Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 4, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FACTORS AFFECTING THE COMPLIANCE OF SUSTAINABLE RICE PRODUCTION IN THE MEKONG DELTA, VIETNAM

Le Canh DUNG, Vo Van TUAN

Mekong Delta Development Research Institute, Can Tho University, Vietnam. Phone: (+84) 292 3833256; Fax: (+84) 0292 3831270; E-mails: lcdung@ctu.edu.vn, vvtuan@ctu.edu.vn, mdi@ctu.edu.vn

Corresponding author: lcdung@ctu.edu.vn

Abstract

This study aims to determine the factors affecting compliance with Sustainable Rice Platform (SRP) standards in rice production in the Mekong Delta, which is considered the largest rice granary in Vietnam and is of great importance in the world rice export market. The study was conducted based on survey data for 426 rice-growing households and implementing SRP standards in the region by 2022. The study results showed that only 6.57% of rice-growing households could fully comply the SRP standard, while the majority of households encountered certain obstacles. The analysis results from the binary regression show that some factors that positively affect the compliance with SRP standards are the education level of the household head, the size of rice land and contract farming. Meanwhile, large demographic size has a negative effect on compliance with SRP standards. In addition, infrastructure factors such as intra-field road condition and post-harvest straw collection services are community-level constraints affecting compliance with SRP standards. Based on the results of this study, some solutions and policy implications are proposed.

Key words**:** *binary logistic, education, Mekong Delta, rice, Sustainable Rice Platform (SRP)*

INTRODUCTION

Vietnam's economy basically based on agriculture so that the rice economy - an important subsector in agriculture, needs to positively change to meet crave of increasing producer's income and adapting to climate change. One of the most necessary transformations for the rice industry was to change the farming mindset from highly intensive farming to reducing investment in inputs and reducing green house gas (GHG) emissions. Particularly for the field of GHG reduction, statistics showed that, Vietnam's agricultural sector annually emitted to the environment 88.3 million tons of CO_2 equivalent, accounting for 33.2% of the total national GHG emissions, in which wet rice cultivation emitted 44.8 million tons of CO_2 equivalent, accounting for 51% of the total agricultural sector's emissions [20]. Mekong Delta was the largest rice producing region in Vietnam, contributing 53.8% of the area and 55.4% of the country's rice production [10]. Reducing GHG emissions in rice production was a national strategy that significantly contributed to achieving the target of "Net zero CO_2" by 2050 [9, 28, 4].

The concept of Sustainable Rice Platform (SRP) was launched over a decade ago in 2011 and it has gradually promoted resource-use efficiency and climate change resilience in rice systems (both on-farm and throughout value chains). Significantly, it pursues voluntary market transformation initiatives by developing sustainable production standards, indicators, incentive mechanisms, and outreach mechanisms to boost wide-scale adoption of best practices throughout rice value chains. SRP's goal was to minimize environmental impacts of rice production and consumption while enhanced smallholder incomes and contributing to food security (www.sustainablerice.org version 2.1, 2020) [27].

SRP has recently applied in several rice-developed economy such as Thailand [23], Cambodia, India and Vietnam [15]. In Vietnam, SRP application played an important role in enhancing qualified rice as well as rice export value, and reducing GHG emission [5]. The SRP package was

recognized one of the measures for restructuring the rice industry, which recently piloted in several provinces in the Mekong Delta [18, 34]. One of the SRP implementation pilots was the "Market Oriented Smallholder Value Chains (MSVC)" project funded by GIZ and collaborated with a private sector Olam Group was practiced in four target provinces/city in the Mekong Delta, including An Giang, Dong Thap, Can Tho and Bac Lieu. The objective of this pilot is to strengthen the capacity of rice farmers to implement SRP standards on rice, thereby gradually upgrading the rice value chain and improving the livelihoods of rice farmers and reducing greenhouse gas emissions in the rice industry.

Given the situation that rice farmers in the Mekong Delta and in the project area in particular have inherited experiences and capacities upgraded by previous extension programs like the Integrated Pest Management (IPM) programs [24, 13, 14], 1 Must 5 Reductions [22, 30], and VNSAT project [29], not many farmers in the above pilot could fully comply with the SRP standard as expected. What restrictions and barriers have impeded compliance with the SRP standard was a matter of concern for the rice sub-sector.

In order to better understand the factors that positively affect or hinder compliance with the SRP standard, this study directly investigated rice farmers under the aforementioned pilot project in 2022.

We based on the SRP requirements and guidelines (https://sustainablerice.org/) [27] to assess compliance with the SRP standard in this investigation. This article attempted to present the investigation's findings including the characteristics of rice farmers, difficulties they faced in complying with the SRP standard, and finally, to determine statistically the factors affecting the ability to meet the SRP standard.

MATERIALS AND METHODS

Data collection and SRP scoring

Data were collected in the year 2022 from 426 rice farmers in An Giang, Dong Thap, Can Tho and Bac Lieu provinces, where rice is intensively cultivated in the Mekong Delta. These were farmers who have been trained to carry out SRP rice production under the MSVC project of GIZ and OLAM organization in the years 2020 and 2021. The content of the survey focused on assessing the extent to which farmers are achieving in term of sustainable rice production based on SRP guidelines (www.sustainablerice.org version 2.1), 2020 [27].

The survey was conducted by Can Tho university research team using a structured questionnaire sheet designed according to the SRP guideline strictly. This questionnaire includes 41 requests spanning 8 topics as shown in Table 1.

Each of the requirements in this questionnaire is assigned the highest score that rice farmers can achieve when they comply with all the contents of that requirement, and it also has corresponding scores to graded according to the level of compliance that the farmer household has made during the rice cultivation process. The number of points marked with an asterisk is referred to as the threshold for that requirement, which means the minimum number of points that a farmer needs to achieve for that requirement in order to qualify for the SRP once their cumulative score is above 90 for all 41 requirements.

The SRP score for each household is the actual score for compliance with the 41 requirements out of the maximum possible score, and is expressed as a percentage, so this score is usually less than 100%. According to the scale guided by SRP, there are 2 levels of SRP scores, a level below 90 is called "toward sustainable rice cultivation" and a level of 90 and above 100 is called "sustainably rice cultivated" as shown in Figure 1. In order to really meet the SRP standard, a farmer must achieve at least 90 points and not violate any threshold of the 41 requirements mentioned above.

The SRP standard was designed and applied to many countries, so there were a few exceptions where not all 41 requirements

were applied. In the Mekong Delta where this study was carried out, there were a number of requirements that were not applicable due to the unique characteristics of the site, and are bold highlighted as shown in Figure 1.

Table 1. Eight themes and forty-one requirements in the SRP Standard

1. Farm management	**2. Preplanting**	**3. Water use**	**4. Nutrient management**
1.Crop calendar (3), (1*) 2.Record keeping (3), (1*) 3.Training (3), (1*)	4.Heavy metals (3), (1*) 5. Soil salinity (3), (1*) 6.Land conversion and biodiversity (3), (1*) 7.Invasive species (3), (3*) 8.Leveling (3), (2*) 9. Pure seed quality (3), (2*)	10.Water management (3), (1*) **11. Irrigation system at community level** (3), (1*) **12. Inbound water quality** (3), (1*) **13. Groundwater extraction** (3), (2*) **14. Drainage** (3), (2*)	15.Nutrient management (organic and/or non-organic) (6), (4*) 16.Organic fertilizer choice (3), (2*) 17.Inorganic fertilizer choice (3), (3*)
5. Integrated pest management	**6. Harvest and postharvest**	**7. Health and safety**	**8. Labor rights**
18.1 Weeds (3), (2*) 18.2 Insect (3), (2*) 18.3 Diseases (3), (2*) 18.4 Molluscs (3), (2*) 18.5 Rodents (3), (2*) 18.6 Birds (3), (1*)	19. Timing of harvest (3), (2*) 20. Harvest equipment (3), (2*) 21.Drying time (3), (3*) **22.Drying technique** (3), (2*) **23.Rice storage** (3), (1*) 24. Rice stubble (3), (1*) 25. Rice straw (3), (1*)	26.Safety instructions (3), (1*) 27. Tools and equipment (3), (1*) 28.Training of pesticide applicator (3), (1*) 29.Personal protective equipment (3), (1*) 30.Washing and changing (3), (1*) 31. Applicator restrictions (3), (2*) 32.Re-entry time (3), (1*) 33.Pesticide and chemical storage (3), (1*) 34. Pesticide disposal (3), (1*)	35. Child labor (3), (3*) **36. Hazardous work** (3), (3*) **37. Education** (3), (1*) **38.Forced labor** (3), (3*) **39. Discrimination** (3), (3*) **40.Freedom of association** (3), (3*) **41. Wages** (3), (3*)

(x): maximum score attainable; (x^*) minimum required score to meet mandatory compliance level (threshold)
Source: www.sustainablerice.org version 2.1, 2020 [27].

For example, the water management requirements (No. 11, 12, 13, 14) were not applicable since this was an intensive rice growing area for many years, irrigation was complete and no groundwater was used. Or No. 22 and 23 also did not apply due to the custom of selling paddy immediately after harvest without drying at home. Requirements related to labor rights and child labor (No. 36, 37, 38, 39, 40 and 41) did not apply since they were not infringed under the provisions of applicable law.

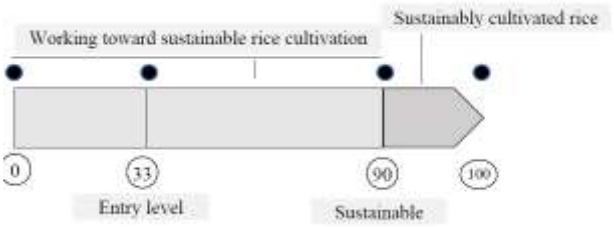

Fig. 1. SRP scoring claim
Source: www.sustainablerice.org version 2.1, 2020 [27].

$$\text{Score standard (0-100)} = \frac{Total\ number\ of\ points\ corresponding\ to\ actual\ performance}{Maximum\ number\ of\ points\ possible} x100$$

Data analysis

We used the cut-off line at 90 points to divide the observed sample into two groups of households, respectively called the SRP group for the households achieved 90 and above 90 points and the Non-SRP for those below 90 points, were then correspondingly assigned for 1 and 0 values. We used these dichotomous outcomes as dependent variables in a binary logistic function [3] to determine explanatory variables that affected the possibility of meeting SRP standard.

Explanatory variables selected were the demographic as well as essential resources of the household like age, education, gender of the household head, family size, number of male workers, number of female workers, children or workers engaged in non-agricultural activities. Variables of rice land and contract farming performance were also taken into account to see how they impact SRP compliance.

As the binary logistic regression analysis performed, a term of Odds was calculated, whereby Odds referred to the state at which the likelihood of an event occurring or not occurring. If the probability of an event occurring was p, the probability of the event

not occurring was (1-p), then the corresponding Odds was a value given by:

Odds of event=p/(1-p)

The form of binary logistic regression model in the study was given below

$$log_e\left[\frac{p}{1-p}\right] = \beta o + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \quad (1)$$

where:
p: probability of attaining SRP standard ($0 \leq p \leq 1$)
1– p: probability of attaining Non-SRP standard
β_0: intercept parameter
β_1, β_2, … βn: coefficients of regression model
X_n: explanatory variables (covariates), including as follow:
X_1: Age of household head (year)
X_2: Gender of household head (0: female, 1: male)
X_3: Education of household head (year of schooling)
X_4: Experience of rice farming of household head (year)
X_5: Household size (person)
X_6: Labor (person)
X_7: Non-farm labor (person)
X_8: Rice land (ha)
X_9: Contract farming (0: no, 1: yes)
The probability of farm household attained SRP standard was p under certain conditions was written as $p = P(Y=1|X_1, X_2, \ldots, X_n)$, and could be estimated by the formula below:

$$p = \frac{e^{(\beta_0+\beta_1X_1+\beta_2X_2+\cdots+\beta_nX_n)}}{1 + e^{(\beta_0+\beta_1X_1+\beta_2X_2+\cdots+\beta_nX_n)}} \quad (2)$$

The p value ranged from 0 to 1, when $p > 0.5$, the probability of an event meeting the SRP standard occurred, the closer it was to 1, the higher this possibility was. Conversely, when $p < 0.5$, the possibility of not meeting the SRP standard were occurred.
For estimating parameter of the logistic regression model, method of Maximum Likelihood Estimation (MLE) was used. This method was designed to maximize the livelihood of obtaining the data given its parameters estimates. The null hypothesis stated that all β_i parameters equal to zero. A rejection of null hypothesis indicated that at least one β not equalled to zero. The MLE typically used value of -2log-livelihood (-2LL) to determine the suitability of the model, the smaller this value was, the more fit the model was. Besides, the R^2 of Cox and Snell [2] and R^2 of Nagelkerke [21] with values ranging from 0 to 1 were also used to evaluate the goodness of fit of the model.
The larger these values were, the better the model fitted, however, in binary regression models, the model fit measures were of certain importance, but the values of the regression coefficients and their statistical significance were equally important [11]. Wald test was used to evaluate the level of statistical significance as well as the contribution of individual regression coefficients in the model [1].

RESULTS AND DISCUSSIONS

Characteristics of rice farm households

As mentioned in the method section, only households that satisfied both conditions of SRP score ≥ 90 and passing all threshold points, are classified as SRP group, and vice versa the Non-SRP group. Accordingly, only 28 households were classifying into SRP group, accounting for 6.57% of the total 426 households assessed. Characteristics of rice farmers in the two groups are summarized in Table 2.
Among the characteristics of the rice-growing households that were compared, only a few characteristics were statistically different between the two groups of households. First of all, the age of the household head who was the most important person in the household's production activities shows that their age was 49.36 years, this was a rather high age and partly affects the management and decisive making process. The age of the SRP group was younger than that of the Non-SRP group and was statistically significant.
The second feature with statistical difference was the education level of the household

head. On average, the head of household had 7.3 years of schooling, but the number of years of schooling in the SRP group was 8.75 years and was higher than 7.2 years in the Non-SRP group. Whether this feature had an impact on the ability to qualify for SRP would be examined in the next section.

The average area of rice land was 1.97ha/household, in which the SRP group tended to have a larger area, but they did not significantly differ between two groups. Accumulation of land in rural areas has recently taken place, but it has not caused too big changes [32]. Another important feature was the proportion of farmers practiced contract farming with rice-trading enterprises. In this study, an average of 18.1% of farmers did contract farming, of which the SRP group had a contract farming rate of 42.9% compared to 16.3% of the Non-SRP group. The percentage of rice farmers having contract farming with enterprises in Mekong Delta was also not high for many reasons [31, 26, 17, 7, 6]. The practice of contract farming was usually a subjective decision between the two parties - farmer and the company, and was signed at the beginning of rice crop. This agreement could influence the behavior of rice farmers to ensure that the quality of rice corresponded to the price of rice that the company has committed to buy. This sometimes certainly effected on compliance with the SRP standard during rice cultivation, and should be tested in the binary regression section of this article.

Table 2. Main household characteristics by household group

		Total (n=426)	**Non-SRP (n=398)**	**SRP(n=28)**	**T value**
Age (year)		52.80 ± 10.34	53.04 ± 10.36	49.36 ± 9.60	1.826^{*}
Gender	0	72	68	4	$\chi^2 = 0.702^{ns}$
	1	354	330	24	
Edu (year)		7.30 ± 3.12	7.20 ± 3.14	8.75 ± 2.38	-3.250^{***}
Exp (year)		28.03 ± 10.93	28.17 ± 10.99	26.00 ± 10.02	1.015^{ns}
Member (person)		4.57 ± 1.62	4.59 ± 1.65	4.32 ± 1.22	0.143^{ns}
Labor (person)		3.12± 1.43	3.11± 1.44	3.18± 1.31	-0.234^{ns}
Non-farm labor		0.90 ± 0.99	0.89 ± 0.99	1.04 ± 0.92	-0.739^{ns}
Land (ha)		1.97± 1.71	1.90± 1.35	2.91± 4.26	-1.245^{ns}
Contract farming	0	349 (81.9%)	333 (83.7%)	16 (57.1%)	$\chi^2 = 12.430^{***}$
	1	77 (18.1%)	65 (16.3%)	12 (42.9%)	

***, ** and * significant at 1%, 5% and 10% respectively; ns: not significant
Source: Author's calculation.

Achievement of SRP score

The average SRP score of all 426 households in the project area was 81.6, of which the mean scores of the two groups of households were quite different (Table 3).For the SRP group, their scores were definitely above 90 points, which averaged of 92.3. For the Non-SRP group, their scores were mostly fallen into the range of 80 - <90 points (accounting for 58%), followed by the range of 70 - <80 points (33%), below 70 points (6.8%), and finally over 90 points (2%).

Table 3. Range of SRP score attained by SRP group

Range	**Total**		**Non-SRP**		**SRP**	
	Freq.	(%)	Freq.	(%)	Freq.	(%)
<60 – <70	27	6.3	27	6.8	0	0
70 – <80	132	31.0	132	33.0	0	0
80 – < 90	230	54.0	230	58.0	0	0
90 – 100	37	8.7	9	2.0	28	100.0
Total	426	100.0	398	100.0	28	100.0
Mean	81.6 ± 6.6		80.8 ± 6.2		92.3 ± 1.6	

Source: Author's calculation.

The percentage of households scoring above 90 points out of the total number of surveyed households was only 8.7%, which could be considered as pioneers in the process of adopting a new technology. This ratio was similar to the new technical diffusion theory [25].

Figure 2 comparatively showed the theme-specific SRP scores for the two groups. SRP scores in the four themes namely "Preplanting", "Water management", "Integrated pest management" and "Labor right" were very similar between the two groups. These were topics considered favorable, both groups of households have the same ability or skill to complete. As for the remaining four themes including "Farm management", "Nutrient management", "Harvest and post-harvest", and "Health and safety", the scores of the two groups were quite different. This implied capacity of farmers was different when they have to implement these themes, and they could be the weakness of farmers in the compliance of SRP standards.

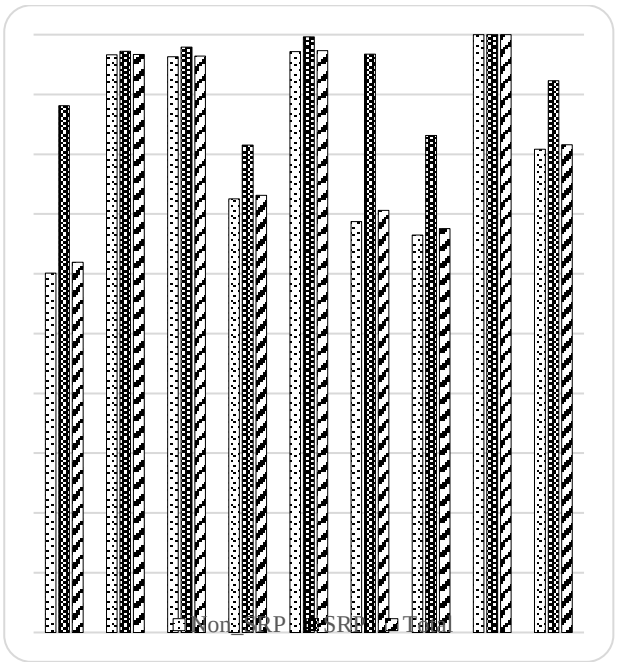

Fig. 2. Scores attained by group and theme
Source: Author's calculation.

The number of thresholds that the Non-SRP group could not pass was statistically shown in Table 4. On average, one household could not pass 2.8 thresholds, particularly few households could not pass up to 11 thresholds. Farmers often failed to pass the thresholds of the requirements that fallen under the four themes of farmer weakness as shown in Figure 2.These thresholds that were difficult for farmers to overcome became issues that the rice sub-sector must pay attention to find solutions to support farmers to comply with the SRP standard.

Table 4. Number of thresholds encountered by Non-SRP group

Theme	Mean	Maximum	Minimum	Std. Dev.
Farm management	0.37	3.00	0.00	0.74
Preplanting	0.00	1.00	0.00	0.05
Water management	0.00	1.00	0.00	0.05
Nutrient management	0.21	2.00	0.00	0.43
Integrated pest management	0.00	0.00	0.00	0.00
Harvest and post-harvest	1.12	4.00	0.00	1.11
Health and safety	1.09	6.00	0.00	1.13
Labor right	0.00	0.00	0.00	0.00
Total	2.80	11.00	0.00	2.13

Source: Author's calculation.

Figure 3 detailed the frequency as well as the percentage of farmers in the Non-SRP group that did not pass the thresholds. For the two requirements No. #24 and No. #25 referring straw and stubble treatment were the biggest challenges for farmers because over 46% of farmers did not exceed these thresholds. The post-harvest treatment of rice straw depended not only on farmers' awareness and their available means, but also on factors outside the household such as the service of straw collection machine or infrastructure condition. In the case of harvesting in the rainy season, it was even more difficult to collect rice straw, especially for rice fields located far from rural roads.

Requirement No. #26 (safety instruction) referred about instructions for farmers to raise awareness of work safety or first aid when encountering a work accident was also a difficulty for farmers. This was a requirement that requires the support of the public health system as well as the local government. Requirement No. #27 on maintenance and adjustment of farming tools was also a

limitation of farmers because it involved changing habits of farmers who were already getting old. A requirement No. #32 (re-entry) was also a difficult threshold to overcome because it was more related to the neighbors' consciousness than to the farmer himself who owned the field. In addition, the requirement referring to keeping farming records was also an obstacle worthy of attention, up to 20.35% of households were encountered.

Fig. 3. Specific thresholds encountered by Non-SRP group
Source: Author's calculation.

Determinants for compliance of SRP standard

Although full compliance with the 41 SRP requirements was a challenge for the majority of farmers, there were still a number of farmers who passed the thresholds to meet SRP standards. In this survey, there were 28 households, accounting for 6.57% who fully complied the SRP standard. This raised the question that there were some differences in household characteristics between the two groups of households meeting and not meeting the SRP standard in terms of their ability to comply with the SRP standard given the similarity of communal socio-economic conditions they lived in.

In search of answers to the above questions, a binary regression function was performed and the results were presented in the followings. Firstly, we tested the appropriateness of the regression model by considering the value of -2 Log Livelihood (-2LL) of 180,753 in Table 5.

The value of -2LL was not too large, so the regression model could be accepted. Additionally, the values of Cox & Snell coefficients R^2 and Nagelkerke R^2were 0.059 and 0.153 respectively, which allowed to conclude that the established regression model was suitable (Table 5).

Table 5. Statistical results of model fitness

-2 Log likelihood (-2LL)	Cox & Snell R Square	Nagelkerke R Square
180.753	0.059	0.153

Source: Author's calculation.

At the same time, the value of $\chi^2 = 25.828$ (df = 9) in the Omnibus test of the model's coefficients was statistically significant at $\alpha = 0.01$ (Table 6), so we rejected the null hypothesis H_0 ($\beta 1, \beta 2, \ldots \beta n = 0$). This meant that this study accepted the hypothesis H_1 that at least one of the regression coefficients was non-zero and they statistically effected to dependent variable.

Table 6. Result of Omnibus test of model coefficients

	Chi-square	df	Sig.
Step	25.828	9	0.002
Block	25.828	9	0.002
Model	25.828	9	0.002

Source: Author's calculation.

Table 7 additionally showed the correctness of the model prediction. The first row showed that out of a total of 398 observations that did not conform to the SRP standard, the model predicted that all such 398 households did not meet the SRP standard, which meant that the prediction was 100% correct. Next, out of 28

observations that met the SRP standard, only 1 case was predicted to meet the SRP standard, the correct prediction rate was 3.6%. Overall, the model's correct prediction rate was 93.7%.

Table 7. Classification table of correct prediction

Observation	Prediction		Correction (%)
	SRP		
	0	1	
0	398	0	100.0
1	27	1	3.6
			93.7

Source: Author's calculation.

After accepting tests of fitness as well as correctness of the model, we finally used the Wald test to determine the level of statistical significance of the independent variables. Wald tested results in Table 8 showed that out of nine socio-economic factors, there were four variables that had a statistically significant impact on the ability of households to meet SRP standards with α = 0.1 to α = 0.01. The first was the education variable of the household head, which had a positive and statistically significant effect on the ability to meet the SRP standard. The level of impact of the education variable was expressed through the value Exp(B) = 1.171 (=$2.7182^{\wedge 0.157}$), that meant when the education of the household head increased by one school year, the probability of meeting the SRP standard increased by 1.17 times as long as other factors remained unchanged.

Table 8. Factors affecting the ability of farmers to meet SRP standards

	B	S.E.	Wald	df	Sig.	Exp(B)
X_1: Age	-0.037	0.035	1.127	1	0.288	0.963
X_2: Gender	0.225	0.588	0.147	1	0.702	1.253
X_3: Education	**0.157**	0.073	4.691	1	**0.030**	1.171
X_4: Experience	0.021	0.031	0.457	1	0.499	1.021
X_5: Member	**-0.334**	0.198	2.850	1	**0.091**	0.716
X_6: Labor	0.182	0.204	0.794	1	0.373	1.199
X_7: Non-farm labor	0.311	0.241	1.661	1	0.198	1.364
X_8: Land	**0.172**	0.088	3.832	1	**0.050**	1.188
X_9: Contract	**1.276**	0.429	8.867	1	**0.003**	3.583
Constant	-2.900	1.785	2.640	1	0.104	0.055

***, ** and * indicate significant different at α = 1%, 5% and 10%, respectively; ns: not significant
Source: Author's calculation.

The family member variable had a negative effect on the ability of meeting the SRP standard with an effect level Epx(B) of 0.716 (equivalent to $2.7182^{\wedge -0.334}$), that was, when the number of family members increased by one person, the probability of meeting the SRP standard decreased by 0.716 times. This could be explained as an increase in family demographics that were often dependents, such as children, which might create certain barriers to SRP compliance, for example when they involved requirement No.#33 and No.#34 for pesticide and chemical storage and pesticide disposal, respectively. Another reason was that an increase in the number of dependents in the family also meant an aging rate of labor due to the fact that young people often migrated in search of income in urban areas [16, 32], adversely affected rice cultivation, which would have a high degree of mechanization [19].

The variable rice land area had a positive effect on the ability to meet the SRP standard with an Exp(B) level of 1,118 (equivalent to $2.7182^{\wedge 0.172}$), meaning that when increased 1 ha of rice land, the possibility of achieving SRP standard increased by 1,118 times once other factors kept unchanged. This could be explained by the "economic to scale" effect that many authors have discovered, which made farm management more convenient and related to SRP compliance [12, 8, 26, 17].

Another independent variable namely "contract farming" had a great impact on the ability to meet the SRP standard, with an impact level of Exp(B) = 3,583 (equivalent to $2.7182^{\wedge 1.276}$). That was, when a farmer practiced a contract farming signed with a rice

purchasing company, the probability of meeting the SRP standard increased by 3.583 times as long as other factors remain unchanged. It was understandable that signing a contract with a rice purchasing company has affected farm management behavior, consequently positively affected the level of compliance of SRP standards.

Table 9 has showed somewhat a correlation between the signing of contract farming and the selling price of rice regardless degree of SRP compliance. In this survey there were 77 households, equivalent to 18% of the total surveyed households that signed a contract with the company with an average price of 6,134 VND.kg^{-1}, while the remaining 349 households (82%) did not signed a contract, consequently the selling price was much lower of 5,815 VND.kg$^{-1;}$.

(Exchange rate: 1 USD = 23,680 VNDhttps://www.sbv.gov.vn/TyGia/faces/ExchangeRate.jspx?_afrLoop=20471777466753466&_afrWindowMode=0&_adf.ctrl-state=1bt04b3u9f_4)

[33].

Table 9. Output price (VND.kg^{-1}) in a matrix of contract farming and SRP compliance level

		Contract farming		Total (n=426)
		No (n=349)	Yes (n=77)	
Compliance level of SRP	Non-SRP	5,817 (78%)	6,115 (15%)	5,865
	SRP	5,781 (4%)	6,236 (3%)	5,976
Total		5,815 (82%)	6,134 (18%)	5,873

Source: Author's calculation.

We verified the probability of qualifying for the SRP based on the binary regression results. Based on the independent variables that had a statistically significant impact in Table 8, combined with the established function (2) and the parameters describing the characteristics of the households in Table 2, the probability of the two groups of households with two levels of SRP compliance were estimated. For the group of Non-SRP households, the probability of meeting the SRP standard was only 0.53, equivalent to 53%. This is a rate that has just crossed the threshold of 0.5, or in other words the probability that this group of households with the current characteristics of households would be difficult to comply with the SRP standard.

$$P_{Non-SRP} = \frac{e^{(0.157*7.2-0.334*4.59+0.172*1.9+1.276*0.163)}}{1+\ e^{(0.157*7.2-0.334*4.59+0.172*1.9+1.276*0.163)}} = 0.53$$

For the group of households reaching the SRP standard, the probability of achieving SRP standard was estimated to be 0.73, equivalent to 73%. This was a much larger rate than the threshold of 0.5, which meant that this group of households was possible to comply the SRP standard, however, it did not mean they would definitely possible complied SRP standard.

$$P_{SRP} = \frac{e^{(0.157*8.75-0.334*4.32+0.172*2.91+1.276*0.429)}}{1+\ e^{(0.157*8.75-0.334*4.32+0.172*2.91+1.276*0.429)}} = 0.73$$

For all surveyed households, the probability of meeting the SRP standard is also quite low, only 0.55, equivalent to 55%. It proved that the current capacity of rice farmers towards compliance with SRP standards was quite uncertain.

$$P_{total} = \frac{e^{(0.157*7.3-0.334*4.57+0.172*1.97+1.276*0.181)}}{1+\ e^{(0.157*7.3-0.334*4.57+0.172*1.97+1.276*0.181)}} = 0.55$$

CONCLUSIONS

Rice cultivation according to SRP standards was a sound strategy, contributing to achieving the Net-zero target on GHG emission of the Vietnamese government. However, given the current situation, this was still challenging, at least for the rice-growing provinces in the Mekong Delta.

The percentage of rice-growing households meeting SRP standards was low, only about 6.57% of surveyed households. The majority of farmers had SRP compliance levels between 80 and less than 90 points compared to above 90 points, meaning they could meet SRP standards but were still weak in a few certain capacities.

Requirements on post-harvest handling of rice straw, pesticide and chemical storage, and farming diary recording were prominent barriers that made it difficult for farmers to comply with SRP standards. Besides the weak

capacity of farmers, community capacity such as rural transport, mechanized service for collecting straw after harvest also affected compliance with SRP standards.

Household characteristics that positively affected SRP eligibility were the education level of the household head, land size and contract farming with rice consumption company. Meanwhile, demographic size had a negative effect on the ability to meet SRP standards.

Recommendations to increase compliance with SRP standards were firstly rejuvenating farmers through how to attract young people into rice production and the agricultural sector in general to improve farm governance capacity as well as recording the farming diary. Secondly, it was to strengthen horizontal farmer linkage as well as link with consumption companies according to value chain approach so that farmers were motivated to comply with SRP standards. Finally, local authorities needed to improve in-field transport to support the development of post-harvest straw handling services.

ACKNOWLEDGEMENTS

The authors were very pleased and grateful to GIZ organization for financial support for this study under the project "Market Oriented Smallholder Value Chains (MSVC)" (Project No.: 12.1003.8-215.01). The authors also expressed their gratitude to farmers and other relevant individuals in the rice industry in 4 provinces in the project area, for taking the time to have direct conversations and helped the research team complete this study.

REFERENCES

[1]Bewick, V., Cheek, L., Ball, J., 2005, Statistics review 14: Logistic regression. Crit Care 9, 112, 2005. https://doi.org/10.1186/cc3045

[2]Cox, D.R., Snell, E.J., 1989, Analysis of binary data. Chapman and Hall/CRC, London.

[3]Cramer, J.S., 2002, The origin of logistic regression. Tinbergen Institute Discussion Paper. Faculty of Economics and Econometrics, University of Amsterdam, and Timbergen Institute.

[4]Dang, P.T., Buruah, B., 2022, An evaluation of Vietnam's pathway to net zero by 2050: Reconciling the Developmental State and Civil Society. Conference: The 11th Congress of the Asian Association of Environmental and Resource Economics (AAERE 2022) - A Pathway Towards Carbon Neutrality in Asia At: Hochiminh City – Vietnam.

[5]Demont, M., Rutsaert, P., 2017, Restructuring the Vietnamese Rice Sector: Towards Increasing Sustainability. Sustainability 2017, 9, 325; doi:10.3390/su9020325

[6]Dung, L.C., Tuan, V.V., Thoa, N.T.K, Son, N.P., Eiligmann, A., 2022, The Potential of the Rice Value Chain in the Mekong Delta to Develop High Value Export Markets. Int. J. Food System Dynamics 13 (3), 2022, 335-348. www.centmapress.org. DOI: https://dx.doi.org/10.18461/ijfsd.v13i3.C7

[7]Dung, L.C., Tuan, V.V., Thoa, N.T.K., 2019, Assessing the impact of cooperative economy on profit of rice production in the Mekong Delta. Journal of Vietnam Agricultural Science and Technology. Vol. 10 (107), 138-144. https://tapchi.vaas.vn. Accessed on June 17th, 2023.

[8]Duyen, N.L., Khiem, N.T., 2019, Influence of land size and labor size on labor productivity of rice farmers in the Mekong Delta. Journal of Science Open University Ho Chi Minh City, 14(1), 76-87.

[9]Government, 2022, Decision No. 888/QD-TTg dated July 25, 2022 of the Prime Minister approving the Scheme on tasks and solutions to implement the results of the 26th Conference of the Parties to the United Nations Framework Convention about climate change (UNFCCC).

[10]GSO, 2021, Agriculture, forestry and fishery data in 2021. https://www.gso.gov.vn/ , Accessed on May 17, 2023.

[11]Gujarati, D., 2011, Econometrics by Example. Palgrave Macmillan Publisher.

[12]Ho, T.T., Shimada, K., 2019, Technical Efficiency of Rice Farming in the Vietnamese Mekong Delta: A Stochastic Frontier Approach. The Ritsumeikan Economic Review, Vol. 67 No.5.6.

[13]Huan, N.V., Thiet, L.V., Chien, L.V., Heong, K.L., 2005, Farmers' participatory evaluation of reducing pesticides, fertilizers and seed rates in rice farming in the Mekong Delta. Vietnam. Crop Prot. 24, 457–464. doi: 10.1016/j.cropro.2004.09.013, Accessed on November 4th, 2021.

[14]Huelgas, Z.M., Templeton, D., Castanar, P., 2008, Three Reductions, Three Gains (3R3G) Technology in South Vietnam: Searching for Evidence of Economic Impact. Contributed paper at the 52nd Annual Conference of the Australian Agricultural Resource Economics Society held at Rydges Lakeside, Canberra ACT, Australia, 5-8 February 2008.

[15]Hung, N.V, Balingbing, C., Sandro, J., Khandai, S., Chea, H., Songmethakrit, T., Meas, P., Hitzler, G., Zwick, W., Viriyangkura, L., Bautista, E., Gummert, M., 2022. Precision land leveling for sustainable rice production: case studies in Cambodia, Thailand, Philippines, Vietnam, and India. Precision Agriculture (2022) 23:1633–1652. https://doi.org/10.1007/s11119-022-09900-8

[16]Huy, H.T., Khoi, L.N.D., 2011, Analysis of Labour Migration Flows in the Mekong Delta of Vietnam. n book: Environmental Change and Agricultural Sustainability in the Mekong Delta, Advances in Global Change Research 45Chapter: 7Publisher: Springer Editors: M.A. Stewart and P.A. Coclanis.DOI: 10.1007/978-94-007-0934-8_8

[17]Kiet, N.T., Duc, T.C., 2017, Effect of large field models: empirical evidence in Can Tho and Soc Trang. National Journal of Science and Technology, 26: 212-222.

[18]MARD, 2021, Decision No. 555/QD-BNN-TT dated January 26, 2021 on approving the Agricultural Restructuring Program for the period to 2025 and vision to 2030.

[19]Matsubara, T., Truong, C.T., Dung, L.C., Kitaya, Y., Maeda, Y., 2020, Transition of Agricultural Mechanization, Agricultural Economy, Government Policy and Environmental Movement Related to Rice Production in the Mekong Delta, Vietnam after 2010. AgriEngineering 2020, 2, 649–675; doi:10.3390/agriengineering2040043. http://www.mdpi.com/journal/agriengineering, Accessed on June 17th, 2023.

[20]MONRE, 2014, GHG inventory report 2010. Project "Strengthening capacity for national greenhouse gas inventory in Vietnam".

[21]Nagelkerke, 1991, A note on general definition of the coefficient of determination. Biometrika.

[22]Phung, N.T.M., Du, P.V., Singleton, G., 2014, One Must Do, Five Reductions (1M5R): Best Management Practices for Lowland Irrigated Rice in the Mekong Delta. Ministry of Agricultural and Rural Development: Vietnam and International Rice Research Institute, Philippines.

[23]Rattanacharoen, N., Yamada R., 2021, Contribution of Sustainability Rice Cultivation Practice for Farmers according to SRP Standard: A Case Study of Ubon Ratchathani Province, Thailand – International Journal of Environmental and Rural Development (2021) 12-2

[24]Rejesus, R. M., Palis, F.G., Lapitn, A.V., Chi, T.T.N., Hossain, M., 2009, The Impact of Integrated Pest Management Information Dissemination Methods on Insecticide Use and Efficiency: Evidence from Rice Producers in South Vietnam. Review of Agricultural Economics. Vol. 31, No. 4 (Winter 2009), pp. 814-833.

[25]Rogers, E.M., 2003, Diffusion of innovations (5th ed.). New York: Free Press.

[26]Son, N.P., Quan, L.B.M., Trang, P.H., 2017, Economic efficiency of rice production of households participating in large rice fields in the Mekong Delta. Journal of Industry and Trade, 12:86-93.

[27]SRP, 2020, The SRP Standard for Sustainable Rice Cultivation (Version 2.1), Sustainable Rice Platform. Bangkok: 2020. http://www.sustainablerice.org, Accessed on May 15th, 2023

[28]Take, K., Nguyen, T.L., Ota, T., Hirayyama, T., Motoki, Y., Hibino, G., Ochi. Y., Masui, T., 2022, Net Zero Emission Scenarios in Vietnam. Global Environmental Research.

[29]Tran, V.T., Mai, V.T., Nguyen, T.D.T., Le, H.A., Richards, M.B., Sebastian, L, Wollenberg, E., Vu, D.Q., Sander, B.O., 2019, An investment plan for low-emission rice production in the Mekong River Delta region in support of Vietnam's Nationally Determined Contribution to the Paris Agreement. CCAFS Working Paper no. 263. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). www.ccafs.cgiar.org, Accessed on June 17th, 2023.

[30]Tho, L.C.B., Dung, L. C., Umetsu, C., 2021, One Must Do, Five Reductions. Technical Practice and the Economic Performance of Rice Smallholders in the Vietnamese Mekong Delta. Sustainable Production and Consumption 28(195). DOI: 10.1016/j.spc.2021.07.018

[31]Tuan, V.V., Dung, L.C., Thoa, N.T.K., 2020, Assessing effectiveness of the linkage models in producing and consuming of specialty and aromatic rice in the Mekong Delta. Scientific Journal of Can Tho University, Volume 56 (5D), Pd: 269-277. DOI:10.22144/ctu.jvn.2020.137

[32]VCCI and Fulbright, 2020. Annual economic report: Improving competitiveness for sustainable development.

[33]VNDhttps://www.sbv.gov.vn/TyGia/faces/ExchangeRate.jspx?_afrLoop=20471777466753466&_afrWindowMode=0&_adf.ctrl-state=1bt04b3u9f_4 Accessed on May 15th, 2023.

[34]World Bank, 2022, Towards Green Agriculture Transformation in Vietnam: Switch to low carbon rice model. Report No: AUS0002201. Washington, DC: World Bank.