Farmer's Intention to Sustainable Rice Farming in the Mekong Delta of Vietnam: An Application of Theory of Planned Behavior

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Abstract: Despite the various benefits of sustainable agricultural practices, sustainable rice cultivation in the Mekong Delta still faces significant barriers, and its total area is still limited. The government has been making efforts to promote national programs such as "Three Reductions, Three Gains," "One Must Do Five Reductions," and the Vietnam Sustainable Agriculture Transformation Project (VnSAT) to improve farm income, farmer health, and the environment. Nevertheless, rice farmers' decisions to implement sustainable agricultural practices depend significantly on their awareness and intention. This study aims to understand what influences rice farmers' intentions and their behavior toward sustainable rice farming in the Mekong Delta, especially in Long An Province. Data were obtained through face-to-face interviews with 163 rice farmers in two districts of Long An Province. Structural equation modeling was applied to explore the relationship among constructs built on the Theory of Planned Behavior. The estimated structural equation model demonstrates substantial effects of knowledge on attitude, of knowledge on intention, of subjective norms on intention, and of intention on behavior toward sustainable agriculture. The knowledge-intention-behavior path has a favorable, fully mediating impact. Knowledge was the most significant variable in forming attitude and intention, while subjective norms also played a crucial role in intention. On the other hand, the findings indicate that the direct influence of subjective norms on farmers' behavior is weaker for farming rice in sustainable ways than for coping with climate change or extreme weather events. Policy initiatives must be implemented to provide more educational programs, such as vocational training, demonstrating model fields to farmers, and pooling land for large-scale production to enable the effective application of technology in agriculture.

Keywords: *behavior, intention, partial least squares structural equation modeling (PLS-SEM), sustainable rice farming, theory of planned behavior, Vietnam.*

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1. Introduction

Rice is a crucial staple food for over 3 billion people worldwide, especially in Asia. Asia is responsible for 88 percent of global rice consumption and 89 percent of global rice production (Papademetriou 2020). Vietnam is the third largest rice exporter in the world, and this trade contributes 3 percent to the national GDP. The remarkable increase in rice productivity in Vietnam, from 4.3 tons per ha in 2001 to 6.01 tons per ha in 2020, is the outcome of new cultivation technologies, the intensification of high-yielding varieties, and the growing use of chemical inputs, such as synthetic chemical fertilizers and pesticides. However, the long-term excessive use of chemical fertilizers and pesticides poses numerous environmental threats. Rice production accounts for 48 percent of the agricultural sector's greenhouse gas (GHG) emissions and over 75 percent of methane emissions in the country (World Bank 2022).

As of 2021, Vietnam ranked as one of the world's top fertilizer consumers, using over 420 kg per ha. This figure surpasses China's consumption of 374 kg per ha and is significantly greater than the global average of approximately 140 kg per ha (World Bank 2024). As of December 2020, the Vietnamese Ministry of Agricultural and Rural Development recognized 24,491 fertilizer products for nationwide circulation. Synthesized chemical fertilizers accounted for 80.4 percent of the total, while organic fertilizers accounted for 19.6 percent. The Mekong Delta region accounts for 5,265 products or 21.5 percent. Long An Province has the highest quantity of recognized fertilizers, with 2,403 products representing 9.8 percent of the country's total and 45.6 percent of the Mekong Delta's total. Unfortunately, the excessive and inefficient use of fertilizers and pesticides in the Mekong Delta has made the quality and value of agricultural products unsustainable. This is alarming, as it poses a threat not only to the environment but also to the health and well-being of local farmers and consumers who rely on these products. Moreover, high seed rates of 150–170 kg lead to increased production costs and decreased rice yield due to excessive tillers and fewer grains per panicle (Kabir et al. 2008). Therefore, it is crucial to manage the use of seed rates, chemical fertilizers, and pesticides in the Mekong Delta and implement effective measures to mitigate their negative environmental and social impacts.

Sustainable agricultural practices (SAPs) are defined as long-term practices that can meet human food needs, improve environmental quality and natural resources, make efficient use of non-renewable and on-farm resources, maintain the economic viability of farm operations, and improve the quality of life for farmers and society as a whole (USDA 2024). SAPs may include crop rotation or intercropping with legumes, residue retention, integrated pest management (IPM), conservation tillage, complementary use of organic fertilizers, and soil and water conservation (Branca et al. 2011; Manda et al. 2016; Piñeiro et al. 2020; Woodfine 2009). The Vietnam Sustainable Agriculture Transformation Project has introduced improved agricultural practices to small-holder farmers since 2015. More specifically, rice farming in the Mekong Delta deployed the "Three Reductions, Three Gains" and "One Must Do, Five Reductions," which advocate the use of certified seeds, reduction in fertilizer and pesticide applications, and more efficient water use (World Bank 2015). In detail, "Three Reductions, Three Gains" (3R3G) was first developed by the International Rice Research Institute to reduce input usage (e.g., seed rates, chemical fertilizer, and agrochemical usage) to improve net farm profit and protect the environment and farmer health. It was introduced to rice farmers in the Mekong Delta River by the Vietnamese Ministry of Agriculture and Rural Development in the early 2000s (Huelgas et al. 2008). This program was the foundation for the "One Must Do, Five Reductions" (1M5R) program. 1M5R promotes the use of good quality and certified seeds (the "One Must Do"). It also advocates for reducing seed rates, chemical fertilizer inputs, and synthetic pesticide use by approximately 30%, irrigation water use (i.e., reducing the frequency of irrigation pumping into the rice field, or applying water-saving techniques like Alternative Wet Dry (AWD)[1] and postharvest losses (the "Five Reductions"). This program is aimed at optimizing rice production, reducing production costs, increasing yield and quality, and enhancing farm profits. It also contributes to water and resource conservation, greenhouse gas reduction, and community health protection (Phung et al. 2014). In this paper, SAPs are defined as applying either 3R3G or 1M5R.

Despite the various benefits of SAPs, sustainable rice farming in the Mekong Delta still faces significant barriers. The government's efforts to encourage rice farmers to implement SAPs are insufficient, as their success depends significantly on farmers' awareness and intention. Although the concept of SAPs is relatively easy to understand, it is not easy to define and apply in practice. Fertilizers are widely used by Vietnamese farmers based on their past experiences and the seller's instructions, without proper orientation or systematic training. This lack of guidance on the benefits of sustainable fertilizers reduces farmers' opportunities to learn how to use them efficiently (Cao and Lee 2021). As a result, farmers need more awareness and professional expertise regarding farming techniques to avoid the inappropriate application of fertilizers and agricultural chemicals. Furthermore, many farmers' insufficient understanding of environmental and health hazards, lack of interest in environmental issues, and fear of low yields contribute to their reluctance to engage in sustainable agriculture. Therefore, this study aims to understand the factors that influence rice farmers' intentions and behavior toward sustainable rice farming in the Mekong Delta, particularly in Long An Province.

Several previous studies have investigated Vietnamese rice farmers' intentions toward climate change (Ho and Shimada 2020; Dang et al. 2014) and coffee farmers' intention toward sustainable agricultural practices in Vietnam (Nguyen and Drakou 2021). The adoption of the "One Must Do, Five Reductions" is mainly driven by factors such as ease of implementation, education, satisfaction, and non-rice income in the Mekong Delta, Vietnam, according to the linear regression model (Connor et al. 2021). Additionally, factors such as labor, production experience, and production area significantly influence farmers' adoption of 1M5R according to the binary logistic model (Nguyen and Anh 2022). However, no previous study has investigated the psychological factors contributing to sustained behavioral change among rice farmers. The importance of psychological factors, such as attitudes, subjective norms, and perceived behavioral control, is emphasized in the Theory of Planned Behavior (TPB), which has been widely used to understand various behavioral intentions and actions (Ajzen 1991). In the context of sustainable agriculture, previous studies have highlighted the significant role of these psychological factors. For instance, Ho and Shimada (2020) found that subjective norms significantly motivated farmers' intention to adapt to climate change. Similarly, the TPB has been effectively applied to understand farmers' behavior in various agricultural settings (Nguyen and Drakou 2021; Connor et al. 2021).

Therefore, this study aims to fill this gap and contribute to the literature on farmers' behavior toward sustainable agriculture by attempting to understand the mechanism of farmers' decision-making and the role of psychological factors in sustainable farming based on a theoretical framework. Furthermore, this study explores the diversity of farmers' behavior toward sustainable

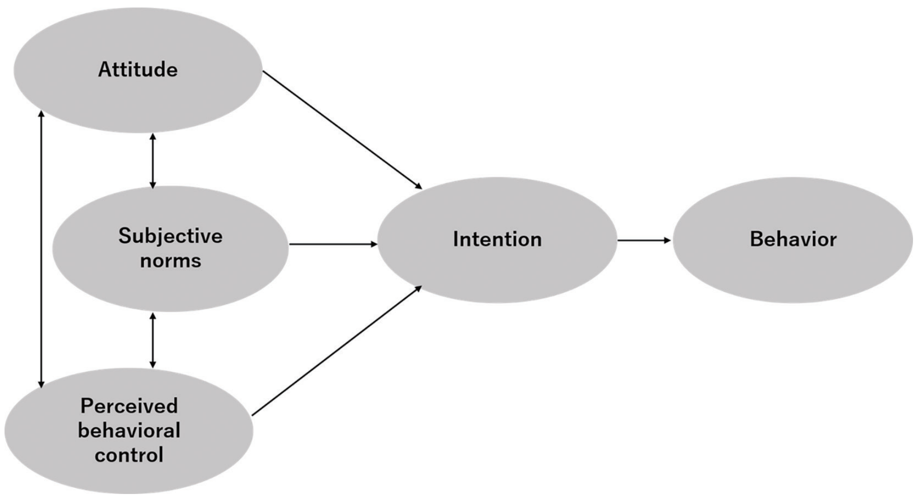
1 AWD developed by The International Rice Research Institute (IRRI) is a system whereby paddy fields are only intermittently irrigated except during the rooting and flowering stages (Yamaguchi et al. 2016). In detail, the crop is intermittently submerged and dried from 20 days after sowing until two weeks before flowering; that is, fields are allowed to drain until water below the surface reaches down to 15cm before re-flooding. Humphreys et al. (2010) reported that applying the AWD technique to rice fields may reduce water use by 15-40% compared to the continuous flooding cultivation technique while not negatively impacting rice productivity.

farming and climate change adaptation. Understanding farmers' decision-making processes and psychological mechanisms is crucial in providing policy support for sustainable rice farming in Vietnam. Firstly, farmers' decisions are influenced by a complex interplay of economic, social, environmental, and psychological factors. Economic factors like cost, yield, and profitability are critical, but they are often intertwined with social influences such as community norms and peer pressure. Psychological factors, as discussed, play a significant role in shaping farmers' attitudes, perceived control, and intentions. Secondly, sustainable agriculture practices require changes in traditional farming methods, which can be challenging without understanding the underlying motivations and barriers faced by farmers. Finally, in the specific context of the Mekong Delta, farmers in this region are particularly vulnerable to climate change impacts and environmental degradation, making the adoption of sustainable practices both urgent and necessary. By comprehensively understanding their decision-making process, policymakers can develop more effective strategies to encourage the adoption of sustainable practices, ensuring long-term agricultural sustainability and resilience in the region.

2. Theoretical Framework

The Theory of Planned Behavior (TPB) (Ajzen 1991) is a psychological model that explains individual intention and behavior by exploring the underlying psychological processes. It is a widely applied behavioral model that extends the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975). The TPB includes the two TRA constructs — *attitude toward behavior* and *subjective norms* — and the additional construct of *perceived behavioral control* to interpret their combined effect on an individual's intention (Figure 1). Besides, the Theory of Planned Behavior (TPB) is a versatile framework, but its application can vary depending on the context. By refining the model to exclude less relevant pathways, we aim to enhance its explanatory power and practical relevance for sustainable rice farming in Vietnam. This approach ensures that the model is tailored to the unique social, cultural, and economic conditions of the Mekong Delta region.

Figure 1: Theory of Planned Behavior (Ajzen 1991)



Ajzen (1991) asserts that *attitude toward behavior* is a fundamental aspect in comprehending the extent to which an individual has a positive or negative evaluation of a particular behavior. This study suggests that positive attitudes toward SAPs can influence an individual's intentions and drive their behavior.

Recently, the factor of *knowledge* has received much attention in the literature, suggesting that high levels of knowledge can lead to highly effective attitudes toward individual intention and behavior (Guru et al. 2021). Thus, this study identifies *knowledge* as a critical construct and explores it as a factor that may positively impact attitudes toward SAPs and enhance an individual's intention. This factor will be added to the proposed model (Figure 2).

Additionally, the level of social pressure perceived from an individual's social networks, known as *subjective norms*, is another construct that may positively or negatively affect their intention and behavior. Therefore, the hypothesis that "*subjective norms* will have a positive or negative effect on intention and behavior toward SAPs" is also explored in this study.

Another significant concept is *perceived behavioral control* (PBC), which explains how simple or difficult it is to perform a behavior or make a choice (Ajzen 1991). The essential distinction between the Theories of Planned Behavior and Reasoned Action is PBC. According to Madden et al. (1992), the TPB, which considers PBC, explains more about significant variance in intention and behavior than the TRA, which does not. As a result, this study hypothesizes that PBC will have a beneficial effect on the intention to implement SAPs.

We removed the pathways from *subjective norms* to *attitude* and *PBC* in our proposed model because, in our previous studies, fieldwork in Vietnam indicated that these connections were not as significant in our specific context. During our fieldwork, we conducted extensive interviews and surveys with rice farmers in Long An Province. The survey revealed that farmers' attitudes and perceived control over sustainable agricultural practices were primarily shaped by their own experiences and knowledge rather than by social pressures or norms. This context-specific insight highlighted the need to adjust the model to better reflect the actual factors influencing farmers' behavior. By omitting the less significant pathways, we emphasize the relationships that are more impactful in this specific context. These include the strong influence of knowledge on attitude and intention, as well as the role of subjective norms directly on intention. This streamlined model provides clearer insights and actionable recommendations for policymakers and stakeholders.

In the realm of psychology, *intention* and *behavior* are two key concepts that are often studied together. *Intention* refers to the internal motivation that drives an individual to act, while *behavior* is the outward manifestation of that internal motivation. This study seeks to explore the relationship between these two concepts, hypothesizing that *intention* can positively influence *behavior.*

Therefore, this study identifies six primary psychological constructs based on TPB — *attitude*, *perceived behavioral control*, *subjective norms*, *intention*, and *behavior* — and the additional construct of *knowledge* and explores the role of these psychological constructs in shaping farmers' decision-making toward SAPs. Figure 2 depicts the proposed model of this study.

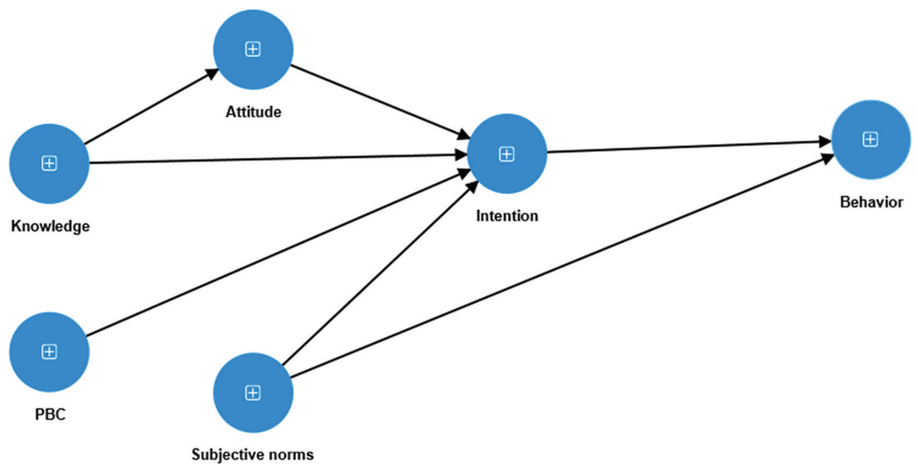


Figure 2: Proposed Model on Farmer's Decision-Making Toward Sustainable Rice Farming

3. Materials and Methods

(1) Study Site and Data Collection

We studied rice farming in Long An Province, one of the largest rice-producing regions in Vietnam, with a total cultivated area of 511,300 hectares (GSO 2022). The selected farmers in this study were located in two districts, Duc Hue and Tan Hung, within Long An Province. To gather data, we conducted face-to-face interviews with 163 rice farmers in November 2022 using a structured questionnaire that consisted of two main sessions. The first session focused on the characteristics of the farmers, while the second session explored their thinking and decision-making processes. During the interviews, farmers were asked to rate statements related to six main constructs in the proposed model using a five-point Likert scale (ranging from 1 = "strongly disagree" to 5 = "strongly agree") (see Table 1). Specifically, we asked the farmers to rate the extent to which they intended to implement SAPs on a five-point Likert scale to assess the farmers' intentions to implement sustainable agricultural practices (SAPs) and how this intention translates into actual actions. To determine actual implementation, we measured the farmers' actions or decisions to implement SAPs using a binary dummy variable. A value of 1 indicated that the farmer implemented SAPs, while 0 indicated otherwise.

Regarding the implemented initiatives, a significant majority, 151 respondents (92.6 percent), are using improved rice varieties, indicating widespread acceptance of this practice. Integrated pest management is also highly adopted, with 130 respondents (79.8 percent) utilizing these methods to control pests. Similarly, the reduction of seeding rates is practiced by 135 respondents (82.8 percent), demonstrating its popularity. In terms of fertilization practices, 128 respondents (78.5 percent) have reduced their use of chemical fertilizers, and 90 respondents (55.2 percent) are using organic fertilizers, showing a good level of adoption of more sustainable fertilization techniques. However, the application of water-saving techniques is less prevalent, with only 59 respondents (36.2 percent) implementing these methods. This indicates that while there is significant uptake of many sustainable practices, there remains room for improvement, particularly in the area of water conservation. Overall, the data highlights that improved rice varieties (151 respondents, 92.6 percent), integrated pest management (130 respondents, 79.8 percent), and reduced seeding rates (135 respondents, 82.8 percent) are the most commonly adopted sustainable practices among respondents. In contrast, the use of organic fertilizers (90 respondents, 55.2 percent) and water-saving techniques (59 respondents, 36.2 percent) are areas where further education and promotion could be beneficial. However, farmers implementing a full package of 1M5R or 3R3G are limited (52 respondents, 32 percent).

(2) Data Analysis

This study used the structural equation modeling (SEM) technique to determine the factors influencing farmers' intention and behavior to implement sustainable rice farming based on the theoretical framework, as shown in the proposed model (Figure 2).

Explanatory factor analysis (EFA) was used first to examine the measurement model's reliability and validity. EFA is a statistical method for analyzing the interrelationships among many variables and identifying the underlying factors that explain the correlations. Then, a multivariate statistical technique, namely the partial least squares (PLS) technique, was used to analyze the relationships between independent variables and a dependent variable. It aims to maximize the explained variance of the dependent variable by the independent variables. Several studies (Anh et al. 2018; Ulhaq et al. 2022) have utilized the PLS technique to estimate the model parameters for theoretical models, including formative indicators (or both reflective and formative). In this study, Smart-PLS 4.0 software was utilized to evaluate the internal consistency of the constructs, estimate the proposed model, and conduct a reliability analysis of collected data. Despite the investigation’s limited and small sample size, the implementation of Smart-PLS assisted in obtaining consistent and reliable approximated results.

A comprehensive process with multiple phases was used to estimate the structural model. First, we looked at the path coefficients, which reflect the degree and direction of the relationship between independent factors and the dependent variable or how each independent variable contributes to the total result. We calculated R_2 values in addition to path coefficients. These numbers indicate the model’s overall explanatory power or the amount of variance in the dependent variable that the independent variables can explain. We employed the bootstrapping resampling approach with 5,000 resamples to confirm the correctness and dependability of our results. This enabled us to calculate the parameters’ confidence intervals or t values.

This technique is convenient when the sample size is small, as it allows for a more accurate estimation of the parameters’ standard error and confidence interval. Overall, using SEM, EFA, PLS, and bootstrapping techniques allowed for a thorough analysis of the factors influencing rice farmers’ intentions and behaviors toward sustainable rice farming in the Mekong Delta.

Table 1: Description of Constructs in the Proposed Model

Construct	Code	Description
Attitude	Attitude1	Sustainable agriculture practices are difficult to implement
	Attitude2	Environmental pollution can be caused by agrochemicals
	Attitude3	The application of sustainable fertilizers can increase soil fertility and maintain soil humidity
	Attitude4	Sustainable agriculture requires more on-farm labor
	Attitude5	The indiscriminate uses of agrochemicals are harmful to human health
	Attitude6	Sustainable rice products can be sold at a higher price
	Attitude7	Chemical residues in rice pose a significant health threat to the consumer
Knowledge	Knowledge1	Sustainable agriculture prevents air and water pollution and destruction of natural resources
	Knowledge2	Sustainable agriculture reduces carbon emissions from crop production by reducing chemical inputs
	Knowledge3	The overuse of chemical fertilizers and pesticides can reduce soil fertility
	Knowledge4	The healthier the soil, the greater the rice productivity
	Knowledge5	Sustainable agriculture can improve crop yield
	Knowledge6	The cost of sustainable agriculture is lower due to the reduction of chemical fertilizer and pesticide use
	Knowledge7	Sustainable agriculture is very important for developing economies, ensuring rural livelihoods and human health
Perceived behavioral control	PBC1	There is no difficulty in the implementation of sustainable agriculture (YES/NO)
	PBC2	Sustainable agriculture consumes more labor (YES/NO)

Perceived behavioral control	PBC3	Sustainable agriculture suffers from higher costs (YES/NO)
	PBC4	The crop yield of sustainable agriculture is low (YES/NO)
	PBC5	The price of sustainably farming products is low (YES/NO)
	PBC6	There is difficulty in selling the output (YES/NO)
	PBC7	Other difficulties (YES/NO)
Subjective norms	Subnorm1	I THINK that my family, neighbors, and community members may support/agree with me in conducting sustainable agriculture.
	Subnorm2	If my neighbors and community members conduct sustainable agriculture, I WILL FOLLOW them.
	Subnorm3	I AM CONDUCTING sustainable agriculture because my friends, relatives, and neighbors do that.
Intention	Inten1	I would like to continue with conventional farming
	Inten2	My intention is to reduce chemical fertilizer and chemical agricultural use
	Inten3	My intention is to change from chemical fertilizer to organic fertilizer
	Inten4	I intend to totally implement organic agriculture
Behavior	SAPapp1	Using certified rice varieties
	SAPapp2	Reducing pesticides, application of integrated pest management (IPM)
	SAPapp3	Reducing chemical fertilizers
	SAPapp4	Reducing seed rate
	SAPapp5	Applying organic fertilizer
	SAPapp6	Saving irrigation water

Source: Author's calculation

(3) Adjusted Model after Construct Validity

Before presenting the results of the proposed model, we conducted several tests to validate the model structure and ensure the reliability of our results. The first test was the *Intention* variable's reliability test and exploratory factor analysis (EFA). We found that removing item *Inten 1* from the construct could improve our results. Removing this item from the model led to a significant improvement in Cronbach's alpha, increasing from 0.700 to 0.781. This improvement was also reflected in the Kaiser–Meyer–Olkin (KMO) test for sampling adequacy of 0.681; the total variance explained increased from 53.59 percent to 69.64 percent.

In addition, a factor analysis of explanatory variables was run. This analysis indicated that there were nine components with eigenvalues larger than 1. However, upon closer examination, it was found that several items had factor loadings lower than 0.5, and some had cross-factor loadings. As a result, removing some items from the initial models is necessary. After making these changes, another factor analysis of explanatory variables was conducted. The final output of this analysis had a KMO test result of 0.731, and Bartlett's test was significant at 0.000, indicating that the output of the EFA was sufficient. We extracted four components whose eigenvalues were larger than 1, and together, they explained 58.2 percent of the total variance (APPENDIX 1 and 2). In general, extensive testing and analysis help to ensure the reliability of our model and improve the study's results.

(4) Collinearity Analysis

Testing for multicollinearity is an important step in examining the measurement model using the variance inflation factor (VIF). During this process, indicators that receive a VIF score higher than 10 must be discarded. The ideal threshold for multicollinearity is below 3.3, as suggested by Petter et al. (2007) and Ringle et al. (2015). Table 2 shows that multicollinearity did not occur among any of the indicators in the measurement models.

Table 2: Collinearity Statistics of Indicators in the Proposed Model

	VIF
Attitude2	1.341
Attitude3	1.212
Attitude5	1.581
Attitude7	1.588
Inten2	1.416
Inten3	1.856
Inten4	1.826
Knowledge5	1.299
Knowledge6	1.116
Knowledge7	1.337
PBC2	1.000
SAPapp2	1.010
SAPapp5	1.010
Subnorm1	1.174
Subnorm2	1.174

Source: Author's calculation

(5) Importance-Performance Map Analysis

By incorporating the average value of constructs and their performance indicators, the Importance-Performance Map Analysis can expand PLS-SEM results. This analysis is based on the path coefficients or overall effects (Importance) and adds the rescaled 0 to 100[2] Performance dimension. The Importance-Performance Map Analysis seeks to discover antecedents with relatively high significance for the target construct (i.e., a significant total impact) but relatively poor performance (i.e., low average latent variable scores). When examining the Importance-Performance Map, constructions in the lower right region (i.e., above-average importance and below-average performance) are the most intriguing to enhance, followed by those in the upper right, lower left, and finally, the higher left regions, in that order. Consequently, this result guides prioritizing

2 According to Ringle et al. (2022), the original data scales are essential for correct rescaling. Users can check and adjust the possible ranges of the manifest variables. For instance, a 5-point Likert scale must have a minimum value of 1 and a maximum value of 5 in the IPMA settings.

management actions that are essential to achieving the specified objective but require performance improvements (Ringle and Sarstedt 2016).

4. Results and Discussion

(1) Sample Descriptive Statistics

Table 3 presents the demographic and socioeconomic characteristics of the respondents and their rice farms. The collected data revealed that more than 90 percent of the respondents were male, while almost 10 percent were female. The average age of the rice farmers was 49 years. This indicates that the majority of the farmers were middle-aged. Regarding their education level, approximately 47 percent of the respondents had a secondary school diploma, meaning that less than half of the farmers had completed secondary education. Thirty percent of respondents had a primary school diploma, while 20 percent had a high school diploma or higher. This suggests a significant disparity in education levels among the respondents. On average, the respondents had 27 years of experience in rice farming. This indicates that they have considerable experience in the field and have likely developed a deep understanding of farming practices. The majority of the respondents owned farms between 1 and 5 hectares in size (66.2 percent), followed by farms more than 5 ha (25.8 percent) and less than 1 ha (8 percent). Nearly 31 percent of rice farmers participated in social groups such as agricultural cooperatives, farmer groups, youth groups, etc. This indicates that a substantial proportion of the respondents were involved in social groups, which may provide them access to resources, knowledge, and networks.

Table 3 – Demographic and Socioeconomic Characteristics of Surveyed Rice Farmers

Characteristic	**Observation**	**Percentage**	**Mean**
Age (years)	163		49.742
Household size (members)	163		4.257
Farming experience (years)	163		26.975
Gender (respondents base)			
Male	*147*	*90.18*	
Female	*16*	*9.82*	
Marriage status			
Single	*5*	*3.10*	
Married	*154*	*94.50*	
Divorced	*4*	*2.50*	
Education			
No education	*3*	*1.80*	
Primary school	*49*	*30.10*	
Secondary school	*77*	*47.20*	
High school	*31*	*19.00*	
Higher education	*3*	*1.80*	
Social groups	50	30.67	
Total cultivated area (ha)			
Less than 1 ha	*13*	*8.00*	
1-5 ha	*108*	*66.20*	
More than 5 ha	*42*	*25.80*	

Source: Author's calculation

(2) The Measurement Model

1) Convergent Validity and Reliability

A factor analysis was performed to assess the validity of the measurement (or outer) model using the PLS algorithm with bootstrapping and a factor-weighting scheme. Correlations among causal indicators provide insights into how different indicators interact and influence each other within a causal framework. Reflective indicators aim to capture the underlying constructs they represent, while formative indicators are designed to measure different aspects of a construct without assuming a common underlying factor (Hulland, 1999), and do not possess the concepts of construct validity and reliability (Lowry and Gaskin 2014). Despite the differences in measurement approach, the weights assigned to formative indicators still play a crucial role in understanding their impact. These weights must have significant t values (i.e., t values above 1.96 at a significance threshold of 0.05) to validate their contribution to the overall construct (Ringle et al. 2012).

According to the factor analysis results, some indicators within the *Behavior* construct (*SAPapp1, SAPapp3, SAPapp4, and SAPapp6*) were found to be insignificant and were thus eliminated from the model. Insignificant factors were also excluded from the second formative construct, *Perceived Behavioral Control (PBC)*. The *PBC2* component is the only one that explains *PBC* in the final model. In the PLS-SEM, single-item variables are permitted (Garson 2016; Hair et al. 2022).

In the case of reflecting constructs, indications with low factor loadings or insignificance were eliminated from the baseline model. Figure 3 depicts the factor analysis results, with factor loading values and p values provided in parentheses. *Knowledge5* had a factor loading of 0.803 and a p-value of 0.000, *Inten2* had a factor loading of 0.802 and a p-value of 0.000, and *Subnorm1* had a factor loading of 0.872 and a p-value of 0.000. Except for the factor loadings of *Attitude2* (0.664), *Attitude3* (0.620), and *Knowledge6* (0.592), the final factor analysis revealed that most of the indicators obtained convergent validity.

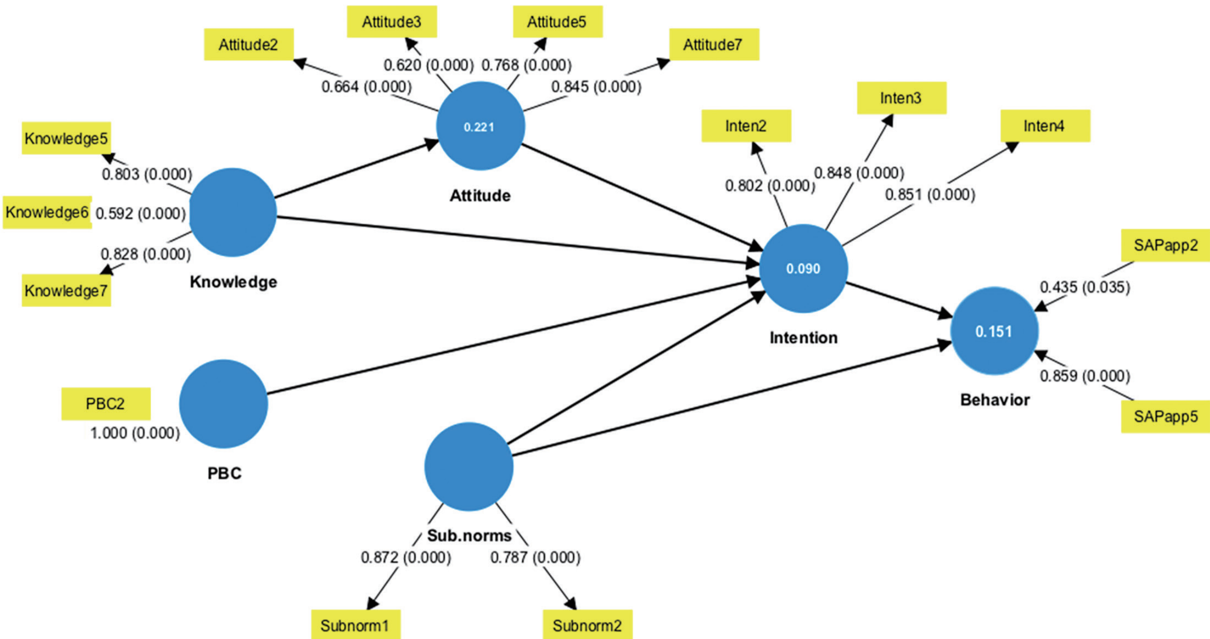


Figure 3: Factor Analysis of the Measurement Model
Note: The numbers on the paths are path coefficients, and their p-values are in parentheses.
Source: Author's calculation

The average variance extracted (AVE) values for *Attitude*, *Intention*, *Knowledge*, and *Subjective norms* were 0.533, 0.696, 0.560, and 0.690, respectively (Table 4). According to Henseler et al. (2016), these AVE values greater than 0.5 are acceptable and indicate solid convergent validity of the construct indicators. The Cronbach's alpha values for *Attitude* (0.709), *Intention* (0.781), *Knowledge* (0.604), and *Subjective norms* (0.556) were also satisfactory. According to Perry et al. (2004), a Cronbach's alpha value greater than 0.5 is still acceptable, confirming the reliability of the indicators. It is worth noting that the test for both Cronbach's alpha and AVE is not applicable to *PBC*, as it is now a formative construct and is solely explained by *PBC2*.

Table 4: Construct Reliability and Validity of Constructs in the Proposed Model

	Cronbach's alpha	**Average variance extracted (AVE)**
Attitude	0.709	0.533
Intention	0.781	0.696
Knowledge	0.604	0.560
Subjective norms	0.556	0.690

Source: Author's calculation

2) Discriminant Validity

Several statistical techniques were utilized to assure discriminant validity and avoid similarities between survey items for distinct constructs. In addition to the Fornell-Larcker criterion (1981), cross-loadings and the Heterotrait-Monotrait ratio were also applied. These procedures ensure that each survey question measures the intended construct without overlapping with questions on other constructs. In the realm of survey research, the Fornell-Larcker criterion is a prevalent technique. According to this criterion, the square root of the average variance extracted (AVE) for each construct must be greater than its correlations with other constructs in the measurement model. Thus, we can ensure that there is no duplication of indicators in the measurement models. In our research, Table 5 demonstrates that the square root of the AVE values for *Attitude*, *Intention*, *Knowledge*, and *Subjective norms* are, in fact, more significant than their correlations with other variables in the measuring model.

Table 5: Fornell-Larcker Criterion of Constructs in the Proposed Model

	Attitude	**Intention**	**Knowledge**	**Subjective norms**
Attitude	0.730			
Intention	0.056	0.834		
Knowledge	0.470	0.225	0.749	
Subjective norms	0.144	0.219	0.152	0.831

Source: Author's calculation

Table 6 reveals that the cross-loadings of each variable on its relevant construct were larger than their cross-loadings on other constructs. This indicates that the survey questions were measuring what they were intended to measure without any overlap with questions about other constructs.

Table 6: Cross-Loading Values of Variables in the Proposed Model

	Attitude	Behavior	Intention	Knowledge	Perceived behavioral control	Subjective norms
Attitude2	**0.664**	0.007	0.085	0.235	0.158	0.138
Attitude3	**0.620**	0.147	0.083	0.288	0.060	0.174
Attitude5	**0.768**	0.066	0.010	0.328	0.051	0.056
Attitude7	**0.845**	0.087	0.015	0.464	0.180	0.084
SAPapp2	0.059	**0.455**	0.203	0.047	0.002	0.065
SAPapp5	0.097	**0.931**	0.347	0.097	0.179	0.128
Inten2	0.130	0.313	**0.802**	0.198	0.072	0.193
Inten3	-0.010	0.332	**0.848**	0.149	0.112	0.163
Inten4	0.014	0.318	**0.851**	0.212	-0.015	0.189
Knowledge5	0.366	0.186	0.225	**0.803**	0.197	0.183
Knowledge6	0.266	-0.061	0.093	**0.592**	0.044	-0.088
Knowledge7	0.408	0.065	0.169	**0.828**	0.218	0.181
PBC2	0.158	0.161	0.067	0.220	**1.000**	0.156
Subnorm1	0.156	0.127	0.200	0.212	0.142	**0.872**
Subnorm2	0.076	0.101	0.16	0.02	0.116	**0.787**

Source: Author's calculation

The study also utilized the Heterotrait-Monotrait ratio to assess the true correlation between the measurement models. A Heterotrait-Monotrait value smaller than 0.9 means that the latent variables achieve discriminant validity (Chua 2022). In Table 7, all pairs of latent variables had values smaller than 0.9, indicating discriminant validity. By employing these techniques, we can be confident in the validity of our survey data and the conclusions drawn from it.

Table 7: Heterotrait-Monotrait Ratio of Latent Variables in the Proposed Model

	Attitude	Intention	Knowledge	Perceived behavioral control	Subjective norms
Attitude					
Intention	0.143				
Knowledge	0.677	0.315			
PBC	0.182	0.090	0.263		
Subjective norms	0.240	0.328	0.334	0.208	

Source: Author's calculation

(3) The Structural Model

The output of the structural model showed that there were four significant paths ($p<0.05$). The influence of *Knowledge* on *Attitude* ($B=0.470$, $p<0.05$), *Knowledge* on *Intention* ($B=0.236$, $p<0.05$), *Subjective norms* on *Intention* ($B=0.198$, $p<0.05$), and *Intention* on *Behavior* ($B=0.177$, $p<0.05$) were all positive and significant (Figure 4). It is worth noting that the R-square values within the constructs are indicative of their predictive power. This means that better knowledge would lead to a more positive attitude toward sustainable agriculture and a higher intention to adopt SAPs. Additionally, social factors surrounding farmers can positively contribute to their intention toward sustainable agriculture. Finally, stronger intention will lead to positive behaviors regarding sustainable agriculture. In addition, this study found no significant path from *PBC* to *Intention*, *Attitude* to *Intention*, or *Subjective norms* to *Behavior*.

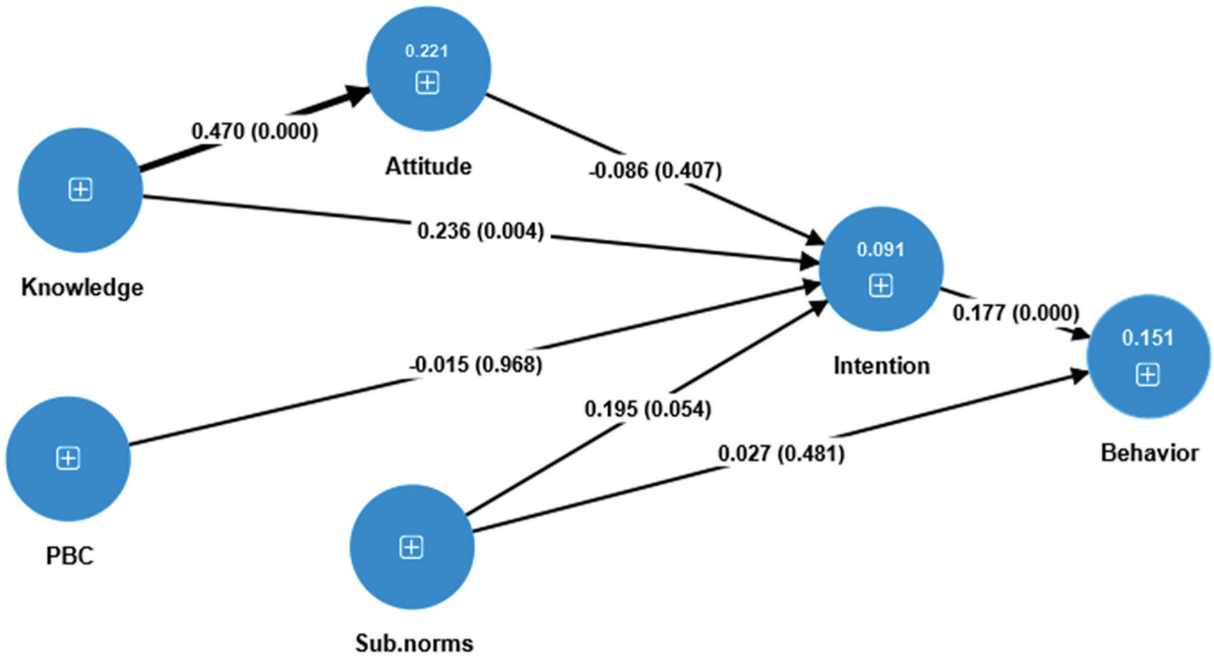


Figure 4: Path Coefficients and Significance of the Structural Model
Note: the numbers within the constructs are R-square values; the numbers on the paths are path coefficients, and their p-values are in parentheses.
Source: Author's calculation

Table 8 provides a comprehensive summary of the direct effect, mediating effect, and total effect of *Knowledge* on *Intention* in the mediation model. The results of the analysis indicate that the existence of the mediator, *Attitude*, led to a reduction in the total effect of *Knowledge* on *Intention*. This is likely because attitude acts as an intermediary between *Knowledge* and *Intention* by shaping an individual's beliefs about the value and importance of the behavior being considered. However, it is important to note that the path from *Attitude* to *Intention* was found to be insignificant, suggesting that there is no mediating effect in the model.

Regarding the mediating role of *Intention* between *Subjective norms* and *Behavior*, the influence of *Subjective norms* on *Behavior* is significant only if the mediator of *Intention* is present. Additionally, the paths from *Subjective norms* to *Intention* and from *Intention* to *Behavior* are all positive. Thus, it can be concluded that a positive full mediating effect is present.

Table 8: Mediation Effect Between Constructs of Intention, Subjective Norms, and Behaviors

	Original sample	Sample mean	Standard deviation	P values
Direct effects				
Knowledge → Intention	0.236	0.249	0.083	0.004
Subjective norms → Behavior	0.027	0.026	0.039	0.481
Total indirect effects				
Knowledge → Attitude → Intention	-0.042	-0.045	0.055	0.450
Subjective norms → Intention → Behavior	0.035	0.037	0.021	0.094
Total effects				
Knowledge → Intention	0.194	0.204	0.086	0.024
Subjective norms → Behavior	0.062	0.063	0.039	0.115

Source: Author's calculation

(4) Importance-Performance Map Analysis

Figure 5 provides advice for designing policy implications to improve farmers' behavior toward sustainable agriculture. *Intention* has the highest importance but only moderate performance (57.375), indicating considerable scope for improvement. In contrast, Knowledge and *Subjective norms* have relatively high performances (76 and 83, respectively) but are very low in importance. Improving *Intention*'s performance from 57.375 to 58.375 would increase the performance of *Behavior* by 0.177 points.

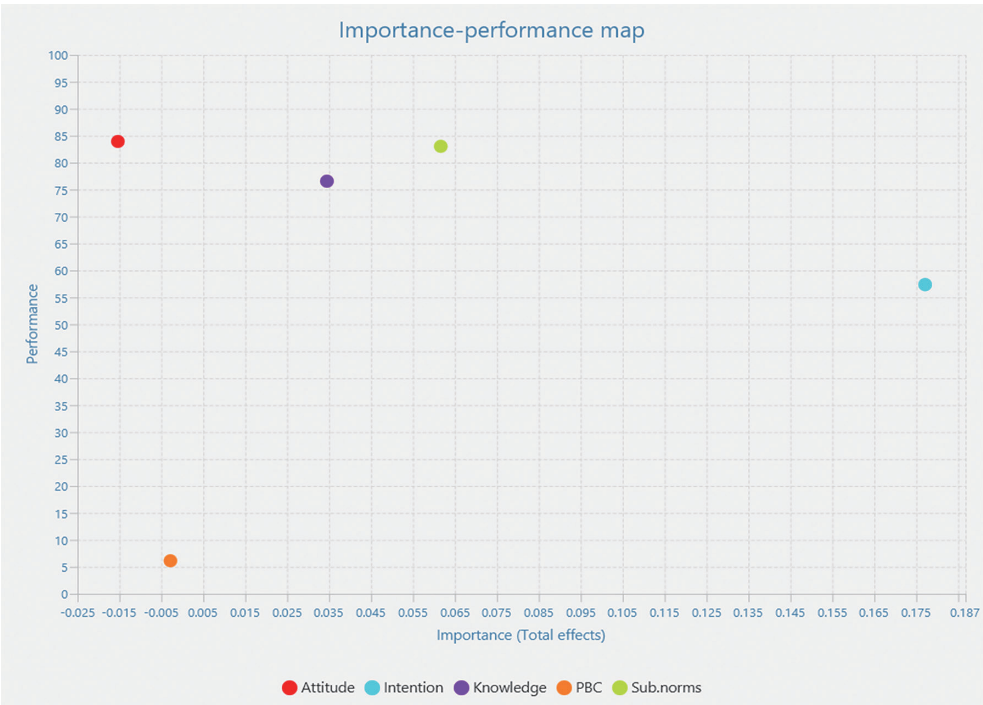


Figure 5: Importance-Performance Map Analysis of the Target Construct (*Behavior*)
Source: Author's calculation

(5) Discussion

1) Better Knowledge Can Lead to Positive Attitudes and Intentions toward Sustainable Agriculture

The findings from the model's output reveal an interesting insight into the relationship between knowledge of sustainable rice farming and attitudes and intentions toward adopting sustainable practices. Specifically, the results suggest that farmers with greater knowledge of sustainable rice farming are more likely to express favorable attitudes (B = 0.236) and intentions (B = 0.194) toward sustainable agriculture. These findings align with a previous study conducted by Tama et al. (2021), further strengthening the argument for the importance of knowledge in promoting sustainable agriculture practices.

According to the survey, 32 percent of farmers practiced sustainable agricultural methods through 1M5R or 3R3G in a full package. Of the remaining 68 percent of farmers, over 37.5 percent cited a lack of technical skills as a reason for not employing modern methods, and over 12.5 percent stated that they needed to learn more about the new techniques to use them. During the study, most respondents expressed a willingness to participate in sustainable agricultural practices as long as they received technical assistance and fair prices for their harvests. Additionally, 70 percent of the sample population relied solely on rice farming for income and had been doing so for more than 26 years. This indicates that these farmers hope sustainable agricultural practices will help them improve their income and rural livelihood. People in Long An province already have strong intentions, which they can strengthen by learning more about the technical aspects of new models. Consistent with these findings, several studies have shown that knowledge and awareness favorably impact intentions to use sustainable farming practices (Adnan et al. 2018; Iqbal et al. 2016; Jiang et al. 2018; Raza et al. 2019). When asked about their knowledge of sustainable farming practices, 22.7 percent of farmers were uncertain about their ability to boost rice yields. Long An Province has two planting seasons, with the average yields for the Winter-Spring season in Duc Hue being 6.7 tons per ha and 7.5 tons per ha in Tan Hung. The average yields for the Summer-Autumn seasons in Duc Hue and Tan Hung were 4.4 tons per ha and 5.7 tons per ha, respectively. Tan Hung has better yields in both crops due to its proximity to the Dong Thap Muoi area, which is the country's "rice bowl" with good alluvium soil and a reliable water source. Therefore, showcasing model farms is necessary before offering their potential and methodologies to farmers. Farmers also cited model farms as a requirement for participating in sustainable practices.

2) Subjective Norms Are a Major Driving Force behind Farmers' Intention to Implement SAPs

Subjective norms favorably and significantly affect farmers' intentions in this study. This causal relationship suggests that farmers' intentions to adopt sustainable farming are influenced by their surrounding communities, which include family members, friends, and neighboring farmers. Because the survey communities have produced rice for over 26 years, social relationships in Duc Hue and Tan Hung are deep and close. Within the examined districts, common knowledge and wisdom about rice growing are shared; therefore, it is reasonable to believe that a farmer's judgment can be impacted by what others think is suitable (Lynne et al. 1995; Martínez-García et al. 2013). A similar result that subjective norms significantly motivated farmers' intention to adapt to climate change was found by Ho and Shimada (2020).

Vietnamese farmers' decisions to embrace a new crop or method are influenced not only by their own experience but also by their observations of neighboring agricultural communities and the ideas and opinions of others. Notably, 20.2 percent of the information about sustainable farming practices comes from the neighbors of surveyed farmers (Author's survey). Farmers are more likely to implement sustainable farming practices if their family members, friends, or neighbors support them or have successfully implemented them. Similar findings were found in the study of Nguyen and Drakou (2021). According to our survey results, 32 percent of the sample has already engaged in sustainable rice farming. Within this group, their experiences, accomplishments, and challenges have been extensively shared with others. Furthermore, 95.1 percent of farmers said they would engage in sustainable agriculture if their friends and neighbors did as well.

On the other hand, this study's results indicated that subjective norms' influence on behavior is significant only if the mediator is present. This means there is no direct effect of subjective norms on farmers' behavior in implementing sustainable rice farming. Meanwhile, a previous study by Ho and Shimada (2020) ascertained that rice farmers' behavior toward climate change adaptation in the Mekong Delta was directly motivated by both intention and subjective norms. This implies that subjective norms have a significant indirect effect on farmers' behavior towards promoting sustainable rice farming. Additionally, the impact of subjective norms on farmers; behavior in tackling climate change and extreme weather events is even greater. A possible reason is that norms are most likely effective where individual actions are immediately evident and have a noticeable effect.

3) Stronger Intentions Lead to Positive Behavior toward SAPs

According to our findings, most farmers polled had a favorable attitude toward SAPs. Individuals who have yet to implement SAPs have stated pricing and profitability concerns that have prevented them from using advanced practices. The average market prices for traditional rice are 6,933 Vietnamese Dong (VND)/kg (or 0.30 USD/kg) for the Winter-Spring crop and 4,760 VND/kg (0.20 USD/kg) for the Summer-Autumn crop. In contrast, the average market prices for "sustainable" rice are higher, with 7,470 VND/kg (or 0.32 USD/kg) for the Winter-Spring crop and 5,706 VND/kg (or 0.24 USD/kg) for the Summer-Autumn crop. The average yield for traditional rice varies by season. The Winter-Spring crop has a higher yield of 6.93 tons per ha compared to the summer-autumn crop's yield of 4.74 tons per ha.

On the other hand, sustainable rice yields are higher on average, with 7.47 tons per ha for the Winter-Spring crop and 5.71 tons per ha for the Summer-Autumn crop. Many farmers considered the differences in these outputs insignificant and insufficient to persuade them to invest more in rice farming. Tilman et al. (2002) also voiced similar concerns.

Farmers implementing all the 1M5R model's guidelines have shown stronger intentions and beliefs (using certified seeds and reducing seed rates, pesticides, fertilizers, water, and postharvest losses). They were satisfied with minor improvements in profit from their harvests and indicated strong intentions to further invest in sustainable farming. This could involve reducing the application rate of chemical pesticides and fertilizers or even replacing chemical fertilizers with organic fertilizers. Nevertheless, profitability is not the primary motivator for farmers to implement SAPs (Lehman et al. 1993). According to Dung et al. (2018), the observable success of SAPs is required for farmers to abandon their current farming practices and accept new technologies. Nguyen and Anh (2022) discovered that rice farmers in Soc Trang Province were more inclined to use 1M5R if they were more familiar with the production model.

5. Conclusion and Implications

This study found that 32 percent of the farmers polled use sophisticated techniques on their crops.

The calculated structural equation model (SEM) demonstrates substantial effects of knowledge on attitude (B = 0.470), knowledge on intention (B = 0.236), subjective norms on intention (B = 0.198), and intention on behavior (B = 0.175). The knowledge–intention–behavior path shows a favorable, fully mediating impact. Greater intentions will have a positive effect on the SAP-related behavior of farmers. In general, Long An rice farmers are aware of SAPs, and most intend to adopt them. However, they face hurdles such as rising investment costs and negligible improvements in harvests and prices, which prevent them from carrying out their plans.

In conclusion, the results of the importance-performance map analysis reveal that encouraging intention is the most effective method for promoting SAP-related behavior. As intention is positively correlated with farmers' knowledge and subjective norms, developing people's profound comprehension of SAPs and familiarizing them with new and innovative practices to achieve long-term success is essential. Various educational programs, such as vocational training and showcasing model fields, can increase farmers' knowledge and positively influence their intentions. The government also plays a crucial role in this process, potentially pooling land for large-scale production to facilitate more technological applications to agriculture methods. This land accumulation model can promote an efficiency of scale in rice production and foster a farmer-business community, enhancing subjective norms. In addition to the government's efforts, the issue of increasing social capital must be addressed because farmers are affected by the decisions of neighboring communities. Therefore, the importance and effectiveness of rural cooperatives such as cooperatives, farmer groups, and women's unions must be strengthened. By doing so, social capital will increase, and farmers will be motivated to make informed decisions.

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APPENDIX 1. Total Variance Explained and the Final Factor Analysis

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.009	25.075	25.075	3.009	25.075	25.075	2.111	17.594	17.594
2	1.497	12.476	37.550	1.497	12.476	37.550	1.854	15.448	33.042
3	1.362	11.350	48.900	1.362	11.350	48.900	1.512	12.597	45.640
4	1.118	9.315	58.215	1.118	9.315	58.215	1.509	12.575	58.215
5	.884	7.368	65.583						
6	.813	6.775	72.358						
7	.689	5.739	78.097						
8	.644	5.364	83.461						
9	.602	5.018	88.479						
10	.528	4.404	92.883						
11	.463	3.855	96.738						
12	.391	3.262	100.000						

Source: Author's calculation

APPENDIX 2. Factor Loadings of the Final Factor Analysis

Rotated Component Matrices

	Component			
	1	2	3	4
Attitude2	0.762	-0.001	0.117	0.094
Attitude5	0.743	0.201	-0.075	0.049
Attitude7	0.676	0.414	-0.062	0.065
Attitude3	0.597	0.140	0.184	0.023
Knowledge7	0.201	0.774	0.157	0.059
Knowledge5	0.167	0.716	0.152	0.167
Knowledge6	0.175	0.605	-0.323	-0.159
Subnorm1	0.035	0.251	0.794	0.046
Subnorm2	0.134	-0.120	0.779	-0.039
PCB3	0.008	0.023	-0.126	0.780
PCB5	-0.043	0.240	0.223	0.666
PCB4	0.214	-0.096	-0.011	0.617

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.
Source: Author's calculation