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Factors Affecting Farmers' Adoption of Sustainable Land Management Practices in Vietnam

Nguyen Mau Dung

Faculty of Economics and Rural Development, Vietnam National University of Agriculture, Hanoi 131000, Vietnam

Abstract

This study aimed to identify the factors affecting farmers' adoption of sustainable land management (SLM) practices to combat land degradation in Vietnam. Based on the survey data from 826 farmers in three representative regions, the study showed that the SLM model and SLM adoption rate were quite varied due to differences of natural and socio-economic conditions. The results of logistic regression showed that household income and access to loans had positive impacts on SLM adoption with statistical significance in all the regions surveyed. More extension visits in the upland and coastal regions, and more agricultural laborers in farm households in the coastal and Mekong delta regions were found to increase the probability of SLM adoption. Meanwhile, the number of plots and number of members in households were found to have negative impacts on adoption. Providing training courses for farmers, building SLM demonstrations, and providing financial support for farmers through credit programs should be enhanced for better SLM adoption in farm households.

Keywords

Adoption, agriculture, farm households, land degradation, sustainable land management

Introduction

Land degradation is a global environment and development issue (Bai *et al.*, 2008). Today, around one-quarter of land around the globe is degraded. It is estimated that each year around 24 billion tons of fertile farmland are lost and the global cost of land degradation is between 6.3-10.6 trillion USD (Sutton *et al*., 2016). Land degradation as a major environmental threat to food security is mostly caused by inappropriate land management (Etter, 2015). Therefore, sustainable land management (SLM) has been implemented in an effort to minimize and rehabilitate the degraded areas. However, investment in SLM is quite low, especially in developing countries (Nkonya *et*

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Correspondence to
maudung@vnua.edu.vn

ORCID
Nguyen Mau Dung
https://orcid.org/0000-0003-3351-6452

al., 2016), and the adoption of SLM is at a low rate and varies among regions and farm households.

Vietnam is still an agriculture-based economy as agriculture is the commanding sector of the national economy. However, Vietnam currently faces serious land degradation issues as around 9.3 million hectares in Vietnam, which support the livelihoods of some 22 million people, are degraded (MONRE, 2010). Land degradation is considered as one of the most striking problems for the nation (Vu *et al.*, 2014). The adoption of sustainable land management practices has been therefore determined by the Vietnamese government as one of the key strategies to address land degradation. Despite the recommendations on SLM adoption from the Vietnamese government, the non-SLM or inappropriate land management practices, such as erosive farming practices, monoculture, and excessive use of chemicals, etc., are still predominant in many regions in Vietnam (Cuong, 2005; Toan, 2011; Tran Thi Hien & Vo Quang Minh, 2014). The need for increasing the SLM adoption rate is thus very essential for land degradation prevention. In addition, farmers in different regions tend to apply SLM at different rates possibly due to variations of natural conditions, but also due to other factors such as socio-economic conditions in the regions. Moreover, through previous research (Do Van Nha *et al.*, 2016) and from discussions with local staff as well as observations in the survey sites during the field trips for this study, it is obvious that farm households in the same region, even in the same village, also apply SLM at different rates or with different models. In many cases, while many farmers in a village have tried to adopt SLM, many others have not followed. What socio-economic factors affect the adoption of SLM and what are the roles of social and economic factors/aspects in promoting or constraining SLM adoption of the farm households? This study was designed to shed light on the impacts of social and economic aspects on SLM adoption of the farm households in Vietnam.

Land degradation can be defined as the loss of land productivity through one or more processes, such as reduced soil biological diversity and activity, the loss of soil structure, soil removal due to wind and water erosion, acidification, salinization, water logging, soil nutrient mining, and pollution (World Bank, 2006). It impedes agricultural growth, increases poverty and vulnerability, and contributes to social tensions as populations increase and impose greater burdens on limited natural resources (UNCCD, 2009).

Sustainable land management is defined as knowledge-based procedures that help integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods (World Bank, 2006). SLM practices include: diversified cropping systems (strip cropping and mixed intercropping), integrated agro-forestry practices with cropping system and soil erosion control structures, and practices such as contour farming and grass barriers (Roberts & Shears, 2008). These practices are key mechanisms for effecting change in the sustainable use and management of land resources (Webb, 2004).

A farmer makes decisions about whether to adopt a farming practice or not by considering different factors. Some factors commonly found in the literature related to the adoption of soil conservation practices fall into several categories: (1) individual characteristics of the farmers, (2) farm characteristics, and (3) social, economic, and institutional context. It has been hypothesized that age is likely to have an impact upon the adoption of best agriculture practices. However, there appears to be no clear correlation between age and best practice adoption (Gould *et al.*, 1989; Okoye, 1998). Assessments of the role of years of farming in adoption reveal both positive correlations (Rahm & Huffman, 1984; Clay *et al.*, 1998) and insignificant ones (Shortle & Miranowski, 1986). There is mixed evidence regarding the relationship between a farmer's educational level and their adoption of sustainable land management practices. Indeed, education, be it specific or general, commonly correlates positively with the adoption of conservation agriculture practices (Gould *et al.*,

1989; Okoye, 1998); however, some studies have found education to be an insignificant factor (Clay *et al.*, 1998) or even to negatively correlate with adoption (Warriner & Moul, 1992). Some studies have emphasized awareness on the part of farm operators as an obvious prerequisite to adoption (Stonehouse, 1991; Mahboubi, 2005). Additional support comes from Marshall (2004) who found that knowledge/awareness of technology leads to its adoption. Furthermore, Roosta (1999) understood that there is a positive and significant relationship between technical knowledge and sustainable agriculture. Without knowledge of the practices associated with conservation agriculture via information or communication channels, adoption is improbable. Indeed, studies of innovation adoption and diffusion have long recognized information as a key variable and its availability is typically found to correlate with adoption.

In this study, firstly, we describe the SLM adoption of the farm households as well as the characteristics of the farm households. Secondly, we examine the effects of the various factors on SLM adoption of the farm households in different regions in Vietnam using the logit model. These factors included: (1) individual characteristics of the farm households (gender of farm household heads, number of members in farm households, number of agricultural laborers in the farm households, households' income, and farm households' loans); (2) farm characteristics (number of plots in the farm households, plot area, and distance from farmers' house to the plot); and (3) institutional context (agricultural extension support). Finally, we make some implications for better SLM adoptions of the farm households in the future.

Methodology

Land degradation occurs in all regions of Vietnam, but it is particularly serious in some parts of the Northwest mountainous region, central coastal region, Mekong delta region, and central highlands (UNCCD, 2002; Vu *et al.*, 2014). This study focused on the three regions of the Northwest mountains, central coast, and Mekong delta to understand the adoption decisions of farmers with regard to SLM practices. Based on the typical characteristics of topography, socioeconomic conditions, and land use management in each region, three districts, namely Da Bac district (Hoa Binh province) in the Northwest mountains, Co Do district (Can Tho province) in the Mekong delta, and Hai Lang district (Quang Tri province) in the coastal region, were selected as the study sites. Secondary data on the natural and socio-economic conditions of the selected districts (natural land areas, agricultural land areas, forest land areas, topography, population, labor, and minority structures) were mainly gathered from yearly statistical books and annual reports of the districts. The data on farming systems, crop areas, crop yields, and irrigation systems, etc., were gathered from related reports of the Department of Agricultural and Rural Development (DARD) at the district level and from related studies when available.

In each district, group discussions with the district staff were organized to select the communes for interviews with the requirements that the communes should be representative of the district in agricultural practices including both farm households with SLM and non-SLM adoption. Around 240-300 farm households in each province were selected for direct interviews (**Table 1**). Stratification was applied for farm household selection. At first, the farm households were divided into two main groups: SLM adopters and non-adopters. The sample farm households were then randomly selected in each group. The team worked with district staff and commune/village staff to understand the SLM adoption situation in the selected districts and communes, and then to randomly select the farm households for interviews. Through discussions with the local staff, the rate of farm households who adopted SLM practices (mainly agroforestry models) in Da Bac district accounted for 30-40%. The adoption rate of SLM practices, i.e. crop rotation models, in Hai Lang district was estimated at 20-30%. In Can Tho, the adoption rate of SLM practices, i.e. crop rotations with upland crops, was around 10-15%.

Table 1. Number of surveyed farm households by district

District	Estimated adoption rate (%)	SLM adopted farm households	SLM non-adopted farm households	Total surveyed farm households
1. Da Bac district	30-40	181	119	300
2. Hai Lang district	20-30	110	129	239
3. Co Do district	10-15	123	164	287
Total	-	414	412	826

Both primary and secondary data were compiled, sorted, and categorized for data analysis. Firstly, the descriptive statistics method was used to describe the situation of current land management practices and SLM adoption, and the respondents' awareness and knowledge of SLM. Secondly, a comparative analysis was done to determine the differences between adopter and non-adopter households on various aspects such as social aspects, economic aspects, farmers' attitudes, and knowledge. Thirdly, the logit model – one specific form of random utility models, was used to identify the factors affecting SLM adoption of the farm households.

A random utility model was used to determine the probability that a farm would choose to adopt SLM practices. Following Ben-Akiva & Lerman (1985), a random utility model is defined as

$U_{in} = V_{in} + \varepsilon_{in}$, i = 1, . . . , I and n = 1, . . . , N (1)

where U_{in} is the n^{th} farmer's expected utility accruing from choosing alternative i, V_{in} is the deterministic portion of the utility (to be maximized), and ε_{in} is the stochastic component. The probability that n chooses i is:

$P_n(i)= Pr(U_{in} \geq U_{jn}) = Pr (V_{in} + \varepsilon_{in} \geq V_{jn} + \varepsilon_{jn}) = Pr(\varepsilon_{jn} - \varepsilon_{in} \leq V_{in} - V_{jn})$ (2)

for all i, j ϵ Cn where Cn is the choice set for farm n [Cn = {i, j} = {Adopt, Don't Adopt}].

Assuming the random errors in Equation (1) are independently and identically distributed across the I alternatives (i= 1, . . . , I) and N individuals (n = 1, . . . , N) as a type I extreme value distribution, and that $\varepsilon_n - \varepsilon_{jn} - \varepsilon_{in}$ in Equation (2) is logistically distributed, Ben-Akiva and Lerman showed that the probability of producer n choosing alternative i is given by:

$$P_n(i) = \frac{e^{\mu V_{in}}}{\sum_{j \in Cn} e^{\mu V_{jn}}}$$

where μ > 0 is the scale parameter, assumed equal to one, because it is unidentifiable within any particular data set and cannot be distinguished from the overall scale of the estimated coefficients of the linear parameters, βs (Ben-Akiva & Lerman, 1985). With two choices (*i = 1* and *j =0*), a binary logit model gives the choice probability for l tentative *i* as (Ben-Akiva & Lerman, 1985):

$$P_n(i=1)=\frac{e^{\mu V_{in}}}{e^{\mu V_{in}}+e^{\mu V_{jn}}} = \frac{1}{1+e^{-\mu(V_{in}-V_{jn})}} = \phi(V) = \phi(\beta' x)$$

This means that Prob(Adoption) = ϕ(β'x) where β'x is the vector of parameters to be estimated and x is the vector of observations.

In this study, the dependent or predicted variable in the model was the adoption status of the surveyed farm households (dependent variable was a 1 if the farm adopted SLM and 0 if the farm did not adopt). Some of the predictor variables in this study were categorical and therefore, this study used a logistic regression model to examine the drivers of SLM adoption. The logistic regression is a simple but very efficient method for dichotomous classification prediction despite the fact that its major limitation is the assumption of linearity between the dependent variable and the independent variables. The reduced form of the logit model in this study is as follows:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X$

where Y is the dependent variable or adoption status of the farm households and the independent or explanatory variables included age and gender of the household heads, total number of household members and agri-laborers,

plot area, number of plots, visits by extension workers, access to credit, and household income per year as these were assumed to be the potential determinants of factors affecting the adoption of sustainable land management technologies. The explanatory variables used in the model and their values are shown in **Table 2**.

Results and Discussion

SLM adoption in the surveyed households

Due to the differences in natural and socio-economic conditions, the SLM practices in each region were quite different. Even in the same region, there were also different SLM practices. In Da Bac district (mountainous region), SLM practices included agroforestry models and crop rotation of maize and legumes while the non-SLM practices included monocultures of crops (two maize crops, two rice crops, cassava, and sugarcane) and crop rotation with cassava or edible canna (maize – cassava, maize – edible canna). Non-SLM practices in the regions usually caused the loss of soil organic matter and the depletion of soil nutrients, and led to difficulties in marketing the products. The salient characteristics of SLM practices in the region were that they could give good land cover, improve soil quality, and most importantly, allow the products of SLM practices to better meet market demands. Almost all the surveyed SLM households adopted agroforestry models in which acacia was grown with upland crops, accounting for 65.2%, followed by the models of growing styrax with a cash crop (13.3%), and Meliaceae with a cash crop (9.9%). For non-SLM households, maize monoculture practices accounted for 31.9%, followed by the intercropping of cassava and maize (19.4%), cassava monocultures (24.4%), and others (14.3%) (**Table 3**).

In Hai Lang district (coastal region), monocultures of rice (two rice crops per year) or cassava were considered the non-SLM practices. These practices often resulted in the depletion of soil nutrients and the loss of organic matter due mainly to overuse of chemical fertilizers or soil exposure to sunshine during the dry season. In non-SLM surveyed households, rice monoculture practices accounted for the majority (54.6%), while single cassava plantations occupied 21.8%, and monocultures of sweet potato were at 19.3% (**Table 3**).

In contrast, the intercropping models based on legumes (i.e., mung bean, peanut, or soybean) or chives could be considered as the SLM models in Hai Lang district since they could maintain and balance soil nutrients thanks to the legumes. Moreover, the farmers in Hai Lang district often used mulching by returning the crop residues from harvest in combination with compost applications. This further helped to maintain soil moisture, increase the soil organic matter, and reduce soil surface degradation. Chives with cassava was the main SLM in the surveyed

Table 2. Variables used in the household adoption model

Variable	Description	Value
Age	Age of the farm household head	Years
Gender	Gender of the farm household head	1 = male; 0 = female
Members	Number of members in the farm household	Persons
Agri-laborers	Number of agri-laborers in the farm household	Persons
Plot	Number of plots in the household	No. of plots
Income	Annual household income	Mil VND/year
Access to extension services	Has the farm received technical guidance through extensive training or visit by extension workers?	1 = yes; 0 = no
Access to credit	Has the farm taken out a loan in the survey year?	1 = yes; 0 = no
Farming Area	The total farming area of the household	1000m^2
Distance	The average distance from the farmer's house to the farming plots	km

Table 3. Type of SLM and non-SLM practices in surveyed households by region

Region	SLM and non-SLM practices		No. of adopted households	Rate (%)
Mountainous region	SLM practices	Styrax with cash crop	24	13.3
		Acacia with cash crop	118	65.2
		Meliaceae with cash crop	18	9.9
		Others	23	11.6
		Total	181	100.0
	Non-SLM practices	Maize – Maize	38	31.9
		Cassava	29	24.4
		Maize and cassava (intercrop)	35	29.4
		Others	17	14.3
		Total	119	100.0
Coastal region	SLM practices	Maize + peanut – Maize + bean	10	9.1
		Chives + bean + cassava	25	22.7
		Chives + cassava	30	27.3
		Colocynth + bean	24	21.8
		Cassava + bean – Melon	21	19.1
		Total	110	100.0
	Non-SLM practices	Rice – Rice	65	54.6
		Cassava	26	21.8
		Sweet potato	23	19.3
		Others	5	4.2
Mekong delta	SLM practices	Rice rotation with seasame	90	73.2
		Rice rotaltion with melon	4	3.3
		Rice rotaltion with bean	14	11.4
		Rice rotaltion with maize	15	12.2
		Total	123	100.0
	Non-SLM practices	Rice – Rice – Rice	155	94.5
		Rice – Rice	4	2.4
		Others	5	3.0

households, accounting for 27.3%, followed by the models of chives - bean - cassava (22.7%), colocynth - bean (21.8%), and cassava - bean - melon (19.1%).

In the Mekong delta, monocultures of rice (i.e. three rice crops per year or two rice crops per year) were considered the non-SLM practices. This is because under continuous rice cultivation, paddy soils experience a degradation of soil quality because of long-term submergence and mineral fertilizer application (Song *et al.*, 2020). Continuous rice cultivation over a long-term period has been recorded to result in rapid nutrient depletion and soil compaction, and the flooding conditions destroy the structure and porosity of soil and reduce aeration (Linh *et al.*, 2014; Linh *et al.*, 2016). In the non-SLM surveyed households, the three rice crop practice accounted for the majority of 94.5% while the figure for the two rice crop practice was quite small (just 2.4%).

A cropping rotation system with upland crops, especially with legumes that can improve soil fertility and nutrients like nitrogen by

returning biomass and fixing gaseous nitrogen, was considered as the main SLM practice in the Mekong delta. The SLM practice of rice rotation with sesame was mainly found in SLM households (73.2%), while rice rotated with bean or maize accounted for small shares (around 11-12% each).

Characteristics and income of farm households

Characteristics of the farm households

A total of 826 farm households, including both SLM adopted and non-adopted farm households, were selected for the direct interviews. According to the survey data, males accounted for about 81.0%. The average age of the respondents (households heads) was 47.7 and most of them completed secondary school. On average, a surveyed household had 4.7 persons with 4.1 persons above 12 years old, and there were 2.2 agricultural laborers in one surveyed household (**Table 4**).

First, the correlation matrix and VIF were employed to diagnose the multicollinearity of the independent variables in the pooled ordinary least squares (POLS) model. As seen in Table 4, the correlation coefficients among variables were appropriate reflecting that there was no the multicollinearity among the independent variables of the model **(Table 4)**.

Table 4. General Information of respondents and surveyed households

Location	Statistical parameters	Age	Education level	No. of members	Agri-labor
1. Da Bac district	Mean	45.7	1.7	4.4	2.4
	Std. Dev	10.9	0.7	1.2	0.9
- Adopters	Mean	46.0	1.7	4.5	2.4
	Std. Dev	10.8	0.7	1.2	1.0
- Non-adopters	Mean	45.2	1.7	4.3	2.4
	Std. Dev	11.0	0.7	1.1	0.9
2. Hai Lang district	Mean	49.7	1.9	4.9	1.8
	Std. Dev	9.2	0.4	1.0	0.5
- Adopters	Mean	48.7	2.0	4.7	2.0
	Std. Dev	7.5	0.4	1.0	0.5
- Non-adopters	Mean	50.6	1.9	5.0	1.7
	Std. Dev	10.5	0.5	1.0	0.6
3. Co Do district	Mean	48.2	2.1	5.0	2.3
	Std. Dev	9.4	0.8	1.2	1.0
- Adopters	Mean	48.4	2.1	4.8	2.0
	Std. Dev	8.6	0.7	1.1	1.0
- Non-adopters	Mean	48.0	2.2	5.0	2.5
	Std. Dev	10.0	0.8	1.3	1.0
4. Total	Mean	47.7	1.9	4.7	2.2
	Std. Dev	10.0	0.7	1.2	0.9
- Adopters	Mean	47.4	1.9	4.6	2.2
	Std. Dev	9.5	0.7	1.1	0.9
- Non-adopters	Mean	48.0	2.0	4.8	2.2
	Std. Dev	10.6	0.7	1.2	0.9

Note: For education level: 1 = primary school; 2 = secondary school; 3 = high school; 4 = college or university

There were only small differences in age, education, number of household members, and number of agri-laborers between the adopter and non-adopter groups, and the statistical tests showed no significant differences in these indicators between the two groups. However, there was a significant difference in age and education of the respondents among the regions. On average, respondents in Hai Lang district were 4 years older than the ones in Da Bac district and 1.5 years older than the ones in Can Tho district. These differences were statistically significant at the 90% confidence interval. The respondents in Can Tho had a higher education level than in Da Bac and Hai Lang districts, and the difference in education level between the districts was statistically significant at the 99% confidence interval. While the surveyed households in Can Tho province had the largest number of family members, the surveyed households in Da Bac district had the largest number of agricultural members per household. This is possibly because most of the people in Da Bac district focused on agricultural activities as they faced difficulties in finding non-farm jobs. The people in Hai Lang district, however, could find some non-farm jobs more easily.

Income from households

In many studies, income is considered as one of the important factors that impacts the adoption of agricultural practices. We therefore investigated the impacts of a household's income on their SLM adoption. According to the survey, the average household income was 57.2 mil VND per year and the average household income differed among the regions (**Table 5**). The income of the households in the Mekong delta was the lowest (48.7 mil/year) while the income of the households in the coastal region was the highest. The average income per household member was highest in the mountainous region while the figure was the lowest in the Mekong delta. The income in the Mekong delta was low mainly because the households mainly focused on rice production and the paddy price in the Mekong delta in the survey year was quite low. The income of households in the mountainous and coastal regions came from more diversified sources such as livestock production, off-farm jobs, and forest timber.

Factors affecting the SLM adoption of farm households

Due to the different contexts for SLM adoption among the regions of Vietnam, logit models for the separate regions were used for estimating the factors affecting the SLM adoption of the farm households in each region. STATA was used for estimating the logit model and the results of the estimates are in **Table 6**. The LR Chi-square and Prob > Chi-square from regressions confirm the statistical significance of the models.

It has been hypothesized that the age of the farmers is likely to have an impact on the adoption

Table 5. Total income of the surveyed households across the survey sites

District	Indicators	Total	Adopted farm households	Non-Adopted farm household	Difference	T-test
1. Da Bac	No. of households	300	181	119	-	-
	Farm household income (mil VND)	59.2	63.2	53.1	10.1	1.054
2. Hai Lang	No. of households	239	110	129	-	-
	Farm household income (mil VND)	65.0	77.4	54.4	23.0***	5.708
3. Co Do	No. of households	287	123	164	-	-
	Farm household income (mil VND)	48.7	47.7	49.4	-1.7	0.392
Total	No. of households	826	414	412	-	-
	Farm household income (mil VND)	57.2	62.4	52.0	10.4***	2.609

Table 6. Results of the logit regression on SLM adoption

Variables	Mountainous region		Coastal region		Mekong delta		Total	
	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|
Gender	**0.500***	**0.064**	-2.206	0.304	0.328	0.517	0.245	0.212
Age	0.006	0.642	**-0.095****	**0.049**	**0.053****	**0.032**	-0.003	0.622
Income	**0.005***	**0.059**	**0.086****	**0.021**	**0.079*****	**0.000**	**0.001*****	**0.001**
Agri-laborers	0.086	0.547	**4.008*****	**0.002**	**0.495****	**0.021**	-0.036	0.692
Plot	-0.169	0.277	**-2.474****	**0.028**	**-3.472*****	**0.000**	0.117	0.160
Farming area	0.007	0.371	0.083	0.584	**-0.614*****	**0.000**	0.002	0.658
Access to extension services	**0.532****	**0.035**	**3.221*****	**0.007**	0.477	0.384	0.904***	0.000
Access to credit	**0.516***	**0.069**	**0.057*****	**0.000**	**1.031****	**0.042**	**0.942*****	**0.000**
Distance	-0.004	0.966	**1.135*****	**0.008**	0.549	0.340	**0.265*****	**0.001**
Education	0.027	0.499	-0.631	0.394	0.063	0.337	0.002	0.940
Members	-0.040	0.859	-0.251	0.823	**-0.677***	**0.069**	-0.094	0.191
Constant	-0.768	0.435	4.831	0.364	**3.450*****	**0.008**	-0.653	0.275
Number of obs.	300		239		287		826	
LR Chi2	25.92		294.42		144.76		101.79	
Prob > Chi2	0.043		0.000		0.000		0.000	

*Note: * Sig at 90%, ** Sig at 95%, *** Sig at 99%.*

of best practices in agriculture. Some studies have shown a positive correlation (Warriner & Moul, 1992; Okoye, 1998), while others have shown a negative correlation (Abd-Ella *et al.*, 1981; Clay *et al.*, 1998). However, there appears to be no clear correlation between age and best practice adoption (Marra & Ssali, 1990). In this study, age appeared to have a positive impact on the SLM adoption of farmers in the Mekong delta while age was found to have a negative impact on farmers in the coastal region with a significance of 95%. In the northern mountain region, the age of farmers was found to have no significant impact on their SLM adoption. The different impacts of age on SLM adoption among the regions could possibly be explained by the fact that the demand for adopting SLM in upland areas is of high necessity for restoring the land fertility as the land is quite steep and severely degraded after a number of years growing cassava or maize. Meanwhile, land degradation is less serious in the coastal and delta regions, and the adoption of SLMs in these regions has been encouraged just recently. In the coastal region, the more complicated SLM practices in the region seemed to be favored by young farmers. In the Mekong region, however, older farmers with more experience in rice production tended to adopt more SLM practices while young farmers tended to look for non-farm employment and paid less attention to SLM practices as opportunities for non-farm employment there were more available.

The results of the logit regression showed that gender of household heads in the northern mountain region had a positive impact on SLM adoption at a statistical significance of 90% while there was no significant impact in the other

regions. This is possibly explained by the fact that most of the surveyed farm households in the northern mountain region were ethnic minorities where male farmers take the principal role in decision-making in agricultural production as well as SLM adoption.

In many studies, income has been considered one of the important factors that impact the adoption of agricultural practices. We therefore investigated the impacts of a household's income on their SLM adoption. The model results showed that income also had a statistically significant positive impact on SLM adoption of the farmers in all the regions. This means that farm households with a higher income tended to adopt SLM more. This result is similar to the findings by Okyoe (1998) in Nigeria, Temu (2013) in Tanzania, and Gensa & Tebeje (2020) in Ethiopia. It was also found that loans had a significantly positive impact on SLM adoption for all the regions. This is because SLM adoption usually costs more than regular agricultural practices and poor farm households face difficulties in adopting SLM. This finding is in line with the studies by Gensa & Tebeje (2020) and Song *et al.* (2020). The farmers who adopted SLM were usually the ones who had better incomes and/or had better access to credit services.

The farm households with better access to extension services in the northern mountain region and coastal region were found to have a higher probability of SLM adoption than those with poorer or no access. This is possibly because farmers in these regions lack knowledge about agricultural techniques due to the complicated combination of agricultural crops for SLM adoption. The support of extension workers therefore played a very important role in the farmers' SLM adoption. In the Mekong delta, the farmers had very rich knowledge about rice farming allowing them to more easily adopt SLM by relying on their own experience.

The number of plots was found to have a negative impact on SLM adoption of the farm households with statistical significance for the coastal region and Mekong delta. The farm households with more plots faced more difficulties in resource allocation among their plots and then had a lower probability of adopting SLM. The total farming area had no clear impact on adoption for the farmers in the mountainous and coastal regions. However, in the Mekong River delta, the total area had a small negative impact on SLM adoption with a statistical significance of 95%. It is possible that because the farming areas in the Mekong delta are larger, compared to the other regions, adopting SLM costs significantly more.

The total number of members of the households was found to have negative impacts on SLM adoption (with statistical significance at 90% in the Mekong delta). However, the model results showed the farm households with more agricultural laborers would have a higher probability of SLM adoption. This is because the adoption of SLM practices usually requires a larger labor force than traditional practices as the survey farmers reported.

Conclusions and Implications

Agriculture plays a very important role in the economy of Vietnam. However, agriculture land in Vietnam is facing serious degradation as 9.3 million hectares (of agricultural land area) are currently degraded. SLM adoption is, therefore, considered very important as it is one of the most effective ways to cope with land degradation in Vietnam. Due to the differences in natural and socio-economic conditions, SLM practices in each region in Vietnam are quite varied. While agroforestry is the dominant SLM in the mountainous areas, intercropping and crop rotation are considered efficient SLM practices in the coastal and Mekong delta regions. The results of the logistic regression showed that household income and access to loans had positive impacts on SLM adoption with statistical significance in all three regions. More extension visits in the upland and coastal regions, and more agricultural laborers in farm households in the coastal and Mekong delta regions were found to increase the probability of SLM adoption. Meanwhile, the number of plots and number of members in households were found to have negative impacts on adoption. For enhancing SLM adoption, several policy implications can be drawn as given below.

Since extension services were confirmed to be very important for SLM adoption, better extension services for farmers, especially on the technical guidance for SLM adoption, are of necessity. For this reason, government and policymakers should focus on improving the skills of extension staff in-line with increasing their numbers and their availability for well-organized and useful dissemination of SLM technologies in each region, creating a trickle-down effect to farmers. Training of Trainers (ToT) training courses for extension workers with a focus on SLM adoption technology and dissemination should be organized. In parallel, training courses for farmers on how to apply SLM practices should be provided. In addition, SLM demonstration areas should be built so that farmers can visit and learn how to viably apply each practice.

As both the variables of income and access to credit had a positive effect on farmers' SLM adoption, credit programs or financial support for SLM farmers through providing loans with low-interest rates or with simple procedures should be considered since many households reported that the high costs for SLM adoption and the delayed return from the agroforestry model were constraints for adoption. In addition, the input supports for farmers such as the provision of crop varieties and fertilizers at low prices in the initial period of SLM adoption should be done to facilitate the adoption of the farm households. Those supports should be made a priority for poor households and for households in the mountainous regions.

References

Abd-Ella M., Hoiberg E. & Warren R. D. (1981). Adoption Behavior in Family Farm Systems: An Iowa Study. Journal of Rural Sociology. 46: 42-61.

Bai Z. G., Dent D. L., Olsson L. & Schaepman M. E. (2008). Global assessment of land degradation and improvement. 1. Identification by remote sensing. Report 2008/01, ISRIC – World Soil Information, Wageningen.

Ben-Akiva M. E. & Lerman S. R. (1985). Discrete Choice Analysis: Theory and Application to Travel Demand. Cambridge, MA: MIT Press.

Clay D., Reardon T. & Kangasniemi J. (1998). Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility, Economic Development and Cultural Change, 45(2): 351-378.

Cuong P. M. (2005). Land-use change in the Northwestern Uplands of Vietnam: empirical evidence from spatial econometric models and geo-referenced analyses and policy implications for sustainable rural development. Cuvillier Verlag Publisher.

Do Van Nha, Nguyen Tuan Anh & Nguyen Do Viet Ba (2016). Assessing Efficiency of Agricultural Land Use Models for Commodity Production in Luong Tai District, Bac Ninh Province. Vietnam Journal of Agricultural Sciences. 14(9): 1418-1427 (in Vietnamese).

Etter H. (2015). The Economics of Land Degradation (ELD) Initiative. Handout of presentation at Sustainable Management of Coastal and Land Resources in Southeast Asia. November 5, 2015. Bangkok, Thailand.

Gensa G. & Tebeje M. (2020). Adoption of Sustainable land management practice: the case of Wolaita Zone, Southern Ethiopia. International Journal of Current Research. 12(2): 9966-9972.

Gould B. W., Kangasniemi W. E. & Klemme R. M. (1989). Conservation tillage: the role of farm and operator characteristics and the perception of soil erosion. Land Economics. 65(2): 167-182.

Linh T. B., Cornelis W.M., Van Elsacker S. & Khoa L. V. (2014). Socio-economic evaluation on how crop rotations on clayed soils affect rice yield and farmers' income in the Mekong Delta, Vietnam. International Journal of Environmental and Rural Development. 4(2): 62-68.

Linh T. B, Khoa L.V., Sara V. E. & Cornelis W. M. (2016). Effect of cropping system on physical properties of clay soil under intensive rice cultivation. Land Degradation and Development. 27(4): 973-982. DOI: 10.1002/ldr.2321.

Mahboubi M. R., Irvani H., Rezvanfar A., Kalantari K. & Mohseni S. M. (2005). Factors Affecting the Adoption Behavior Regarding Soil Conservation Technologies in the Zarrin Gol, Watershed in Golestan Province. Iranian Journal of Natural Resources. 57(4): 595-606.

Marra M. C. & Ssali B. C. (1990). The role of human capital in the adoption of conservation tillage: The case of Aroostook County, Maine, potato farmers. Experiment Station Bulletin 831. Department of Agricultural and Resource Economics, University of Maine, Bangor.

Marshall G. R. (2004). Farmers Cooperating in the Commons? A Study of Collective Action in Salinity Management. Ecological Economics. 51(3-4): 271-286.

MONRE – Ministry of Natural Resources and Environment (2010). Report of Investigation, Assessment of Land

Degradation in the North Mountainous Region, Vietnam. Hanoi, Vietnam.

Nkonya E., Mirzabaev A. & Braun J. V. (2016) Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development. Springer Cham Heidelberg New York Dordrecht London.

Okoye C. (1998). Comparative analysis of factors in the adoption of traditional and recommended soil erosion control practices in Nigeria. Soil and Tillage Research. 45: 251-263.

Rahm M. R. & Huffman W. E. (1984) The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables. American Journal of Agricultural Economics. 66: 405-413.

Roberts D. & Shears R. (2008). Good Agricultural Practices for Climate Risk Management in Grenada. Agricultural Extension Service Ministry of Agriculture, Grenada. 40pp.

Roosta K. (1999). Impacts of Technical Knowledge and Sustainable Agriculture on Product Performance and Farming System Stability. MSc Thesis, Agricultural Extension and Education, Tarbiat Modares University

Shortle J. S. & Miranowski J. A. (1986). Effects of risk perceptions and other characteristics of farmers andfarm operations on the adoption of conservation tillage practices. Applied Agriculral Resources. 1(2): 85-90.

Song N. V., Cuong H. N., Huyen N. V. & Ranola R. F. (2020). The determinants of sustainable land management adoption under risks in upland area of Vietnam. Sustainable Futures. 2: 339-345. DOI: 10.1016/j.sftr.2020.100015.

Stonehouse P. D. (1991). The economics of tillage for large-scale mechanized farms. Soil and Tillage Research. 20(2-4): 333-352.

Sutton P. C., Anderson S., Constanza R. and Kubiszewski I. (2016). The ecological economics of land degradation: Impacts on ecosystem service values. Ecological Economics. 129: 182-192.

Temu E. J. (2013). Adoption of Sustainable Land Management Technologies: Revisiting impact to Community livelihood in West Usambara Mountains, Tanzania. Master Thesis. Sokoine University of Agriculture, Morogoro, Tanzania.

Toan P. V. (2011). Pesticide use and management in the Mekong delta and their residues I surface and drinking water. PhD dissertation. Institute for Environment and Human Security - United Nations University in Bonn.

Tran Thi Hien & Vo Quang Minh (2014). The change of rice crop calendar in Mekong Delta using remote sensing and geographic information systems. Journal of Science, Can Tho University. 3: 101-110 (in Vietnamese).

UNCCD (2002). Vietnam National Action Programme to Combat Desertification. Retrieved from https://www.unccd.int/sites/default/files/naps/vietnam-eng2002.pdf on April 10, 2022.

UNCCD (2009). Understanding Desertification and Land Degradation Trends - Proceedings of the UNCCD First Scientific Conference, September 22-24, 2009, during the UNCCD Ninth Conference of Parties, Buenos Aires, Argentina. Retrieved from http://unccd_confproc_online-version_hr.pdf on May 5, 2021.

Vu Q. M., Le Q. B., Frossard E. & Vlek P. L. (2014). Socio-economic and biophysical determinants of land degradation in Vietnam: An integrated causal analysis at the national level. Land Use Policy. 36: 605-617.

Warriner G. K. & Moul T. M. (1992). Inship and personal communication network influences on the adoption of agriculture conservation technology. Journal of Rural Studies. 8(3): 279-291.

Webb T. (2004). Understanding Behavior: Social and economic influences on land practice change, Australia. A Paper Presented at the Workshop on Land Management Practices Information Priorities, Classification and Mapping – Towards an Agreed National Approach, Kamberra Winery, Canberra May 11-12, 2004, Bureau of Rural Sciences, Australia.

World Bank (2006). Sustainable Land Management: challenges, Opportunities, and Trade-Offs. The International Bank for Reconstruction and Development/The World Bank. Washington, DC 20433. Retrieved from http://siteresources.worldbank.org/INTARD/Resources/Sustainable_Land_Management_ebook.pdf on October 15, 2017.