and fluctuating.

The vulnerability of oil palm farmers to fluctuations and falls in FFB prices can be increased by growing the farmers' adaptive capacity through increasing the productivity of smallholder palm plantations and optimizing the utilization of the resources owned by oil palm farmers. Increasing the productivity of smallholder oil palm plantations is possible, since productivity is still low (i.e., 2.3 tons Crude Palm Oil (CPO) ha^{-1} $year^{-1}$), when compared to high plantation productivity (i.e., 3.1 tons CPO ha^{-1} $year^{-1}$). The low productivity of oil palm plantations is due to the lack of technical efficiency.

Research in Western Sumatera by Hasnah et al (2004) shows that the technical efficiency of an oil palm plantation is 0.66, meaning that the average output of smallholders is only 66% of the farmers' best farm output with an equivalent input level. Alwarritzi et al (2015) found that plasma palm oil farmers have a higher technical efficiency, when compared with smallholder palm oil farmers in the Riau Province. These findings indicate that the technical efficiency of the self-employed oil palm plantation is the lowest technical efficiency and is followed by the plasma plantation farmers.

Productivity can be increased with Good Management Practices (GMP). The implementation of GMP in the management of large oil palm plantations proves that productivity can increase to 5.7 tons CPO ha^{-1} $year^{-1}$ or 24.3 tons of FFB ha^{-1} $year^{-1}$ (Amri 2014). The reduction in the gap between exploitable and realized yields and the increased productivity or intensification of smallholder oil palm plantations has enormous potential to support economic growth and the reduction of social and environmental problems arising from the extensification of oil palm plantations (Euler et al 2016).

The conditions faced by the palm oil industry, especially that of the smallholder oil palm plantations, reveals considerable challenges if the smallholder oil palm plantations are still expected to support the survival of prosperous farmers and, at the same time, continue to contribute to the Indonesian economy in the long run. Oil palm plantations should be managed using sustainable best practices so that the economic benefits can be sustainable, socially acceptable and environmentally friendly.

There are currently many technologies and research results widely available to support environmentally friendly and sustainable palm oil management. Indeed, the use of inappropriate or excessive agricultural chemicals, in addition to potentially polluting the environment, also increases production costs and reduces profits. This ultimately harms the farmers (Suarez et al 2013). The application of the sustainable oil palm principles and criteria (i.e., Indonesian Sustainable Palm Oil (ISPO)) can encourage the development of oil palm plantation industries. In this way, they can continue to provide economic benefits and lessen the negative impacts of oil palm plantations (i.e., social and environmental effects (Corley 2009)).

Malini & Aryani (2012) point out that the implementation of ISPO in plasma oil palm plantations provides higher incomes than non-self-employed oil palm plantations that do not implement ISPO. However, various obstacles (e.g., socioeconomic factors of farmers (Anaglo et al 2014), farmer organizations, institutional contexts (Brandi et al 2015)) exist in relation to the application of ISPO in the management of smallholder oil palm plantations (e.g., non-plasma plantations).

Since 2014, the CPO per year generated from sustainable oil palm plantations trend has been increasing. The implementation of the sustainable palm oil management provides benefits to producers (e.g., income), due to increased production and the quality of the CPO. Better and more profitable prices are also offered. In addition, market opportunities for CPO generated from sustainable oil palm plantations are more in demand (Brandi et al 2015).

In Indonesia, the application of the sustainable palm oil is either mandatory or voluntary. Oil palm plantation organizations are required to implement sustainable palm oil management. However, plasma and non-plasma oil palm plantations do not face this requirement.

According to Brandi et al (2015), the existence of non-plasma oil palm plantations and the livelihood of farmers is vital from the perspective of development and the environment. The participation of non-plasma smallholder oil palm plantations in the implementation of the sustainable palm oil management will improve the practice of plantation management and reduce environmental impacts, due to the improvement in agricultural chemical applications. In addition, the application of the sustainable palm oil will increase the potential for economic benefits, due to improved yields (Nagiah & Azmi 2012). It will also provide more open market opportunities for palm oil produced from sustainable oil palm plantations due to consumer demand (Rival et al 2016).

Few studies provide an overview of the challenges and interventions of the sustainable oil palm plantation implementation on smallholder plantations (Brandi et al 2015). Therefore, more research is needed to encourage and facilitate the adoption of the sustainable palm oil on smallholder plantations, especially non-plasma oil palm plantations. Hence, the primary research objective of this investigation is to design a sustainable palm oil management technology for a smallholder plantation adoption model. The specific research objectives for the first year include identifying the factors affecting the intentions and barriers to the adoption of the sustainable palm oil application on smallholder oil palm plantations.

Material and Method

Location. This study was conducted between April and August of 2018 in the Bengkulu Province of Indonesia. Respondents were spread over the 2 districts of North and Central Bengkulu.

Methodology. The process for collecting the primary and secondary data included: (i) a literature review; (ii) surveys, field observations, and the completion of respondent questionnaires; (iii) brainstorming and focus group discussions (FGD); and (iv) in-depth interviews. The Structural Equation Modeling (SEM) technique was the chosen analytical tool, because it is a flexible second-generation multivariate analysis tool for analyzing causal relationships and latent variables. The latent variables were measured indirectly using measurement variables in the form of one or more indicators (Chin 1998).

The SEM analysis makes it possible to study the relationship between some non-free variables and independent variables (Hair et al 2010). The SEM-based variants, or PLT SEMs, are suitable for use in predictive designed analyses. This is the case, because we will predict the intention of the self-employed smallholder farmers to adopt the continued management of oil palm plantations (Reinartz et al 2009).

According to Jaya & Sumertajaya (2008), the PLS-SEM steps involve:

1) Designing a structural model (Inner Model): the design of a structural model of a relationship between exogenous latent variables and endogen or endogenous latent variables is based on the formulation of the problem or hypothesis proposed. For this study, the exogenous and endogenous latent variables include:

a. variable attitude towards sustainable palm oil;
b. variable subjective norms;
c. variable perceptions of behavior control;
d. variable socio-economic characteristics of farmers;
e. variable perceptions of environmental benefits;
f. farmer organization variables;
g. institutional context variables;
h. socio-economic variables of farmers;
i. the variable intention of the sustainable palm oil adoption.

2) Designing measurement model (Outer Model): the design of the measurement model is particularly related to whether the designed indicators are reflective or

formative. For this study, the measurement variables for each variable will be constructed through literature and elicitation reviews.

3) Line diagram construction: to facilitate the understanding of the results of the design of the structural and measurement models expressed in the form of lane diagrams.

4) Conversion of path diagrams in the system of equations.

5) Estimates.

6) Model fit (Goodness of fit).

7) Hypothesis testing.

The bootstrap resampling method will be used to conduct the hypothesis testing (β, γ, and λ). The t-statistic or t-test will be the test statistic used.

The application of the resampling method, allowing the free distribution of data to be distributed, does not require the assumption of a normal distribution, nor does it require a large sample. The t-test is used; if the p-value ≤ 0.05 (alpha 5%), it is significant, and vice versa. If the result of the hypothesis testing on the outer model is significant, the indicator is considered to be a latent variable measuring instrument.

The basis of this research is the modified Theory of Planned Behavior (TPB) (Ajzen 1991). The TPB is used to study the influence of attitudes, objective norms, the perception of behavior control, the awareness and knowledge of farmers on sustainable palm oil, the socio-economic characteristics of farmers, the organization and institutions of farmers and the perceptions of production and environmental benefits in relation to the adoption intentions of the sustainable palm oil technology.

According to Fielding et al (2008) and Zeweld et al (2017), attitudes, subjective norms, and perceptions of behavioral control affect the adoption intentions of smallholder farmers to sustainable agriculture technology. Other researchers have found that the awareness, knowledge and demographic characteristics of farmers may influence conservation intentions in agricultural practices (Jacobson et al 2003; Terano et al 2015). Brandi et al (2015) showed that farmers' intentions to adopt sustainable agriculture are influenced by farmers' characteristics, particularly financial and knowledge capabilities, farmer organizations and institutional contexts.

Chin et al (2016) revealed that the perception of the benefits of production and the environment affect farmers' intentions to adopt the innovative management of oil palm plantations. Therefore, in this study, the modification of TPB is conducted by adding the awareness and knowledge of farmers to sustainable palm oil, the socioeconomic characteristics of farmers, the organizations and institutions of farmers and the perception of the economic and environmental benefits. These variables are expected to influence the farmer adoption of the sustainable palm oil technology.

Results and Discussion

Instrument testing. Instrument testing is conducted to test the validity and reliability of the questionnaire (Garson 2013). The purpose of testing the validity and reliability is to ensure that the instruments used can absorb the respondents' opinions without bias and consistency. The function of the testing validity is to ensure that the questions on the instrument that will be used in the ISPO adoption survey are valid instruments. The validity test is conducted to make conclusions based on the study instrument valid, because the instruments used are valid. The validity test is conducted by calculating the correlation between the response scores of the same respondents' opinions for the same question items that were asked twice with a lag time.

The attributes or questions in the survey are declared valid if the same respondent's questions are significantly correlated or if the two responses from the respondent are not significantly different. Attributes are declared valid if they have a p-value of less than 0.05 or $\alpha = 0.05$. While the reliability test is intended to determine the consistency of the questionnaire as a measure in its use, reliability refers to the consistency and stability of the scores measured. A questionnaire's measuring instruments must provide consistent results if they are used multiple times. The results of the retrieval of the data using a questionnaire on the same respondents with the same questions should provide relatively the same responses. This is termed consistent. The questionnaire measurement tool must provide consistent results; this is called reliable.

The attributes or questions on the questionnaire are declared reliable if the Cronbach alpha value is greater than 0.7. The results of testing the validity illustrate that all questions on the questionnaire are valid, because the results of the correlation testing have a p-value of less than 0.05. This means that the dimensional attributes or questions on the questionnaire can be used as effective data collectors.

The reliability test results show that all attributes or questions on the questionnaire are reliable, because the consistency test results have a Cronbach alpha of more than 0.7. This means that the dimensional attributes or questions on the questionnaire can be used as consistent data collectors. The results of testing the validity and reliability of the instrument's measuring instrument indicate that the primary data collected using questionnaires from the respondents who were sampled could be declared valid and reliable. Therefore, the questionnaire instrument, as a measuring instrument, can be used to measure and analyze the factors that influence the ISPO using a SEM analysis.

Adoption model. The conceptual model of ISPO adoption to be tested is based on the hypothesis that the intention of the ISPO adoption influences ISPO adoption. The intention of ISPO adoption is influenced by the subjective norms latent variables, attitudes, behavioral control perceptions, perceptions of economic benefits and perceptions of environmental benefits. These five latent variables are thought to be influenced by the socio-economic conditions of farmers, farmer activities in the organization and institutional farmers. A reliability analysis is used as a measure of the ability of measurement variables or indicators to reflect latent variables using SEM with the results of the analysis presented in Tables 1, 2 and 3. The outer model analysis results illustrate that all measurement variables can be accepted as reliable indicators of each latent variable, because the overall p-value is less than 0.05.

Table 1

Loading factor analysis and the p-value of the perceived economic and environmental benefits measurement variables

	Latent and measurement variables	*Loading factor*	*P value*
	Perceived economic benefits		
1)	Managing oil palm plantations in groups, in the form of farmer groups and cooperatives, will be more profitable.	0.642	< 0.001
2)	Maintenance of oil palm plants that are environmentally friendly and support productivity will provide economic benefits.	0.792	< 0.001
3)	Integrated pest control and the use of environmentally friendly pesticides will be more profitable.	0.781	< 0.001
4)	Collaboration on the sale of fresh fruit brunch production with factories will provide mutual benefits.	0.738	< 0.001
5)	Management of oil palm plantations that are free from conflicts, both land conflicts, and other conflicts, will be more profitable.	0.817	< 0.001
	Perceived environmental benefits		
1)	Sustainable management of oil palm plantations will conserve land and water resources.	0.657	< 0.001
2)	Sustainable management of oil palm plantations will preserve biodiversity.	0.718	< 0.001
3)	Non-excessive use of pesticides in the management of oil palm plantations will have a good impact on biodiversity.	0.697	< 0.001
4)	Integrated control of plant pest organisms under sustainable management of oil palm plantations will support biodiversity conservation.	0.717	< 0.001

Table 2

Loading factor analysis and the p-value of the subjective norms and attitudes towards the sustainable management measurement variables

	Latent and measurement variables	Loading factor	P value
	Subjective norm		
1)	Management of oil palm plantations can be effective if carried out with/alongside farmer group organizations.	0.771	< 0.001
2)	Management of oil palm plantations can be effective if carried out with/alongside a cooperative forum.	0.727	< 0.001
3)	Management of oil palm plantations will be sustainable if plantations are free from land and other disputes.	0.784	< 0.001
4)	Management of oil palm plantations will provide long-term benefits if carried out by environmentally friendly cultivation technique guidelines.	0.768	< 0.001
5)	Management of oil palm plantations will be sustainable if business and production increases sustainably.	0.774	< 0.001
	Attitudes toward sustainable management		
1)	Oil palm management should be carried out in a sustainable manner.	0.461	< 0.001
2)	Farmers, farmer groups and cooperatives under the guidance of government institutions or agencies should jointly improve the performance of the plantation, as well as the social, economic and environmental aspects.	0.521	0.002
3)	Sustainable oil palm management will provide benefits for future generations.	0.571	< 0.001
4)	I will apply an environmentally friendly behavior in the management of oil palm plantations.	0.732	< 0.001
5)	My contribution as an oil palm farmer in protecting the environment will be very meaningful.	0.749	< 0.001
6)	My concern for the environment must be realized in the management of oil palm plantations.	0.800	< 0.001
7)	I consider the conservation of land and animals in the management of oil palm plantations.	0.746	< 0.001

Table 3

Loading factor analysis and the p-value of the perceived control behavior, intentions and adoption of the Indonesian Sustainable Palm Oil measurement variables

	Latent and measurement variables	Loading factor	P value
	Perceived control behavior		
1)	The application of the sustainable management of oil palm plantations is needed because of increasing TBS competitiveness.	0.616	< 0.001
2)	The implementation of the sustainable management of oil palm plantations is not difficult if I want to implement it.	0.669	< 0.001
3)	The application of the sustainable management of oil palm plantations is not difficult because many parties support it.	0.679	< 0.001
4)	The application of the sustainable management of oil palm plantations is difficult because of the complexity of the administration and financing.	0.508	0.037
	Intentions to adopt the ISPO		
1)	I will implement the ISPO in managing oil palm plantations because it provides economic benefits, avoids social problems or conflicts and is environmentally friendly.	0.625	< 0.001
2)	I am interested in implementing the ISPO even though I do not fully understand the ISPO.	0.662	< 0.001
3)	Oil palm plantation management based on the ISPO is in accordance with my needs, so I will implement it.	0.676	< 0.001
4)	I will improve the image of palm oil management with the ISPO	0.657	< 0.001
	ISPO adoption		
1)	I have implemented an oil palm plantation management plan. based on the Indonesian Sustainable Palm Oil	0.780	< 0.001

The compatibility test of the ISPO adoption model and the variables that influence it, as presented in Figure 1, show that the ISPO adoption model is a good fit. The model match test uses the average path coefficient (APC) and the average R-squared (ARS) value measurements. The APC value is the average absolute value of the model path coefficient, while the ARS value is the absolute value of the R^2 coefficient of the model. The test results illustrate that the APC value = 0.237, $p < 0.001$ and ARS = 0.198 (p < 001).

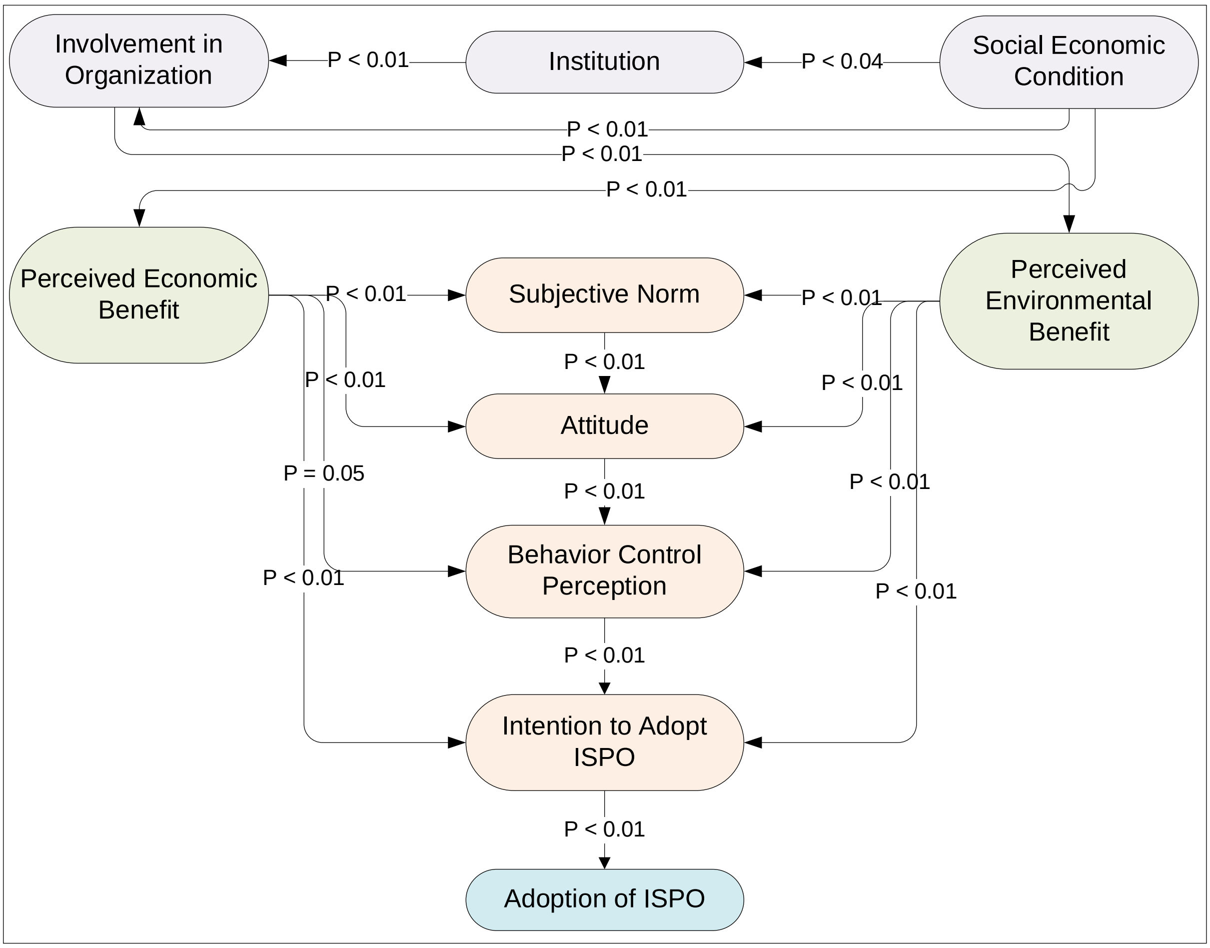

Figure 1. Adoption model of the ISPO.

In the overall model, no multicollinearity exists between the latent variables used to describe ISPO adoption. Multicollinearity is the strength of the correlation between two or more independent variables. If two or more independent variables are highly correlated, this condition indicates that the correlated variables do not measure different constructs. Instead, they measure the same construct or have variable redundancy. If there is variable redundancy, one of the correlated variables needs to be removed from the model (Kline 2010). A multicollinearity analysis uses the average block variance inflation factors (AVIF) and the average full collinearity variance inflation factors (AFVIF). A multicollinearity test illustrates that the AVIF and AFVIF values meet the requirements that there is no multicollinearity in the model. The value of the average block variance inflation factors (AVIF) (1,184) has met the requirements, as the AVIF requirements to show the absence of multicollinearity must be less than or equal to 5 and the AVIF value is ideally less than 3.3. The average full collinearity variance inflation factors (AFVIF) value is 1,490 and can be accepted, because the AFVIF value requirements are less than or equal to 5 and the AFVIF value is ideally less than 3.

An analysis to test the significance of the relationship between exogenous and endogenous latent variables and endogenous and endogenous latent variables was carried out using SEM. The results of testing on the inner model illustrate that the latent variable "Adoption of ISPO" is influenced by "Intention to adopt ISPO", while "Intention to adopt ISPO" is influenced by "Behavioral Control Perception," "Perception of Environmental Benefits", and "Economic Benefit Perception". The variable "Behavioral Control Perception" is influenced by the variable "Attitude" and the variable "Attitude" is influenced by the variable "Subjective Norms". The variables "Perception of Environmental Benefits" and "Perception of Economic Benefits" affect the variables "Subjective Norms", "Attitudes", "Perception of Behavior Control" and "Intention to Adopt ISPO". The variable "Farmer's Socio-Economic Conditions" directly affects the variables "Perception of Environmental Benefits", "Perception of Economic Benefits", "Institutional" and "Engagement of Farmers' Groups".

The results of the model reveal that the hypothesis of the variable "Adoption of ISPO" is positively influenced by "Intention to adopt ISPO". However, the hypothesis that the variables "Subjective Norms" and "Attitudes" affect "Intention to adopt ISPO" cannot be proven. The variables "Behavioral Control Perception", "Economic Benefit Perception" and "Environmental Benefit Perception" were proven to influence "Intention to adopt ISPO positively". The variable "Farmer's Socio-Economic Condition" directly affects the variables "Perception of Environmental Benefits" and "Perception of Economic Benefits"; it also affects the variables "Institutional" and "Engagement of Farmers' Groups".

Directly accelerating the ISPO adoption process can be encouraged by the "Intention to adopt ISPO". In addition, to increase the "Intention to adopt ISPO", the three variables that can directly change include "Control Behavior Perception", "Perception of Environmental Benefits" and "Perception of Economic Benefits". The "Perception of Environmental Benefits" has the driving force to improve the behavior that facilitates the intention to adopt an ISPO that is bigger than the "Perception of Economic Benefits". To increase the awareness for smallholder oil palm farmers that the sustainability of oil palm businesses is highly dependent on increasing environmental benefits can be done through farmer group organizations. The involvement of farmers in farmer group organizations can increase the "Perception of Environmental Benefits" which, in turn, will encourage the increased behavior and intentions of farmers to adopt the ISPO.

Conclusions. People that have intention to adopt Indonesian Sustainable Palm Oil can easily be encouraged to adopt it. Therefore, to increase the intention to adopt ISPO, the three variables that can directly change including "Control Behavior Perception", "Perception of Environmental Benefits" and "Perception of Economic Benefits". The "Perception of Environmental Benefits" has the driving force to improve the behavior that facilitates the intention to adopt an ISPO that is bigger than the "Perception of Economic Benefits". To increase the awareness for smallholder oil palm farmers that the sustainability of oil palm businesses is highly dependent on increasing environmental benefits can be done through farmer group organizations. The involvement of farmers in farmer group organizations can increase the "Perception of Environmental Benefits" which, in turn, will encourage the increased behavior and intentions of farmers to adopt the ISPO.

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