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Overcoming Barriers to ISPO Certification: Analyzing the Drivers of Sustainable Agricultural Adoption among Farmers

Nugra Irianta Denashurya *, Nurliza, Eva Dolorosa, Dewi Kurniati and Denah Suswati

Faculty of Agriculture, Tanjungpura University, Pontianak 78124, Indonesia; nurliza.spmm@gmail.com (N.); edolorosa@gmail.com (E.D.); dewi.kurniati@faperta.untan.ac.id (D.K.); denah.suswati@faperta.untan.ac.id (D.S.)
* Correspondence: nugrairianta@gmail.com

Abstract: The palm oil industry, integral to Indonesia's economy and the United Nations Sustainable Development Goals (SDGs), faces emerging economic, environmental, and social challenges. These compel the adoption of sustainable agricultural practices, particularly in light of the Indonesian Sustainable Palm Oil (ISPO) certification system's implementation by 2025. This study develops a model integrating Ajzen's Theory of Planned Behavior and Rogers' Diffusion of Innovation theory to elucidate factors influencing farmers' adoption of sustainable palm oil farming. Data from 300 palm oil farmers in West Kalimantan, Indonesia, were analyzed using structural equation modeling. The results indicated significant positive effects in terms of attitudes, subjective norms, perceived behavioral control, relative advantage, compatibility, and trialability on sustainable practice adoption, while the complexity negatively influenced adoption. These findings underscore the need to address farmers' motivations, social norms, perceived control, and practice advantages for successful implementation. The study offers critical insights for policymakers and practitioners to formulate strategies that encourage the voluntary adoption of sustainable practices, balancing farmers' needs and environmental sustainability.

Keywords: Indonesian Sustainable Palm Oil (ISPO) certification; theory of planned behavior; diffusion of innovation theory; structural equation modeling; sustainable agriculture adoption

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Citation: Denashurya, N.I.; Nurliza; Dolorosa, E.; Kurniati, D.; Suswati, D. Overcoming Barriers to ISPO Certification: Analyzing the Drivers of Sustainable Agricultural Adoption among Farmers. *Sustainability* **2023**, *15*, 16507. https://doi.org/10.3390/su152316507

Academic Editor: Ricardo García Mira

Received: 13 November 2023
Revised: 30 November 2023
Accepted: 1 December 2023
Published: 2 December 2023

1. Introduction

The palm oil industry in Indonesia holds a pivotal position in the nation's economy and its commitment to the United Nations' Sustainable Development Goals (SDGs). It generates employment for over 16 million individuals and contributes approximately 3.5% to the national GDP [1]. Given Indonesia's prominent global role as a palm oil producer, the country possesses significant potential to advance sustainable agricultural practices, specifically related to palm oil cultivation [2]. By embracing sustainability measures, Indonesia can make substantial contributions toward the attainment of multiple SDGs, including SDG 2 (zero hunger), SDG 12 (responsible consumption and production), and SDG 13 (climate action) [3,4].

Despite the numerous advantages associated with palm oil production in Indonesia, significant economic, environmental, and social concerns have emerged. These concerns encompass deforestation, habitat degradation, exploitation of local communities, forest fire incidents, ambiguous land ownership, excessive pesticide use, human rights violations, worker welfare issues, controversies surrounding palm oil-based biodiesel, and inadequate monitoring and enforcement of laws [5,6]. Nevertheless, various endeavors were initiated to promote sustainable palm oil production. One such example is the forthcoming extension of the Indonesian Sustainable Palm Oil (ISPO) certification system to independent small farmers in Indonesia by 2025 [7–9].

The implementation of the Indonesian Sustainable Palm Oil (ISPO) certification system without considering farmers' willingness to adopt it could lead to unintended consequences [7,10–12]. Understanding farmers' motivations and barriers is vital to ensure that certification requirements align with their capabilities. Neglecting this may result in resistance, non-compliance, and a lack of motivation to participate. Failure to promote sustainable practices in the palm oil industry may have long-term repercussions, such as international market restrictions and negative consumer perception. This would negatively impact Indonesian farmers' ability to sell their products and harm the economy [13]. Balancing sustainability and farmers' needs requires a comprehensive approach involving effective communication, capacity-building, financial incentives, and supportive policies [14]. This approach encourages the voluntary adoption of sustainable practices, ensuring the well-being of farmers and the environment.

Studies on sustainable agricultural practices in the context of palm oil production are also abundant globally. Foreign research has delved into the adoption of sustainable practices in countries like Malaysia, Thailand, and Colombia, which share similarities with Indonesia in terms of their tropical climate and significant role in the palm oil industry [15,16]. These studies demonstrate a wide array of factors that influence farmers' adoption of sustainable practices, such as economic incentives, access to information and technology, and government policies. Specifically, Malaysia's implementation of the Malaysian Sustainable Palm Oil (MSPO) certification system shows that providing adequate training, financial assistance, and market access can significantly encourage adoption [17,18]. Furthermore, research in Thailand and Colombia points out that a clear and equitable land rights system is pivotal in avoiding conflicts and ensuring the sustainability of palm oil production [19,20]. These findings provide relevant insights that can help to inform and improve the implementation of the ISPO certification system in Indonesia. It is worth noting that while these countries provide useful reference points, the specific context of Indonesia, with its unique socio-economic and environmental conditions, must be taken into consideration.

This study fills a critical research gap by investigating the motivations and barriers influencing farmers' voluntary adoption of sustainable palm oil practices, with a specific focus on the Indonesian Sustainable Palm Oil (ISPO) certification system. While prior research has addressed the economic, environmental, and social concerns associated with palm oil production, limited attention has been given to understanding farmers' perspectives and decision-making processes regarding the adoption of sustainable practices [21–23]. By integrating Ajzen's Theory of Planned Behavior (TPB) and Rogers' Diffusion of Innovation theory (DOI), this study offers a unique and comprehensive perspective on the individual-level and contextual factors that drive the adoption and diffusion of sustainable palm oil practices. Understanding what motivates farmers to willingly adopt sustainable agriculture practices is of utmost importance for both farmers and policymakers. Successfully implementing the ISPO certification system in 2025 without imposing it forcefully requires a thorough understanding of the factors that drive farmers' decision-making. The adoption of a certification scheme that promotes sustainable agriculture entails substantial efforts and costs for farmers, particularly considering the requirement for field inspections once the scheme is established [24,25]. By understanding farmers' motivations, it becomes possible to mitigate the economic, environmental, and social impacts and ensure the successful and sustainable implementation of the ISPO certification system [7].

Ajzen's Theory of Planned Behavior (TPB) and Rogers' Diffusion of Innovation theory (DOI) offer valuable insights into the adoption of sustainable palm oil practices, such as the ISPO certification system. These two theories complement each other and provide a comprehensive understanding of the factors influencing farmers' attitudes and behaviors [26,27]. According to Ajzen's Theory of Planned Behavior (TPB), attitudes (ATT), subjective norms (SNM), and perceived behavioral control (PBC) are crucial factors that influence adoption [28]. Complementing this perspective, Rogers' Diffusion of Innovation theory (DOI) emphasizes several key determinants that shape the process of adoption and diffusion. These determinants include relative advantage (RAD), compatibility (COA), complexity (COE), trialability (TRA), and observability (OBV) [29]. Integrating Ajzen's Theory of Planned Behavior (TPB) and Rogers' Diffusion of Innovation (DOI) provides a comprehensive understanding of adoption and diffusion, considering individual-level factors and broader contextual influences [30,31]. By combining the insights from both theories, stakeholders and policymakers can develop targeted strategies to promote the adoption of sustainable palm oil practices, address barriers and concerns, and facilitate a successful implementation of the ISPO certification system.

The central purpose of this study is to construct a comprehensive model that integrates the Theory of Planned Behavior (TPB) and the Diffusion of Innovation (DOI) theory, with the intent of enriching our understanding of the factors influencing the adoption of sustainable agricultural (ASA) practices. This integrative model is designed to create a holistic view by combining the internal determinants underlined by TPB [32] with the external factors emphasized by the DOI theory, particularly pertaining to the perceived attributes of Innovation [33], which are considered external factors as they encompass the characteristics or qualities of the innovation itself that are perceived by individuals.

The TPB illuminates the internal determinants of behavior by focusing on attitudes (ATT), subjective norms (SNM), and perceived behavioral control (PBC). These are cognitive processes influenced by values and social factors that shape behavioral intentions, thereby influencing an individual's decision to adopt or reject a behavior [34]. On the other hand, the DOI theory delves into the distribution of innovations within a social system, underlining factors such as relative advantage (RAD), compatibility (COA), complexity (COE), trialability (TRA), and observability (OBV). These external factors emphasize how an innovation's characteristics, perceived benefits, compatibility with existing systems, and visibility can impact the decision to adopt the innovation [35]. The fusion of the TPB and DOI theories allows for a balanced consideration of internal and external factors. It acknowledges that the TPB's internal determinants are not impervious to influences from the external environment, just as the DOI's external factors are susceptible to individual cognitions and attitudes. The model also recognizes the non-absolute nature of the decision to adopt an innovation, which can vary over time and under different circumstances. This dynamic interplay between internal perceptions and external environmental factors provides a powerful analytical tool for understanding the complex behaviors associated with the adoption of sustainable agricultural practices [36,37].

This research primarily aims to understand the motivations and barriers influencing the voluntary adoption of the Indonesian Sustainable Palm Oil (ISPO) certification system among Indonesian palm oil farmers. Specifically, the objectives include identifying and analyzing the key motivations that influence farmers to voluntarily adopt the ISPO certification system, considering a range of potential economic, socio-cultural, and institutional factors. Equally important is understanding the barriers that these farmers face, whether they be economic, technical, or institutional obstacles that might discourage them from embracing the certification system. Additionally, the research seeks to delve into farmers' perceptions of the ISPO certification system's benefits and drawbacks, which provides essential insights into its perceived advantages and disadvantages from the farmers' perspective. Finally, the goal is to synthesize these findings into concrete recommendations to inform policymakers and stakeholders about strategies for promoting and implementing the ISPO certification system successfully and sustainably.

The pragmatic implications of this research are manifold. By uncovering the key factors that drive the adoption of sustainable farming practices, the study can inform the development of effective strategies, programs, and policies that foster the voluntary adoption of these practices among farmers. Aligning with the goal of the successful implementation of the Indonesian Sustainable Palm Oil (ISPO) certification system by 2025, this approach underlines the importance of understanding and accommodating farmers' motivations and readiness to adopt sustainable practices, as opposed to imposing these practices forcefully. This comprehensive model and its findings are thus invaluable not only in theory but also in practice, paving the way for successful sustainable palm oil practice implementation in Indonesia and beyond.

The intention to adopt a particular behavior, as proposed by Ajzen's Theory of Planned Behavior (TPB), is influenced by three key constructs: attitudes (ATT), subjective norms (SNM), and perceived behavioral control (PBC). These constructs play a significant role in shaping an individual's motivation or willingness to adopt a specific behavior [34]. In parallel, Rogers' Diffusion of Innovation theory (DOI) introduces five factors that effectively complement the TPB framework, contributing to a comprehensive understanding of the factors driving farmers' adoption of new innovations. These factors include relative advantage (RAD), compatibility (COA), complexity (COE), trialability (TRA), and observability (OBV) [29]. By considering both TPB and DOI, researchers can examine and identify the factors that encourage farmers' Adoption of Sustainable Agriculture (ASA) as intended by implementing the ISPO certification, considering both internal determinants (TPB) and external influences (DOI).

Adoption of Sustainable Agriculture (ASA) as a concept is directly linked to a farmer's perception of the practice [38,39]. In fact, in the context of the research at hand, perception was directly measured to understand its role in adoption. ASA encompasses the ecological, economic, and social dimensions of farming, each of which provides clear indicators for measurement. As farmers evaluate these dimensions in relation to their existing practices, their direct perceptions become pivotal in guiding their behavior toward ASA adoption. Evidence from the study confirms that when farmers hold a favorable view of ASA from environmental, economic, or societal perspectives, they are inclined toward adopting sustainable practices [39,40]. While the TPB and DOI frameworks have historically been used to understand such behaviors through various determinants, in this research, a more straightforward approach was taken. By measuring perception directly, a clear and unambiguous link between how farmers view ASA and their consequent actions was established. This approach not only simplifies the process but also provides clear insights, suggesting that the choice of measurable variables under the ASA latent variable is not as problematic as it may first appear. The direct correlation between adoption behavior and perception highlighted by this research further underscores the potential of this approach in promoting a broader adoption of sustainable agriculture.

Attitudes (ATT) toward the Adoption of Sustainable Agriculture (ASA) encompass individuals' psychological dispositions, beliefs, and evaluations related to the acceptance and implementation of sustainable farming practices. These attitudes play a crucial role in shaping farmers' intentions and decisions regarding the adoption or resistance of sustainable agriculture methods. Bagheri et al. (2021) highlight the significant influence of farmers' attitudes towards safe pesticide use on their intention to adopt appropriate pesticide handling practices, emphasizing the importance of fostering positive attitudes to promote responsible agricultural practices [41]. Similarly, Borges et al. (2014) establish a strong association between farmers' attitudes and their intention to adopt improved natural grassland practices, underscoring the pivotal role of attitudes in driving sustainable agricultural behavior [42]. Moreover, empirical evidence from various case studies [26,43,44] further supports the influential impact of farmers' attitudes in determining their adoption of specific agricultural practices.

Subjective Norms (SNM) toward the Adoption of Sustainable Agriculture (ASA) encompass the perceived social pressures and influence from significant others, including family, peers, and experts, which shape individuals' attitudes and intentions regarding the adoption of sustainable farming practices. These norms play a vital role in guiding farmers' decisions and actions towards embracing sustainable agriculture. Meijer et al. (2015) found that farmers who have participated in tree planting activities demonstrate more positive subjective norms towards sustainable agriculture, indicating that tree planting serves as an indicator of farmers' readiness to embrace sustainable farming practices [45]. Additionally, Wang et al. (2019) highlight the influence of subjective norms on farmers' intention to engage in pro-environmental behavior, showing that farmers' beliefs about societal expectations and norms associated with environmental practices significantly impact their decision-making [46]. Furthermore, multiple case studies [47–50] have emphasized the influential role of farmers' subjective norms in shaping their adoption of specific agricultural practices.

Perceived Behavioral Control (PBC) towards the Adoption of Sustainable Agriculture (ASA) encompasses individuals' subjective assessment of their capability to successfully adopt and implement sustainable farming practices, considering their skills, resources, and external constraints. PBC plays a crucial role in farmers' inclination to embrace sustainable farming practices. Despotović et al. (2019) emphasize the significant influence of perceived behavioral control, along with farm size, on farmers' intentions to adopt integrated pest management practices, highlighting the importance of personal beliefs and control in driving sustainable agricultural behavior. Conversely, factors such as environmental knowledge, education level, and the use of extension services do not exhibit substantial impacts on the adoption of integrated pest management practices [51]. Additionally, Lynne et al. (1995) suggest that farmers' perceived behavioral control significantly influences their decision-making process regarding the adoption of conservation technology and their level of investment in such technology [52]. Farmers' perception of their ability to effectively implement and control the use of conservation technology shapes their choices and actions in embracing sustainable agricultural practices. Furthermore, multiple case studies [43,53,54] further strengthen the influential role of farmers' perceived behavioral control in determining their adoption of specific agricultural practices.

Relative Advantage (RAD) towards the Adoption of Sustainable Agriculture (ASA) encompasses the perceived benefits and advantages associated with embracing sustainable farming practices compared to conventional or alternative approaches, including improved profitability, environmental impact, resource efficiency, and long-term sustainability. RAD plays a significant role in farmers' inclination to adopt sustainable farming practices. The research by Adebayo, S.A. and Oladele, O.I. (2012) highlights the influential role of perceived relative advantage in farmers' adoption of sustainable agriculture practices, indicating that positive perceptions of the relative advantage of organic agriculture increase the likelihood of adopting and engaging in organic farming methods [55]. Similarly, Tutkun and Lehmann (2006) underscore the significant effects of variables such as 'Goal' and 'Communication' on farmers' adoption of sustainable agriculture practices, emphasizing the relative advantage they offer. The inclusion of personal goal-setting and rational decision-making processes, along with effective communication through personal channels, demonstrates the importance of relative advantage in shaping individual decision-making [56]. Furthermore, multiple case studies [57–60] further reinforce the influential role of farmers' perceived relative advantage in determining their adoption of specific agricultural practices.

Compatibility (COA) towards the Adoption of Sustainable Agriculture (ASA) encompasses the extent to which sustainable agricultural practices or technologies align with farmers' existing knowledge, skills, resources, and goals. It plays a significant role in influencing farmers' decisions to adopt sustainable farming practices. Aubert et al.'s (2012) research highlights the importance of aligning precision agriculture (PA) technology components with farmers' existing farming systems, emphasizing its impact on adoption decisions. When the PA technology is compatible with farmers' knowledge, skills, resources, and objectives, they are more likely to adopt sustainable agricultural practices [61]. Mannan (2014) further emphasizes the role of compatibility, indicating that farmers are more inclined to adopt innovations that align with their values, experiences, and needs. This is evident in the study on *New Technologies Adoption* by Paddy Farmers, where higher adoption rates are observed when innovations align well with a farmer's context. Understanding compatibility is essential for the successful adoption of sustainable agricultural technologies [62]. Multiple case studies [63–65] further support the influential role of farmers' perceived compatibility in determining their adoption of specific agricultural practices.

Complexity (COE) towards the Adoption of Sustainable Agriculture (ASA) refers to the perceived level of difficulty, intricacy, or technical requirements associated with adopting and implementing sustainable agricultural practices or technologies. It encompasses various factors that contribute to the perceived complexity, such as technical knowledge, operational procedures, skill requirements, and the need for additional resources. Perceived complexity significantly influences farmers' reluctance to adopt sustainable farming practices. Mannan et al. (2017) research reveals that perceived complexity plays a crucial role in farmers' decision-making process, leading to their resistance to adopting technologies like Green Fertilizer among Paddy Farmers in Perak State. Farmers are more likely to resist adoption when they perceive high levels of complexity associated with implementing and managing a technology, influenced by factors such as technical requirements, operational procedures, and the need for additional skills [66]. Similarly, Peshin et al. (2009) highlight the impact of complexity on farmers' reluctance to adopt Integrated Pest Management (IPM) practices, where the perceived complexity of IPM procedures and technical requirements can deter adoption. Addressing the perceived complexity of sustainable agricultural technologies and providing support to overcome challenges can facilitate adoption [67,68]. Multiple case studies further support the role of complexity in determining farmers' adoption of specific agricultural practices [69–71].

Trialability (TRA) towards the Adoption of Sustainable Agriculture (ASA) refers to the extent to which farmers can experiment with and evaluate sustainable agricultural practices or technologies on a small scale before making a full commitment. It involves providing farmers with the opportunity to test and assess the benefits, feasibility, and compatibility of new approaches within their specific farming contexts before adopting them more extensively. Trialability is a crucial factor influencing farmers' adoption of sustainable farming practices. The research by Lavoie et al. (2021) demonstrates the significant role of trialability in farmers' willingness to adopt cover crops, which enhance soil and water quality. When farmers perceive cover crops as trialable, allowing them to experiment on a small scale and assess the benefits, they are more motivated to adopt them. The opportunity to trial cover crops provides farmers with firsthand experience and the ability to observe the positive impacts on soil and water quality, thereby increasing adoption rates [69]. Similarly, Ploll et al. (2022) highlight the influential role of trialability in farmers' adoption of beneficial soil microbes in Germany and the U.K. Farmers are more likely to adopt beneficial soil microbes when they perceive the trialability of using them. By promoting trialability and providing farmers with resources and support to experiment with cover crops and beneficial soil microbes, the adoption of sustainable agricultural practices can be facilitated [64]. Multiple case studies further support the influential role of farmers' trialability in determining their adoption of specific agricultural practices [65,72,73].

Observability (OBV) towards the Adoption of Sustainable Agriculture (ASA) refers to the visibility and tangible evidence of the positive outcomes and benefits associated with sustainable agricultural practices or technologies. It involves farmers being able to observe and perceive the successful implementation and results of these practices, which can enhance their motivation and confidence to adopt them. Observability is a crucial factor influencing farmers' decisions regarding the adoption of sustainable farming practices. The research by C.-L. Lee et al. (2021) highlights the significant role of observability in farmers' adoption of Precision Agriculture (PA) techniques as part of sustainable agricultural practices. The ability of farmers to visually observe the positive outcomes and benefits of implementing PA, either through demonstrations or by witnessing successful adoption on neighboring farms, motivates them to adopt these practices themselves. This visual perception of the effectiveness and impact of PA enhances farmers' confidence and trust in its potential benefits, thereby leading to increased adoption rates [74]. Similarly, Dewi et al. (2023) found that observability plays a significant role in increasing the adoption of the Internet of Things (IoT) in Indonesian agriculture. When farmers can observe the tangible benefits and positive outcomes associated with IoT applications in farming, they are more inclined to embrace and adopt these technologies. The visibility of improved efficiency, enhanced productivity, and optimized resource utilization achieved through IoT implementations serves as a powerful motivator for farmers to integrate IoT solutions into their agricultural practices. By witnessing the observable advantages of IoT in agriculture, farmers are encouraged to embrace sustainable farming practices and leverage technology for improved agricultural outcomes [65]. Additionally, multiple case studies have further demonstrated the influential role of observability in determining farmers' adoption of specific agricultural practices [69,75,76].

Figure 1 presents the conceptual model that illustrates the relationships among the factors influencing the adoption of sustainable agriculture (ASA) practices. The model includes eight key factors: attitudes (ATT), subjective norms (SNM), perceived behavioral control (PBC), relative advantage (RAD), compatibility (COA), complexity (COE), trialability (TRA), and observability (OBV). These factors are hypothesized to play a significant role in shaping farmers' adoption decisions. Attitudes (ATT) refer to individuals' psychological dispositions, beliefs, and evaluations regarding the acceptance and implementation of sustainable farming practices. Subjective norms (SNM) capture the perceived social pressures and influence from significant others, shaping individuals' attitudes and intentions. Perceived behavioral control (PBC) reflects individuals' subjective assessment of their capability to successfully adopt and implement sustainable farming practices. Relative advantage (RAD) represents the perceived benefits and advantages of adopting sustainable practices compared to conventional or alternative approaches. Compatibility (COA) refers to the alignment and fit between sustainable practices and farmers' existing knowledge, skills, resources, and goals. Complexity (COE) reflects the level of perceived difficulty or technical requirements associated with adopting and implementing sustainable practices. Trialability (TRA) represents the opportunity for farmers to experiment with and evaluate sustainable practices on a small scale before making a full commitment. Observability (OBV) refers to the visibility and tangible evidence of the positive outcomes and benefits associated with sustainable practices.

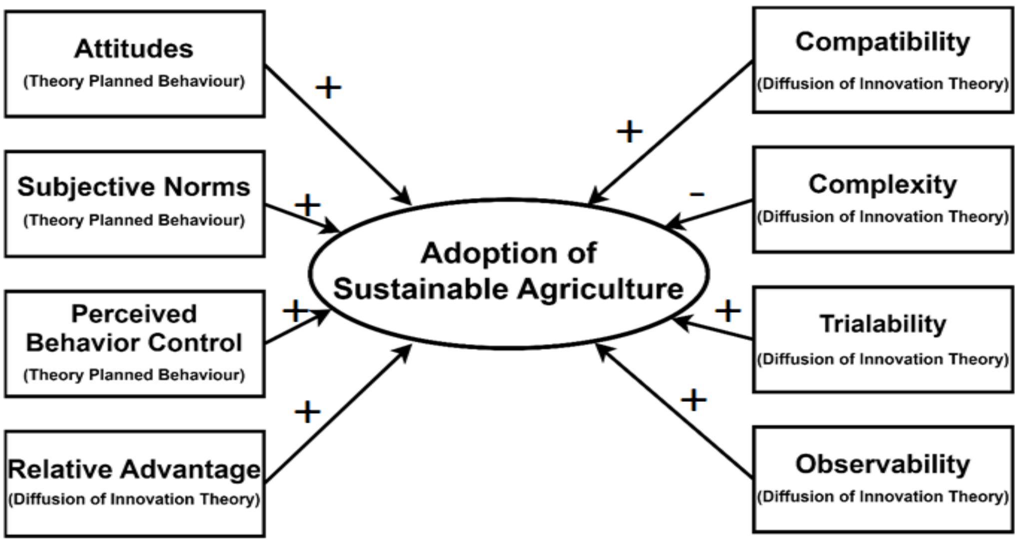

Figure 1. Conceptual framework: model of farmers' adoption of sustainable agriculture practices.

Based on the conceptual model, several hypotheses were formulated to test the causal relationships among these factors. The relationships between these factors will be examined through empirical research, contributing to a deeper understanding of the adoption of sustainable agricultural practices by palm oil farmers:

H1. *Attitudes (ATT) have a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

H2. *Subjective Norms (SNM) have a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

H3. *Perceived Behavioral Control (PBC) has a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

H4. *Relative Advantage (RAD) has a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

H5. *Compatibility (COA) has a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

H6. *Complexity (COE) has a significant negative influence on the Adoption of Sustainable Agriculture (ASA).*

H7. *Trialability (TRA) has a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

H8. *Observability (OBV) has a significant positive influence on the Adoption of Sustainable Agriculture (ASA).*

2. Materials and Methods

This study employed a structural equation model (SEM) to rigorously examine the key determinants influencing farmers' propensity to adopt sustainable agricultural practices. A detailed graphical representation of this SEM is provided in Figure 2 for clarity and comprehensive understanding. Our investigation specifically focused on palm oil farmers in West Kalimantan, Indonesia. This province is notably significant due to its substantial contribution to the nation's palm oil production. In conducting our research, we randomly selected palm oil farmers who were available at the time of the survey. This method was chosen to ensure a diverse and representative sample from this key region, capturing a wide range of experiences and perspectives crucial for understanding the dynamics of sustainable practice adoption in Indonesian palm oil farming [1,77].

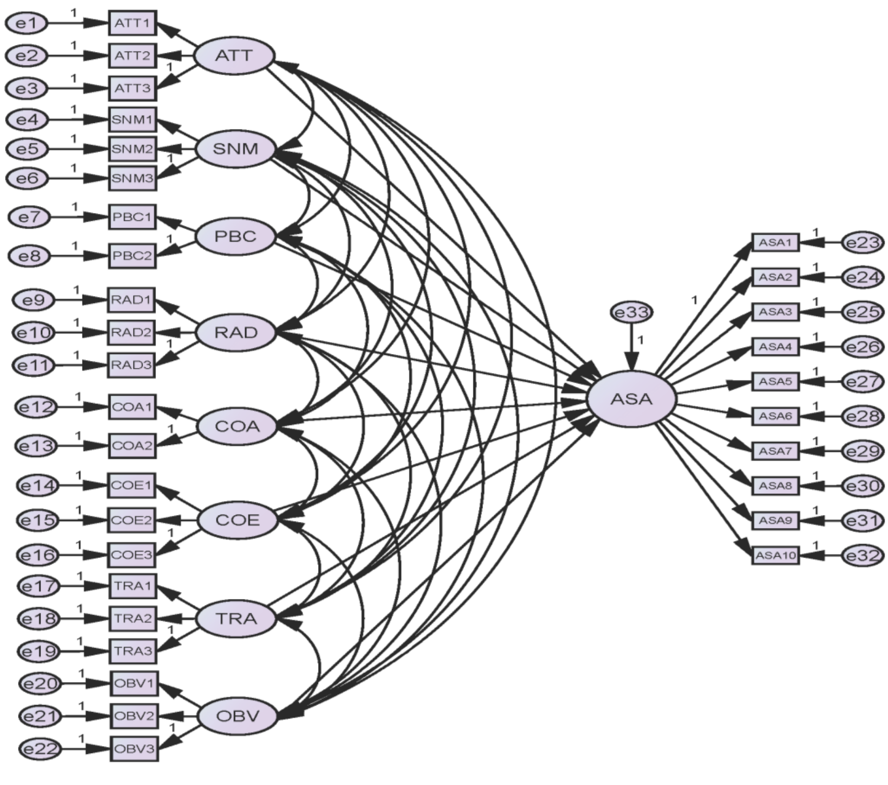

Figure 2. Graphical representation of the structural model.

The selection of measurable variables was based on a thorough review of existing literature, which encompassed both theoretical and empirical studies. This review helped identify key constructs and variables that are consistently linked to the adoption of sustainable agricultural practices. Variables were selected based on their conceptual relevance and alignment with the research objectives. The researcher devised a questionnaire that integrated the Theory of Planned Behavior (TPB) and the Diffusion of Innovation (DOI) frameworks within the agricultural sector, drawing upon the relevant literature (Table 1).

Table 1. Literature review.

Latent Variables	Measured Variables	References
Attitudes (ATT)	I am convinced that adopting sustainable agricultural methods will enhance yields, improve soil health, and lessen environmental impact (ATT1)	[78,79]
	I am of the view that sustainable agricultural practices will not significantly increase labor and input costs (ATT2)	[78,79]
	My prior experiences with sustainable agriculture have encouraged me to continue using and expanding these practices in my farming activities (ATT3)	[80,81]
Subjective Norms (SNM)	I feel that my family, peers, and community leaders endorse the use of sustainable agricultural methods (SNM1)	[50,82]
	I sense industry pressure to adhere to certification standards and implement sustainable agricultural methods (SNM2)	[81,83]
	I place high value on environmental respect and believe that employing sustainable agricultural practices reflects this principle (SNM3)	[84]
Perceived Behavioral Control (PBC)	I have the necessary resources like land, finances, and labor to adopt sustainable agricultural practices (PBC1)	[38,85]
	I have access to educational and advisory services related to sustainable agriculture (PBC2)	[61]
Relative Advantage (RAD)	I am persuaded that utilizing sustainable agricultural practices will bring increased benefits to me (RAD1)	[60,83]
	I am convinced that sustainable agricultural practices will reduce my environmental footprint (RAD2)	[86,87]
	I believe that practicing sustainable agriculture will elevate my social standing (RAD3)	[88]
Compatibility (COA)	I consider sustainable agricultural practices to be culturally and socially significant to me (COA1)	[89]
	Based on my positive past experiences with new farming techniques, I am confident in successfully implementing sustainable agricultural practices (COA2)	[90,91]
Complexity (COE)	I think that sustainable agricultural practices do not demand extensive knowledge and skills (COE1)	[38,92]
	I am of the opinion that sustainable agricultural practices can positively affect crop yields or profits (COE2)	[93]
	I believe that the support provided by agricultural organizations or government agencies is adequate (COE3)	[94]
Trialability (TRA)	I am confident about trialing sustainable agricultural practices before fully committing to them, considering the local economic and market conditions for sustainable agriculture (TRA1)	[95]
	I am open to experimenting with sustainable agricultural practices with limited resources and low risk, in line with local economic and market conditions (TRA2)	[96]
	am ready to adopt sustainable agricultural practices to meet my specific needs and preferences, factoring in local economic and market dynamics (TRA3)	[86,93]
Observability (OBV)	I believe that the visible benefits and outcomes of using sustainable agricultural practices are encouraging others to adopt them (OBV1)	[81,97]
	I am convinced that the availability of reliable and trustworthy information on sustainable agricultural practices is motivating others to adopt them (OBV2)	[98,99]
	I think that the chance to learn from those who have already embraced sustainable agricultural practices is inspiring others to follow suit (OBV3)	[98,99]

Table 1. *Cont.*

Latent Variables	Measured Variables	References
Adoption of Sustainable Agriculture (ASA)	I am confident that my farming techniques maximize efficient water usage (ASA1)	[80]
	I believe my farming methods effectively conserve energy (ASA2)	[91,100]
	I feel my agricultural practices have positively impacted local biodiversity (ASA3)	[93,101]
	I am certain that I have invested significantly in sustainable agricultural practices (ASA4)	[100,102]
	I am assured that my farming showcases a high degree of crop diversity (ASA5)	[101,102]
	I am convinced that the soil health on my agricultural land is well maintained (ASA6)	[80,103]
	I believe my agricultural methods substantially contribute to climate change mitigation (ASA7)	[78,104]
	I am certain that my soil is rich in organic matter (ASA8)	[78,101]
	I am of the opinion that greenhouse gas emissions from my farming are at an acceptable level (ASA9)	[100,105]
	I believe that my agricultural practices involve minimal use of synthetic fertilizers and pesticides (ASA10)	[78,105]

The questionnaire covers various areas, including demographic characteristics, knowledge and perception of the ISPO certification, motivations for adopting sustainable practices, perceived barriers to adoption, and overall attitudes toward sustainability. The specific method employed in the questionnaire survey is face-to-face interviews conducted in the local language, using easy-to-understand language. During the interviews, the interviewer explains the questions when necessary to ensure participants' understanding [106,107].

Furthermore, to ensure the validity and reliability of the questionnaire used in the study, a pre-test was conducted [108]. This involved engaging a focus group comprising a small group of 10 experienced palm oil farmers. The purpose of the pre-test was to gather feedback and assess the clarity, comprehensibility, and relevance of the questionnaire items. The participants were asked to provide their insights, suggestions, and any difficulties they encountered while answering the questions. The feedback obtained from the focus group was invaluable in refining the questionnaire, ensuring that it captured the specific needs and experiences of palm oil farmers. After making necessary adjustments based on the feedback received, the final version of the questionnaire was prepared and administered to the primary sample, ensuring the validity and appropriateness of the instrument for data collection.

Data collection will be carried out through the utilization of a structured questionnaire incorporating closed-ended questions and a Semantic Differential scale, employing a range of 1 to 7 to assess the selected variables on a continuum from "strongly disagree" to "strongly agree". Prior to participation, informed consent was obtained from all participants in accordance with the ethical guidelines and regulations governing human subjects research. This critical step ensured that participants were fully aware of the study's purpose, procedures, potential risks, and provided their voluntary agreement to take part in the research [109].

Subsequently, the present study utilized a random distribution method to distribute 300 questionnaires among potential participants, resulting in 291 completed responses. Upon careful examination, it was determined that 18 responses were invalid, leaving a final count of 273 valid responses available for subsequent analysis. In accordance with best practices in measurement modeling, the research employed a measurement model consisting of 32 observed variables. This approach necessitated a sample size of $n = 256$ (32×8) to ensure adequate statistical power [110,111].

Moreover, the evaluation of the model fit index was conducted using confirmatory factor analysis (CFA) to test hypotheses regarding the factor structure [112]. Fit indices such as CMIN/df, RMSEA, TLI, and CFI were employed to measure the extent to which the theoretical model aligns with the existing data. If the indices satisfy the stipulated constraints, it indicates a good level of fit, meaning that the resulting model can be used to interpret the phenomenon under investigation [113,114]. The applied methodology ensures that the study's findings are robust and that the conclusions drawn are grounded in statistically valid interpretations, contributing to the reliability and validity of the research within the broader scientific discourse on the subject.

To ascertain the validity and reliability of the questionnaire, the study employed several statistical measures. The reliability was assessed by calculating the Composite Reliability (CR) and Cronbach's alpha (CA) for each construct in the questionnaire. The validity was determined through the Average Variance Extracted (AVE) and Mean Square Variance (MSV) for each construct [115]. High values of CR and CA would indicate high internal consistency of the items within each construct, while AVE and MSV would provide insights into the amount of variance captured by the construct in relation to the amount due to measurement error, and the maximum shared variance between any one construct and others in the model, respectively. These statistical measures would be calculated after the data collection process to ensure the reliability and validity of the constructs used in the questionnaire [116].

3. Results

Table 2 shows that the majority of participants were in the middle-aged group, particularly those aged 30–50, which bears significant implications for the adoption of sustainable farming practices. The mature experiences and knowledge within this age range can considerably shape the acceptance and implementation of such practices [81,89]. Nonetheless, the age variable may simultaneously present hurdles to the assimilation of novel innovations.

Table 2. Socio-demographic characteristics of palm oil farmers in this research.

Variable	Category	Frequency	Percentage
Age (year)	<30 (Younger farmers)	13	4.76%
	30–50 (Middle-aged farmers)	190	69.59%
	>50 (Older farmers)	70	25.65%
Experience (year)	1–10	16	5.86%
	11–20	182	66.67%
	21–30	75	27.47%
Level of Education	Primary School	75	27.47%
	Secondary School	153	56.04%
	High School	29	10.62%
	Higher Education	16	5.86%
Primary Access of Information	Government	17	6.22%
	Non-Governmental Organizations	169	61.9%
	Internet	18	6.59%
	Peers	68	24.9%
	Other Sources	1	0.36%

The analysis also exposed that the average work experience among independent palm oil farmers spanned roughly a decade, varying between 1 and 30 years. This extensive experience can potentially sway the attitudes and readiness of these farmers towards embracing sustainable agricultural practices, with a longer work duration likely to facilitate a more profound understanding of the benefits and challenges accompanying these practices [117]. However, the factor of experience can alternatively serve as an obstruction to the acceptance of fresh innovations.

In terms of education, the study revealed that the lion's share of independent palm oil farmers had completed primary education or lower. This lean towards lower educational attainment can influence the farmers' risk perceptions and their capacity to adopt innovations and advancements in sustainable agricultural practices. Therefore, there is a pressing need to furnish effective education and extension services to enhance the understanding and awareness of these farmers about the benefits and significance of sustainable agricultural practices [82,118].

Finally, the findings underscored that non-governmental organizations (NGOs) represent the primary information source for independent palm oil farmers. This insight into the prevalent practices and information channels influencing the adoption of sustainable agricultural practices among these farmers underscores the instrumental role NGOs play. Their contribution to imparting information, delivering training, and offering mentorship to independent farmers is crucial to fortifying their comprehension and grasp of sustainable farming practices [82,117]. Yet, an overreliance on a solitary information source could also erect barriers to the acceptance of innovations.

The goodness-of-fit for the model was evaluated using confirmatory factor analysis, where the beta estimates of the measured items were examined. As presented in Table 3, all the beta estimates exceeded the recommended level (>0.1) and were statistically significant at $p < 0.01$ [119]. The minimum beta estimate observed was 0.614. It is widely recognized in the literature that a beta estimate of 0.10 or higher is considered indicative of a strong validation for the variables.

Table 3. Research measurement, variables, and estimates (β).

Latent Variables	Measured Variables	Estimate (β)
Attitudes (ATT)	Perceived Yield Impact (ATT1)	0.631 a
	Perceived Cost Impact (ATT2)	0.784 a
	Influence of Experience (ATT3)	0.874 a
Subjective Norms (SNM)	Community Support Perception (SNM1)	0.823 a
	Industry Pressure Perception (SNM2)	0.874 a
	Environmental Respect Perception (SNM3)	0.774 a
Perceived Behavioral Control (PBC)	Resource Availability Perception (PBC1)	0.987 a
	Training Access Perception (PBC2)	0.697 a
Relative Advantage (RAD)	Perceived Benefit Increase (RAD1)	0.894 a
	Perceived Environmental Reduction (RAD2)	0.854 a
	Social Status Perception (RAD3)	0.776 a
Compatibility (COA)	Cultural Importance Perception (COA1)	0.689 a
	Success Confidence Perception (COA2)	0.913 a
Complexity (COE)	Skill Requirement Perception (COE1)	0.845 a
	Impact on Yield Perception (COE2)	0.783 a
	Support Sufficiency Perception (COE3)	0.614 a
Trialability (TRA)	Confidence in Experimentation (TRA1)	0.734 a
	Risk Acceptance Willingness (TRA2)	0.846 a
	Modification Willingness (TRA3)	0.774 a
Observability (OBV)	Observable Benefit Perception (OBV1)	0.675 a
	Trustworthy Information Perception (OBV2)	0.757 a
	Learning From Others Perception (OBV3)	0.788 a
Adoption of Sustainable Agriculture (ASA)	Water Efficiency (ASA1)	0.778 a
	Energy Conservation (ASA2)	0.685 a
	Biodiversity Impact (ASA3)	0.739 a
	Investment in Sustainability (ASA4)	0.699 a
	Crop Diversity (ASA5)	0.886 a
	Soil Health (ASA6)	0.854 a
	Climate Change Mitigation (ASA7)	0.823 a
	Organic Matter Presence (ASA8)	0.688 a
	Greenhouse Gas (ASA9)	0.824 a
	Synthetic Input Usage (ASA10)	0.678 a

a—significant at $p < 0.01$.

Table 4 presents the Average Variance Extracted (AVE), Mean Square Variance (MSV), Composite Reliability (CR), and Cronbach's alpha (CA) values. These metrics serve as indicators of the reliability and validity of the measurement constructs used in the study. The results show that the AVE, CR, and CA values meet the recommended thresholds, indicating satisfactory internal consistency and construct reliability (CR > 0.7), convergent validity (AVE > 0.5), and discriminant validity (MSV < AVE), indicating adequate discriminant validity between the constructs [120,121].

Table 4. Reliability and convergent validity analysis results.

	ATT	SNM	PBC	RAD	COA	COE	TRA	OBV	ASA
Composite reliability (CR)	0.774	0.747	0.745	0.746	0.775	0.754	0.723	0.743	0.846
Cronbach alpha (CA)	0.864	0.812	0.735	0.766	0.773	0.734	0.846	0.836	0.942
Average Variance Extracted (AVE)	0.552	0.535	0.663	0.562	0.626	0.526	0.572	0.525	0.535
Mean Square Variance (MSV)	0.212	0.341	0.161	0.216	0.163	0.286	0.399	0.248	0.397

Furthermore, Table 5 provides the Pearson's correlation coefficients between the variables. The results reveal that the correlations among the variables are all less than 0.800, suggesting no issues with multicollinearity. These findings support the reliability, validity, and distinctiveness of the measurement constructs employed in the study, thereby enhancing confidence in the subsequent data analysis and interpretation [122].

Table 5. Pearson's correlation coefficients between variables.

Variables	ATT	SNM	PBC	RAD	COA	COE	TRA	OBV	ASA
ATT	1.000								
SNM	0.463 **	1.000							
PBC	0.574 **	0.674 **	1.000						
RAD	0.473 **	0.564 **	0.673 **	1.000					
COA	0.336 **	0.662 **	0.732 **	0.523 **	1.000				
COE	0.473 **	0.426 **	0.563 **	0.485 **	0.383 **	1.000			
TRA	0.473 **	0.793 **	0.663 **	0.784 **	0.583 **	0.736**	1.000		
OBV	0.675 **	0.651 **	0.577 **	0.484 **	0.638 **	0.546 **	0.647 **	1.000	
ASA	0.786 **	0.721 **	0.744 **	0.585 **	0.736 **	0.584 **	0.688 **	0.523 **	1.000

** $p < 0.01$.

Table 6 presents the results of the reliability analysis for all factors in the study. The findings indicate that the factors meet the necessary requirements for reliability, suggesting that the measurement instruments employed in the study are consistent and dependable.

Table 6. Evaluation of Model Fit Indices and Actual Values.

Model Fit Index	Evaluation Standard	Actual Value
CMIN/df	$\leq$2 (acceptable)	1.63
RMSEA	$\leq$0.08 (acceptable)	0.033
GFI	$\geq$0.9 (acceptable)	0.953
TLI	$\geq$0.9 (acceptable)	0.962
CFI	$\geq$0.9 (acceptable)	0.924

The fit indices used to evaluate the model's goodness-of-fit include the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Root Mean Square Error of Approximation (RMSEA), and the ratio of the Chi-square value to the degrees of freedom (CMIN/df). The obtained results demonstrate that the model exhibited satisfactory fit indices. Specifically, all the values for the fit indices met the recommended criteria for model fit in structural equation modeling (SEM). The CFI, GFI, and TLI values were all greater than 0.900, indicating a good fit between the model and the observed data. The RMSEA value was less than 0.070, suggesting a reasonable fit of the model to the data. Furthermore, the CMIN/df value was less than 2, which indicates an acceptable fit [123,124].

These findings indicate that the proposed model fits the data well, providing support for the theoretical framework and the relationships among the variables under investigation. The satisfactory fit indices contribute to the validity and reliability of the model, enhancing confidence in the study's conclusions and implications.

The statistical analyses conducted in this study were performed using the model of factors that influence ASA (Figure 3). The results of the hypothesis tests are presented in Table 7, which includes standardized path coefficients, along with corresponding estimates (β), standard errors (S.E.), critical ratios (C.R.), and *p*-values. These statistical parameters provide valuable insights into the significance of the relationships among the variables under investigation. By examining the standardized path coefficients, one can determine the strength and direction of the relationships between the variables. The estimates (β) indicate the magnitude of the effect, while the standard errors (S.E.) represent the level of uncertainty associated with the estimates. The critical ratios (C.R.) are used to assess the statistical significance of the coefficients, indicating the extent to which the observed relationships deviate from zero. The *p*-values provide further evidence regarding the significance of the relationships, indicating whether they are statistically different from zero [125,126].

The inclusion of these statistical measures in Table 7 allows for a comprehensive evaluation of the hypothesis tests and their implications. The standardized path coefficients, along with their corresponding statistical parameters, contribute to a better understanding of the relationships among the variables studied. These findings enable researchers and readers to assess the strength and significance of the associations, thereby enhancing the robustness and validity of the study's conclusions.

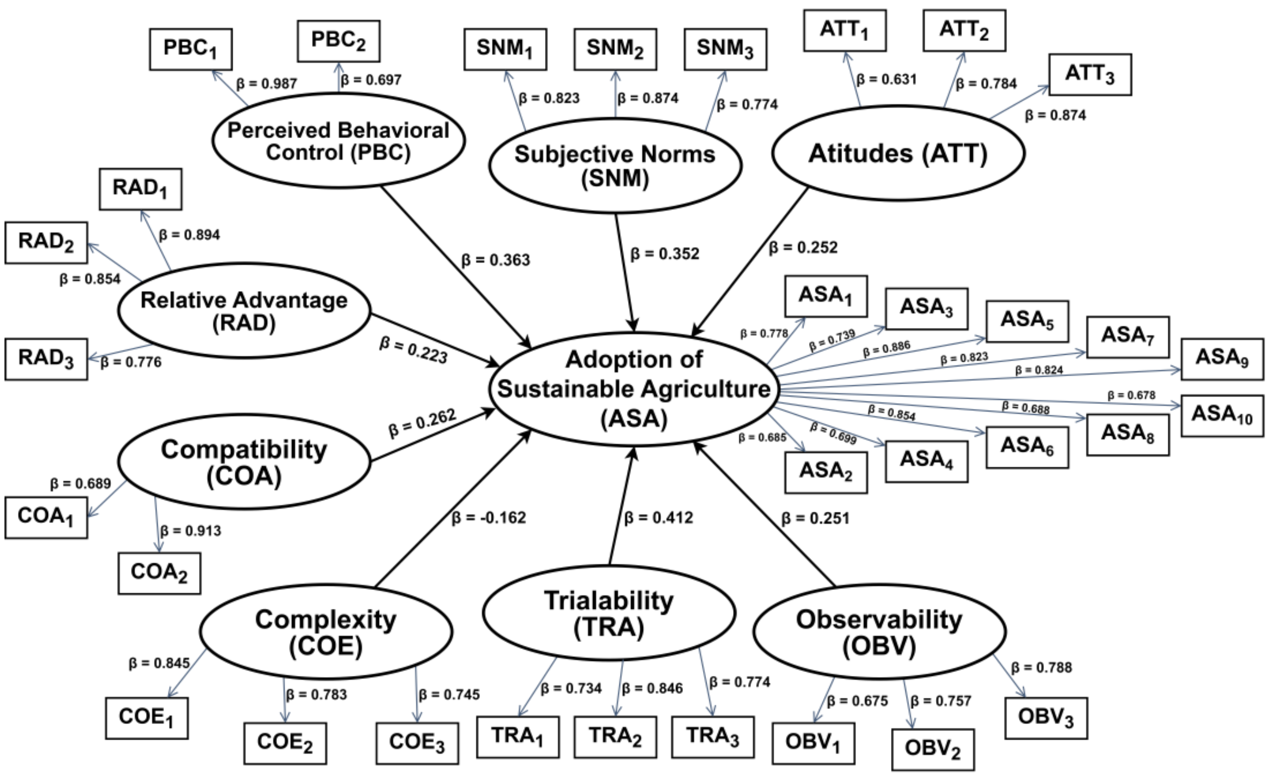

Figure 3. The result of structural equation model (SEM).

Table 7. Hypothesis testing results and statistical significance.

Hypothesis	Relationship	Estimate (β)	S.E.	C.R.	*p*-Value
H1	ATT → ASA	0.252	0.032	1.452	0.035
H2	SNM → ASA	0.352	0.051	1.262	0.042
H3	PBC → ASA	0.363	0.015	2.561	<0.01
H4	RAD → ASA	0.223	0.061	2.061	<0.01
H5	COA → ASA	0.262	0.026	1.926	<0.01
H6	COE → ASA	−0.162	0.026	−1.462	0.035
H7	TRA → ASA	0.412	0.062	1.362	0.012
H8	OBV → ASA	0.251	0.023	2.464	<0.01

Note: ATT = Attitudes; SNM = Subjective Norms; PBC = Perceived Behavioral Control; RAD = Relative Advantage; COA = Compatibility; COE = Complexity; TRA = Trialability; OBV = Observability; ASA = Adoption of Sustainable Agriculture.

4. Discussion

4.1. Attitudes towards Farmers' Adoption of Sustainable Agriculture

The results of the analysis indicate a statistically significant positive correlation (β = 0.252, $p < 0.05$) between farmers' attitudes (ATT) towards the adoption of sustainable agriculture (ASA) practices and their actual adoption. This finding underscores the importance of actively promoting the benefits associated with sustainable practices, such as higher crop yields, improved soil health, and reduced environmental impact, as a means to encourage greater adoption rates. To effectively facilitate this process, it is essential to educate farmers about the multiple advantages associated with sustainable agricultural practices, including increased yields, enhanced soil health, reduced environmental impact (ATT_1), and improved social standing. This can be achieved through the implementation of well-designed awareness campaigns, workshops, and training programs, which serve to disseminate accurate and comprehensive information and enhance farmers' knowledge and awareness (ATT_3). Moreover, it is strongly recommended to furnish farmers with evidence-based information and empirical data that substantiate the cost-effectiveness of adopting sustainable practices (ATT_2). By presenting successful case studies and illustrating the long-term benefits, such as improved profitability, increased resilience, and enhanced market access, farmers can be reassured that any perceived increases in labor and input costs associated with sustainable practices can be mitigated by overall gains [127,128]. By adopting these recommendations, stakeholders, policymakers, and researchers can contribute to the widespread adoption of sustainable practices in the agricultural sector, thereby fostering long-term environmental, social, and economic sustainability [129].

4.2. Subjective Norms towards Farmers' Adoption of Sustainable Agriculture

The results of the analysis indicate a statistically significant positive correlation (β = 0.352, $p < 0.05$) between farmers' subjective norms (SNM) towards the adoption of sustainable agriculture (ASA) practices and their actual adoption. This finding underscores the significance of social influences, including support from family members, peers, and community leaders, in shaping farmers' decisions to adopt sustainable practices. It highlights the importance of considering the broader social and cultural contexts within which farmers operate and the need to engage key stakeholders in promoting sustainable agricultural practices. To effectively promote the adoption of sustainable practices, it is crucial to engage and involve key stakeholders, such as family members, peers, community leaders, agricultural organizations, and government agencies, who can contribute to creating a supportive environment (SNM_1) [130]. Such collaboration and collective efforts are essential for establishing social norms that endorse and encourage the adoption of sustainable practices, while also providing the necessary support and resources to farmers (SNM_2) [131]. By fostering an environment where farmers feel motivated and supported, the likelihood of their adoption of sustainable practices can be enhanced, ultimately contributing to the broader goals of sustainability in agriculture (SNM_3) [132].

4.3. Perceived Behavioral Control towards Farmers' Adoption of Sustainable Agriculture

The results of the analysis demonstrate a significant positive correlation (β = 0.363, $p < 0.05$) between farmers' perceived behavioral control (PBC) and their adoption of sustainable agriculture (ASA) practices. This finding underscores the significance of farmers' beliefs regarding their access to necessary resources and training in influencing their decisions to adopt sustainable practices. It highlights the critical role of addressing factors such as land availability, financial resources, labor availability, and access to training and extension services in enhancing farmers' perceived control over the adoption of sustainable practices. Policymakers and stakeholders should prioritize efforts to improve farmers' access to essential resources for sustainable agriculture, including land allocation, financial incentives, labor support, and comprehensive training and extension services (PBC_1) [133]. Providing financial incentives, subsidies, and streamlined access to loans can facilitate the adoption of sustainable practices by alleviating financial constraints [134]. Furthermore, strengthening training and extension services can enhance farmers' knowledge, skills, and technical capacities, enabling them to effectively implement sustainable practices on their farms (PBC_2) [135]. By addressing these key factors, policymakers can create an enabling environment that empowers farmers and increases their perceived control, ultimately fostering the widespread adoption of sustainable agriculture practices.

4.4. Relative Advantage towards Farmers' Adoption of Sustainable Agriculture

The findings of the analysis demonstrate a statistically significant positive correlation (β = 0.223, $p < 0.001$) between farmers' perceptions of the relative advantage (RAD) of adopting sustainable agriculture (ASA) practices and their likelihood of adoption. This highlights the importance of farmers' beliefs regarding the financial, environmental, and social benefits associated with sustainable practices in influencing their adoption decisions. Specifically, this study reveals that farmers who perceive sustainable practices as offering improvements in crop yields and reduced input costs (RAD_1), environmental protection (RAD_2), and enhanced community reputation (RAD_3) are more inclined to adopt sustainable agriculture practices. To promote the adoption of sustainable practices, it is crucial to emphasize and communicate the economic, environmental, and social benefits associated with their implementation [61]. Emphasizing how adopting sustainable practices can lead to increased profits, reduced input costs, enhanced reputation, and positive impacts on the environment and community can serve as motivational factors for farmers. By effectively communicating these potential advantages, policymakers, agricultural organizations, and other stakeholders can create awareness and motivation among farmers, thereby encouraging the widespread adoption of sustainable palm oil practices [136].

4.5. Compatibility towards Farmers' Adoption of Sustainable Agriculture

The findings of the analysis reveal a statistically significant positive correlation (β = 0.262, $p < 0.001$) between farmers' perceptions of compatibility (COA) towards the adoption of sustainable agriculture (ASA) practices and their likelihood of adoption. This highlights the importance of considering farmers' existing beliefs, traditions, and social norms when promoting sustainable practices. The study indicates that farmers are more likely to adopt sustainable agriculture practices if they perceive them as aligning with their desire to be good stewards of the land, preserve natural resources, and maintain the health and well-being of their communities. To increase the likelihood of successful adoption (COA_2), it is crucial to recognize and respect the cultural and social values of farmers and align sustainable practices with their existing beliefs, traditions, and social norms (COA_1) [137]. Emphasizing how sustainable practices contribute to farmers' goals of responsible land management and community well-being can further enhance their adoption. By effectively communicating the compatibility between sustainable practices and farmers' values, policymakers and stakeholders can increase the likelihood of successful adoption and promote the long-term sustainability of agricultural practices [61,138].

4.6. Complexity towards Farmers' Adoption of Sustainable Agriculture

The findings of the analysis indicate a significant negative correlation (β = −0.162, $p < 0.05$) between farmers' perceptions of complexity (COE) towards the adoption of sustainable agriculture (ASA) practices and their likelihood of adoption. This highlights the challenge of complex perceptions that may hinder farmers from adopting sustainable practices. Farmers who perceive sustainable practices as demanding extensive knowledge and skills are less inclined to adopt them. Moreover, concerns about potential negative impacts on crop yields or profits and insufficient support from agricultural organizations or government agencies may further discourage adoption (COE_2). To address these barriers, it is important to simplify the adoption process by providing farmers with clear and practical guidelines, practical demonstrations, and step-by-step implementation plans [97]. Simplifying the complexity associated with sustainable practices can help alleviate farmers' concerns and increase their willingness to adopt (COE_1) [139]. Additionally, providing robust support from agricultural organizations and government agencies can help overcome the perceived barriers and ensure that farmers have the necessary resources and guidance to adopt sustainable practices effectively (COE_3) [140].

4.7. Trialability towards Farmers' Adoption of Sustainable Agriculture

The findings of the analysis demonstrate a significant positive correlation (β = 0.412, $p < 0.05$) between farmers' perceptions of trialability (TRA) towards the adoption of sustainable agriculture (ASA) practices and their likelihood of adoption. This highlights the importance of providing farmers with opportunities to test and observe the outcomes of sustainable practices on a limited scale before fully committing to adoption. Farmers who have the chance to assess the feasibility, effectiveness, and potential benefits of sustainable practices in their specific agricultural contexts are more inclined to adopt them. To promote trialability, it is recommended to create platforms and initiatives that allow farmers to experiment with sustainable practices on a limited scale (TRA_1) [141]. These trial opportunities enable farmers to gain firsthand experience and evaluate the feasibility and potential benefits of sustainable practices before implementing them more widely (TRA_2). Furthermore, facilitating knowledge sharing among farmers who have already adopted sustainable practices can inspire others and provide practical insights (TRA_3). This exchange of experiences and best practices can enhance farmers' confidence and motivation to adopt sustainable agriculture practices [142].

4.8. Observability towards Farmers' Adoption of Sustainable Agriculture

The findings of the analysis reveal a significant positive correlation (β = 0.251, $p < 0.001$) between farmers' perceptions of observability (OBV) towards the adoption of sustainable agriculture (ASA) practices and their likelihood of adoption. This underscores the importance of farmers being able to easily observe the positive results of sustainable practices either on their own farms or in neighboring farms. Observable benefits, such as improved soil health, reduced use of chemical inputs, enhanced biodiversity, and increased community recognition, have a considerable influence on farmers' decisions to adopt sustainable agriculture practices. To encourage adoption, it is recommended to highlight and showcase the positive outcomes of sustainable practices through visible and tangible examples (OBV_2) [143]. This can be achieved by demonstrating how sustainable practices have led to notable improvements in soil health, reduced reliance on chemical inputs, enhanced biodiversity, and gained recognition and support from the community (OBV_3) [144]. By showcasing these observable benefits, farmers are more likely to be motivated to adopt sustainable agriculture practices as they witness the tangible advantages firsthand (OBV_1) [145].

4.9. Comparative Analysis with Similar Studies in Sustainable Agriculture

In the comparative analysis of similar studies in sustainable agriculture, this research makes a distinctive contribution to the academic discourse by focusing on the adoption of sustainable practices among palm oil farmers in West Kalimantan, Indonesia. This approach aligns with global trends in sustainable agriculture research, while also delving into the complex interplay within this regional context. These findings contrast with and complement those from other geographical areas, such as Malaysia's palm oil sector and African subsistence farming, highlighting the significance of localized strategies alongside broader policy implications [146–149]. The incorporation of the ISPO certification system and the pivotal role of local NGOs in these findings offer a nuanced understanding that enriches the broader narrative on sustainable agricultural practices. This study employs a quantitative lens and SEM methodology, contributing to a diverse methodological landscape that includes qualitative and mixed-methods research in sustainable agriculture. Therefore, it resonates not only with common themes in global sustainable farming research but also introduces unique perspectives specific to the Indonesian palm oil industry, enhancing the collective understanding of sustainable agriculture practices in various contexts [150,151].

5. Conclusions

Through rigorous statistical analysis, this study has demonstrated the significant influence of attitudes, subjective norms, perceived behavioral control, and various innovation characteristics such as relative advantage, compatibility, trialability, and observability on the adoption of sustainable agriculture among independent palm oil farmers in West Kalimantan. The emergence of complexity as a factor exerting a negative impact, contrasted with trialability and compatibility showing strong influence, emphasizes the need to align sustainable practices with farmers' motivations, societal norms, and perceived control. To further the adoption of the Indonesian Sustainable Palm Oil (ISPO) certification system by 2025, this study proposes comprehensive measures including augmenting farmers' awareness, fostering stakeholder participation, enhancing resource accessibility, emphasizing the relative advantages of sustainable practices, ensuring alignment with societal norms, simplifying perceived complexity, and promoting trialability. By focusing the study's design on perceptions as measurable variables and analyzing them under the ASA variables, the research provides valuable insights into farmers' attitudes and beliefs, paving the way for understanding their ultimate decisions regarding the ISPO certification system and aligning them with existing research to form a coherent framework for interpreting the underlying factors that steer the adoption of sustainable practices. This study also points to future research, including exploring mediating or moderating variables, assessing farmers' willingness after the ISPO certification is widely socialized, investigating regional disparities, assessing long-term effects, comparing different agricultural sectors, and understanding the role of stakeholders. These areas can contribute to an enriched understanding of the complex dynamics underlying sustainable agricultural adoption. In sum, this study maintains its substantial contribution to the understanding of the motivations and barriers influencing the adoption of sustainable practices among farmers, adding depth with its strategic choice of perception-based variables, resonating with the intricate nature of sustainability and the pragmatic needs of policy and implementation, and consolidating itself as a vital stepping stone towards a more holistic comprehension of this multifaceted issue.

Based on the findings of this study, policymakers and practitioners can utilize the following recommendations to develop targeted strategies, programs, and policies that promote the voluntary adoption of sustainable palm oil practices among farmers and address potential challenges that may arise during the implementation of the Indonesian Sustainable Palm Oil (ISPO) certification system by 2025, in order to avoid unintended consequences:

1. **Enhance awareness and education**: It is crucial to educate farmers about the benefits of sustainable agricultural practices, such as increased yields, better soil health, reduced environmental impact, and improved social status. Awareness campaigns, workshops, and training programs should be organized to disseminate information and increase knowledge among farmers.
2. **Engage stakeholders**: To promote the adoption of sustainable practices, it is essential to engage key stakeholders such as family members, peers, community leaders, agri-

cultural organizations, and government agencies. Creating a supportive environment where farmers feel encouraged and motivated to adopt sustainable practices is crucial. Collaborative efforts involving various stakeholders should be implemented to help in building social norms and providing necessary support.

3. **Improve access to resources**: Policymakers should focus on improving farmers' access to essential resources required for sustainable agriculture, including land, finance, labor, and training and extension services. Providing financial incentives, subsidies, and easy access to loans should facilitate the adoption of sustainable practices. Additionally, strengthening training and extension services should enhance farmers' knowledge and skills in implementing sustainable practices effectively.
4. **Highlight the relative advantages**: It is essential to emphasize the economic, environmental, and social benefits associated with sustainable practices by highlighting how adopting sustainable practices should lead to increased profits, reduced input costs, enhanced reputation, and positive impacts on the environment and community. Communicating the potential advantages should motivate farmers to adopt sustainable palm oil practices.
5. **Ensure compatibility with existing beliefs and norms**: It is important to recognize and respect the cultural and social values of farmers and align sustainable practices with farmers' existing beliefs, traditions, and social norms. Furthermore, it is vital to emphasize how sustainable practices align with the farmers' desire to be responsible stewards of the land and contribute to the well-being of their communities.
6. **Simplify complexity**: Policymakers should address the perceived complexity of sustainable practices by providing farmers with simplified guidelines, practical demonstrations, and step-by-step implementation plans. Simplifying the adoption process should help overcome the barriers associated with complexity. Additionally, providing support from agricultural organizations and government agencies should alleviate concerns related to complexity.
7. **Encourage trialability**: Creating opportunities for farmers to try out sustainable practices on a limited scale before full adoption should help farmers assess the feasibility, effectiveness, and potential benefits of sustainable practices in their specific contexts. Moreover, facilitating knowledge sharing among farmers who have already adopted sustainable practices to inspire others and provide practical insights would be helpful.
8. **Showcase observability**: Highlighting the positive outcomes of sustainable practices through visible and tangible examples, demonstrating how sustainable practices improve soil health, reduce chemical inputs, enhance biodiversity, and gain community recognition, and showcasing such observable benefits should serve as motivation for farmers to adopt sustainable agriculture practices.

To further advance the understanding of the factors influencing the adoption of sustainable palm oil practices among farmers, future research can focus on the following areas:

1. **Regional and contextual differences**: Explore how the factors influencing farmers' adoption of sustainable agriculture practices may vary across different regions in Indonesia or other palm oil-producing countries. Consider the cultural, economic, and environmental variations that may impact farmers' decision-making processes.
2. **Long-term impact assessment**: Investigate the long-term effects of farmers' adoption of sustainable practices on their economic outcomes, environmental sustainability, and social well-being. Assess the changes in productivity, income, resource use, and community dynamics resulting from the adoption of sustainable palm oil practices.
3. **Policy and program evaluation**: Evaluate the effectiveness of existing policies, programs, and interventions aimed at promoting sustainable palm oil practices. Identify strengths, weaknesses, and areas for improvement to enhance the adoption rates and outcomes.
4. **Comparative analysis**: Compare the adoption of sustainable practices in the palm oil industry with other agricultural sectors. Identify similarities, differences, and

transferable lessons that can be applied to promote sustainability in other agricultural contexts.

5. **Stakeholder collaboration**: Investigate the role of various stakeholders, including government agencies, NGOs, industry associations, and consumer groups, in driving the adoption of sustainable palm oil practices and analyze their interactions.

Author Contributions: Methodology, N.I.D., N., E.D. and D.K.; validation, N., E.D. and D.K.; formal analysis, N.; data curation, N.I.D.; writing—original draft, N.I.D., N., E.D. and D.K.; writing—review and editing, N.I.D.; supervision, N., E.D., D.K. and D.S.; project administration, N.I.D. and D.S.; funding acquisition, N.I.D. and D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of the Faculty of Agriculture at Tanjungpura University. Approval Code: 5758/UN22.3/PT.01.05/2022. Approval Date: 7 July 2022.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical restriction.

Conflicts of Interest: The authors declare no conflict of interest.

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