Hue University Journal of Science: Economics and Development
pISSN: 2588–1205; eISSN: 2615–9716
Vol. 128, No. 5B, 2019, pp. 37–50, DOI: 10.26459/hueuni-jed.v128i5B.5068

ECONOMIC EVALUATION OF TYPICAL SUSTAINABLE LAND MANAGEMENT MODELS IN SELECTED PROVINCES OF VIETNAM

Bui Dung The[1, *], Hong Bich Ngoc[2]

[1] University of Economics, Hue University, 99 Ho Dac Di St., Hue, Vietnam
[2] University of Agriculture and Forestry, Hue University, 102 Phung Hung St., Hue, Vietnam

Abstract: This study undertakes an economic analysis of selected sustainable land management (SLM) models in three selected provinces: Hoa Binh province in the Northwestern Mountainous region, Quang Tri province in the North Central Coast and Can Tho province in the Mekong Delta. The SLM models in Hoa Binh province are agroforestry models and those in the provinces of Quang Tri and Can Tho are annual crop rotations and intercropping with improved cultivation methods. The present study uses primary data from a multipurpose survey of 826 farm households. The results show that the agroforestry systems in Hoa Binh province are not financially attractive to farmers as their net returns are low, but their off-site benefit of soil erosion reduction in terms of saved removal and dumping cost of sediment is remarkable, about VND 300,000–320,000 per hectare per year. The SLM models in Hai Lang district (Quang Tri) are profitable with a much higher net return than that of prevailing non-SLM model with cassava mono-cropping. For Can Tho province, the SLM models with rice and upland crop rotations have significantly higher net returns than those of the triple-rice rotation model. However, the profitability of the studied SLM models is significantly affected by the risks associated with poor development or lack of outlet markets. Enhancing farmers' agribusiness knowledge making them be able to deal with risks in the adoption of SLM models is of vital importance.

Keywords: sustainable land management, economic analysis, Hoa Binh, Quang Tri, Can Tho

1 Introduction

In Vietnam, land degradation, which is considered one of the most striking problems for the nation [7], is described as the decline of land biological productivity as a result of unfavorable natural conditions and improper uses of land [2]. About one third of the country's total land area is degraded, and the area of severely degraded land is estimated at 7.6 million ha [8]. Land of all types is in danger of erosion, low fertility, nutrient imbalance, salinization, acidulation, and being covered with sand or polluted with chemicals, among others [3]. Four regions in Vietnam are identified as priority areas to implement the programs to combat land degradation, namely: (i) the Northwest Mountainous region, (ii) the Central Highlands region, (iii) the Central Coast region, and (iv) the Mekong Delta region. The adoption of sustainable land

** Corresponding: buidungthe@yahoo.com*
Submitted: December 08, 2018; Revised: January 12, 2019; Accepted: January 16, 2018

management (SLM) practices has thus been determined by the Vietnamese government in the National Action Program to Combat Desertification as one of the key strategies to address land degradation.

Sustainable land management is defined as a knowledge-based procedure that helps 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 [9]. Not only to prevent land degradation, has SLM included practices to stop and reverse degradation or at least to mitigate the adverse effects of earlier misuse [10]. Despite the recommendations from the Vietnamese government, the adoption of SLM remains limited, and non-SLM practices or inappropriate land management are still predominant in many regions in Vietnam [6, 1]. This is a matter of constant concern for researchers, policy-makers, and planners. According to many researchers, farmers' land management practices are actually influenced by many macro-level and micro-level factors, including the availability of resources, biophysical, socioeconomic constraints, and policy environment.

From the standpoint of farming households, the economic benefit is one of several important impacts on adoption. The net economic benefit of a certain SLM model as perceived by the landholder plays an important role in shaping an adoption decision. The economic analysis of SLM practices may help us to understand and increase adoption. The economic drivers at the farm level have been one of the key factors influencing the adoption of SLM practices. Often, the potential financial gain plays an important role [4] although sometimes it is counterbalanced by concerns over issues such as time, lifestyle, or risk. However, many farmers place a high emphasis on gaining higher income from adopting SLM models.

As a contribution to gaining a comprehensive insight into constraints to adoption of SLM practices in Vietnam, this study undertakes an economic evaluation of selected SLM models at the study sites in Vietnam and provides policy implications to improve the financial and economic return of selected SLM models.

2 Research methodology

2.1 Study sites and selected SLM models

To study the land degradation and adoption of SLM status in Vietnam, three study sites in three typical geographical areas of the country (mountainous area, coastal area and lowland delta area) were selected. They are (i) Da Bac district, Hoa Binh province in the Northwestern mountainous region, (ii) Hai Lang district, Quang Tri province in the North Central Coast, and (iii) Thot Not and Co Do districts, Can Tho province in the Mekong Delta.

Da Bac district, Hoa Binh province

Da Bac is one of the highest elevation districts of Hoa Binh province with a total area of about 78.000 ha, occupying 17% of the province's territory. Its topography is very diverse with a combination of high mountains (some are higher than 1000 m), hills, rivers, and streams, and the average slope is 3°. Forest is the dominant land use in the district. The narrow plains are interspersed between mountains. In Da Bac district, the main cause of land degradation is erosive farming and sloping topography. In the past, monoculture of cassava was widely adopted. In recent years, agroforestry models (forest trees and cash crops) and the model of cash crop rotation with beans have been introduced. In addition, terraced or contoured cropping models with limited tillage are also adopted to prevent soil erosion and landslide.

Typical SLM models in Da Bac district are agroforestry models where a single forestry tree such as *acacia*, *meliaceae*, and *Styrax tonkinensis* is intercropped with a cash crop such as maize or cassava. For the first two years of the rotation, the land surface is not covered by the canopy of forest trees and farmers plant maize or cassava in the middle of *acacia*/*meliaceae*/*Styrax tonkinensis* rows. Maize is planted with two crops per year: crop 1 from February to May and crop 2 from July to October. Cassava is planted with a density of 2,500 trees/ha in February and harvested in December. At year 7 or 8, farmers clear cut the plantation.

Hai Lang district, Quang Tri province

Hai Lang is a coastal district in Central Vietnam. Its total area is nearly 43,000 ha, occupying 9% of the province's territory. The topography comprises three categories: mountains (55% of the total area), plains (32%) and sand-bank zone (12%). Sandy soil with low fertility and severe drought in the dry season is the distinctive feature of the district. About 48% of the district's land area is highly degraded [7].

Diversified crop rotations with improved cultivation methods are considered as SLM models while monoculture cultivation is identified as non-SLM. Specific SLM models in Hai Lang district include maize intercropped with green bean – maize intercropped peanut; bitter gourd – green been rotation, chive intercropped with cassava.

Maize intercropped with green bean – maize intercropped with peanut: Local people have adopted the model since the year 2010. In the first crop, from January to May, maize is intercropped with green bean. Beans are sowed between maize rows. Similarly, from June to October maize is intercropped with peanut. This model with legume crops (bean, peanut) can improve soil fertility and prevent pests. From November to December, the land is fallowed; it is the rest time for the soil to regain productivity.

Bitter gourd – green bean rotation: The model was introduced from the year 2010 by the local agricultural department. In this model, the crops are planted on furrow. Green bean is

planted in January and harvested in May. Bitter gourd is planted in August and harvested in November

Chives intercropped with cassava: This SLM model is introduced by extension services in the district. In this cropping model, the two crops are grown in bed: chives planted in October, leaves harvested in November, and bulb harvested in April. Cassava is planted in October in the two edges of the chives bed and harvested in June.

Thot Not and Co Do districts, Can Tho province

Thot Not and Co Do districts are located in the Mekong Delta where land degradation due to intensive rice mono-cropping is an important problem. The districts lie in the half-flooded plains that are gradually sloping from northeast to southwest, including three kinds of terrain: dykes alongside the river, half-flooded plains, and delta plains. There are two main groups of soil: alluvial soil and alkaline soil. The conventional cropping system with triple rice crops is considered to bring risks of soil degradation because of long-term soil submergence, intensive cultivation, and overuses of chemicals such as fertilizers and pesticides.

The SLM models adopted at the districts are crop rotations consisting of cash crop and rice that are promoted to replace the triple rice-cropping. The typical cash crop-rice rotations are the sesame-rice-rice rotation, the soy bean- rice- rice rotation, and the rice-rice-melon rotation. These rotations improve soil fertility, reducing soil compaction and improve the soil nutrient balance. The local government and farmers express a strong interest in these newly introduced crop rotations.

2.2 Data collection

Secondary data

The secondary data necessary for the study were mainly gathered from the annual reports of the surveyed communes and districts. The data on farming systems, crop areas, crop yields, irrigation systems, etc. were gathered from the relevant reports of the agricultural office at the district level and reports at the commune level, and from related studies.

Primary data

This study uses primary data from a multipurpose farm-household survey. The sampling method adopted in this survey is a combination of stratification and randomization. At first, a group discussion with the staffs from the district agricultural offices and extension centers was organized to select typical communes where household interviews would be conducted. The communes selected are Tu Ly, Tan Minh and Cao Son in Da Bac district; Hai Ba and Hai Duong in Hai Lang district; Trung Nhat, Trung Kien and Thoi Thuan in Thot Not district; and Thanh Phu, Dong Thang, and Dong Hiep in Co Do district. The farm households in the selected

communes were divided into two main groups: SLM adopters and SLM non-adopters. Households were then randomly selected from each household group. The number of farm households selected in each district for direct interviews is presented in Table 1. The questionnaires were designed to collect information on the farm households, land management adopted by each household, income and assets of the households, and the knowledge, attitude and perceptions of the respondents regarding SLM.

Table 1. Number of interviewed farm households by study site

Locality	SLM adoption households	SLM non-adoption households	Total households for survey
Da Bac district	181	119	300
Hai Lang district	110	129	239
Thot Not and Co Do districts	123	164	287
Total	414	412	826

Source: Household survey by the research team

In each district, six in-depth individual interviews and three focus group discussions with extension workers and village leaders and SLM adopters were conducted. The purpose of these two activities is to understand the current land management practices clearly and to solicit their assessment of sustainability as well as the costs and benefits associated with each SLM model. The participants' opinions on the external benefits/costs of SLM models were investigated thoroughly.

2.3 Data analysis

Cost and benefit valuation

To perform the economic analysis, it is necessary to estimate the cost and benefit/return of the SLM models. The methods to value the costs and benefits of SLM models are presented in Table 2.

Table 2. Cost and benefit valuation methods used in the study

Items	Valuation method
Production costs	
Seed, chemical fertilizer, pesticide, land preparation, hired labor, harvesting, other costs.	Market price
Organic fertilizer supplied by farm households	Opportunity cost/shadow price
Family labor	Opportunity cost
Benefits	
Production value	Market price
Off-site impact of soil erosion reduction	Reduced cost of sediment removal

It should be noted that the agroforestry systems adopted by farmers at the study sites are to reduce soil erosion and to restore soil fertility and consequently the off-site effect on the downstream communities. The off-site effects of soil erosion are mainly the result of sedimentation, increasing the risk of flooding, blocking irrigation channels, and shortening the useful lives of reservoirs. The level of soil loss due to erosion under the selected agroforestry models and corresponding mono-cropping of maize and cassava was estimated with the help of the software SCUAF (Soil Changes Under Agriculture, Agroforestry and Forestry) [11].

Estimating economic and financial criteria

The selected SLM models can be divided into two groups: annual cropping systems and long-term agroforestry systems. Therefore, different criteria were used for each cropping system. For the agroforestry systems, the net present value (NPV) and equivalent annual annuity (EA) of each SLM agroforestry model were calculated. For the annual cropping systems, the annual net return of each SLM model was calculated. The sensitivity analysis was also conducted. The scenarios were identified on the basis of the information from focus group discussions (FGDs) on the likelihood of how factors would affect the net return such as the price of inputs and the price of output in the future.

3 Economic analysis of selected SLM models

3.1 SLM models in Da Bac district, Hoa Binh province

Financial analysis

A discount rate of 10% was chosen for the calculation of the NPV of three agro-forestry models in Da Bac district. It is the estimated opportunity cost of capital at the study site. For the agro-forestry model, the investment cost is relatively big in the first year. It is the cost of land preparation, seed, fertilizer, pesticides, and family labor. In the second year, the investment cost decreases, except the cost of annual crops intercropped. From the third year, farmers do not invest any additional expenses, except the family labor to perform the weeding and streaming of forestry trees.

All three agroforestry systems at the study sites have a positive NPV. However, the value of the NPVs and respective values of the equivalent annual annuity are low, ranging from VND 6.65 to VND 8.59 million per hectare per year. Information from the interview of adopter farmers also confirms that the net financial return of the selected SLM models is a little higher than that of forestry plantation. So what the incentive for farmers to adopt these agroforestry models is. The responses from the farmer interviews show that for some farmers, the adoption of agroforestry models is a method to restore soil fertility and productivity, and when the soil fertility improves, farmers may adopt mono-cropping of other annual crops such as maize and

cassava. Another answer is that their plot is so steep and only two possibilities are available: forestry and agroforestry, and the farmers adopt agroforestry because it brings about higher income compared with forestry.

Table 3. Financial NPVs and EA of the agroforestry models in Da Bac district (per ha)

Agroforestry models	T (year)	NPV (Million VND)	EA (Million VND)
Acacia intercropped with maize	8	35.48	6.65
Meliaceae intercropped with cassava	10	50.33	8.19
Styrax tonkinensis intercropped with cassava	8	45.85	8.59

Source: Field survey data and calculation by the author

A risk is also an important factor affecting the adoption of SLM practices. Most farmers in the study sites are very much concerned about the risk of the fluctuation of input and output prices. Three scenarios were developed. The first scenario is that the price of outputs of agroforestry models decreases by 5%. This would happen due to the fact that the market in the upland district is not competitive with only a few buyers (chip-wood factories and pulp paper factories). There would be likely that factories may use their bargaining power to set a decrease in the output price by 5%. The second scenario is the most likely one. Over the past years, the input prices of chemical fertilizer, insecticides, and labor wages in rural areas increased slowly. Meanwhile, the price of timber of domestic and international markets increased faster. Hence, for the second scenario, it was assumed that the input price increased by 3% and the output price increase by 5%. The third scenario is the worst one where the input price increased by 3%, and the output price decreased by 5%.

Table 4. Scenario analysis of NPV of the agroforestry models in Da Bac district (Unit: Million VND per ha)

		Scenario 1	Scenario 2	Scenario 3
	Base case	5% decreased of output price	Input price increased by 3% and output price increased by 5%	Input price increased by 3%, and output price decreased by 5%
Acacia intercropped with maize	35.48	32.71	37.66	31.11
Meliaceae intercropped with cassava	50.33	47.09	53.13	45.65
Styrax tonkinensis intercropped with cassava	45.85	42.73	48.47	42.24

Source: Field survey data and calculation by the author

As shown in Table 4, the NPVs of the three scenarios are all low and positive, even in the worst scenario. NPV is more sensitive to output price and less sensitive to input prices. This is

because the farmers invest little in the agroforestry systems due to resource constraints and the difficulty in transporting inputs to sloping and far-from-home agroforestry plots. Some farmers even do not apply any manure but use only little chemical fertilizer. They just exploit the soil. The improvement of soil fertility mainly depends on the ecological functions of the forest trees.

Environmental benefits of the selected agroforestry models

The estimated soil loss with different land use practices is presented in Table 5. Given the fact that the rotation of the agroforestry models at the study sites is 8 years, in this study, the soil loss due to erosion was calibrated for an 8-year period. The magnitude and pattern of soil loss differ greatly across the land use systems. The mono cassava cropping has the highest estimated annual soil loss of 39 ton/ha/year. The level of soil loss under this land management increases over time, and in the last year, the level of soil loss is 54 ton/ha/year. In the three agroforestry systems, the levels of soil loss are more or less the same. Their estimated annual soil loss is just about one half of that of mono-cassava cropping.

Table 5. Predicted soil loss due to erosion under different land managements in Da Bac district

Land managements	Soil loss (ton/ha/year)	Cumulative soil loss over 8 years (ton/ha)
Acacia intercropped with maize	18	144
Meliaceae intercropped with cassava	17	136
Styrax tonkinensis intercropped with cassava	20	160
Mono cassava cropping (non SLM)	39	312

Source: Field survey data and calculation by the author

It should be noted that mono-cassava cropping was selected as the base case for comparison because it is the most common land use in the sloping land. In other words, for high-slope land, if agroforestry is not adopted, the land use in most cases is mono-cassava cropping.

Compared with the corresponding land management for mono-cassava cropping, the reduction of soil loss due to erosion over 8 years per hectare for *acacia* intercropped with maize, *meliaceae* intercropped with cassava, and *styrax tonkinensis* intercropped with cassava are 168 tons, 176 tons, and 152 tons, respectively (Table 5).

The reduction of soil loss due to erosion brings about on-site and off-site benefits. There are several possible downstream or off-site impacts of soil erosion that results from runoff. These impacts are location-specific and vary from place to place. In this study, given the fact that the study site is in the watershed of the Da River with a hydropower plant and an irrigation reservoir downstream, sedimentation would be the most important impact of soil erosion. Therefore, the off-site benefit of soil erosion reduction was estimated on the basis of the

reduction in the cost to remove sediment of eroded soil from the downstream reservoir. The sediment load was estimated on the basis of the predicted soil loss and the sediment delivery ratio which are given by experts. Given the short distance from Da Bac district to the Hoa Binh hydropower dam as well as the network of rivers to transport eroded soil, the sediment delivery ratio was estimated at 28%.

The cost to remove a tone of sediment depends on many factors such as the technology used, the reservoir attributes, and the distance to where the sediments are dumped. Given the popular sediment removal methods at the study site as well as the geographical and topographical features of Hoa Binh reservoir, the removal cost per tone of sediment given by consulted experts and irrigation experts is VND 50,000, and the dumping cost is VND 5,000 per tone.

Table 6 shows that the off-site benefits of soil erosion reduction associated with the studied agroforestry are relatively significant, about VND 2,500,000 per hectare over 8 years. On average, one hectare of the agroforestry could bring an annual off-site benefit, as measured by the saved sediment removal and dumping cost, of about VND 292,000 to 323,000.

Table 6. Off-site benefits of soil erosion reduction by the agroforestry systems in Da Bac district

Land management practices	Soil loss reduction over 8 years (ton/ha)	Equivalent Sediment load reduction (ton)	Saved sediment removal cost (thousand VND/ha)	
			Over 8 years	Annual average
Acacia intercropped with maize	168	47.0	2,587.2	323.4
Meliaceae intercropped with cassava	176	49.3	2,710.4	338.8
Styrax tonkinensis intercropped with cassava	152	42.6	2,340.8	292.6

Source: Field survey data and calculation by the author

3.2 SLM models in Hai Lang district, Quang Tri province

As discussed above, the SLM models in Hai Lang district, Central Coast are the annual crop rotation and intercropping to improve soil fertility and income. They are adopted mostly in flat sandy land. Therefore, the off-site benefits of these SLM models are limited, and only financial analysis is performed for the selected SLM models.

As shown in Table 7, the annual net return of the selected SLM models in Hai Lang district is relatively high compared with that of the non-SLM model, mono cassava cropping. The sustainable land management model with chive intercropped with cassava has the highest net return. However, the adoption of this SLM model remains limited; only a few communes in Hai Lang adopt this SLM model. Information from farmer interviews and FGDs points out that

chive is a high-value crop, and growing this crop is very labor-intensive and technically complicated. Furthermore, organic matter such as straw is needed as mulching materials. Therefore, not many farmers can grow this crop although they recognize that this cropping can bring about a high net return.

Table 7. Financial analysis of selected SLM models in Hai Lang district (Unit: Million VND/ha/year)

SLM models	Total benefit	Total cost	Net return
Peanut intercropped maize – maize intercropped with green bean	82.00	53.20	28.80
Bitter gourd – green been rotation	91.00	60.50	30.50
Chives intercropped with cassava	110.00	68.80	41.20
Mono cassava cropping (non SLM)	29.95	16.30	13.65

Source: Field survey data and calculation by the author

The scenario analysis was also used to see how the annual net return is affected when the market price changes. Three scenarios were developed, they include (i) 5% increase in out prices – the best scenario, (ii) input price increases by 3% and output price increases by 5% – the most likely to happen scenario, and (iii) input price increases by 3%, and output price decreases by 5% – the worst case. The results of the scenario analysis show that in all cases the net returns remain positive and are quite sensitive to the changes of input and output prices.

Table 8. Scenario analysis of net return of selected SLM models in Hai Lang district

(Unit: Million VND/ha/year)

	Base case	Scenario 1	Scenario 2	Scenario 3
SLM Models		5% increase in out prices	Input price increased by 3% and output price increased by 5%	Input price increased by 3%, and output price decreased by 5%
Peanut intercropped maize – maize intercropped with green bean	28.8	32.9	31.3	23.1
Bitter gourd – green been rotation	30.5	35.1	33.2	24.1
Chives intercropped with cassava	41.2	46.7	44.6	33.6

Source: Field survey data and calculation by the author

3.3 SLM models in Thot Not and Co Do district, Can Tho province

The three SLM models in the Mekong Delta selected for the economic analysis are the sesame-rice-rice rotation, the soy bean-rice-rice rotation, and the rice-rice-melon rotation. As shown in Table 9, the annual net return of the selected SLM models is rather high, ranging from VND

30,000,000 to 50,000,000 per hectare per year compared with the corresponding management model, the triple rice rotation. The sesame-rice-rice rotation SLM model has the highest net return of about VND 50,000,000, almost double the net return of the triple-rice rotation. However, the adoption of this SLM model remains limited. This is due to several constraints. The most important constraint is the fragmentation and uncompetitive market for outputs, especially the upland crops; it is relatively difficult for farmers to sell sesame, maize and melon. There is a risk that farmers may not be able to sell upland crop products. So the market development to establish a cooperative value chain for these crop products is very important.

Table 9. Financial analysis of selected SLM models in Thot Not and Co Do districts

(Unit: Million VND/ha/year)

Crop rotation	Total benefit	Total cost	Net return
Sesame-rice-rice rotation	106.92	57.21	49.71
Soy bean-rice-rice rotation	91.51	55.17	36.34
Rice-rice-melon rotation	81.36	51.78	29.58
Triple rice rotation (non-SLM)	78.35	54.11	24.24

Source: Field survey data and calculation by the author

Table 10 shows the scenario analysis of the net return of SLM models in Thot Not and Co Do districts, Can Tho province. Even in the worst case (Scenario 3), the net return from all three SLM models remains positive and relatively high. The sesame-rice-rice rotation appears to be the most profitable SLM model in all scenarios.

Table 10. Scenario analysis of net return of selected SLM models Thot Not and Co Do districts
(Unit: Million VND/ha/year)

	Base case	Scenario 1	Scenario 2	Scenario 3
SLM Models		**5% increase in out prices**	**Input price increased by 3% and output price increased by 5%**	**Input price increased by 3%, and output price decreased by 5%**
Sesame-rice-rice rotation	49.7	55.1	53.3	42.6
Soy bean-rice-rice rotation	36.3	40.9	39.3	30.1
Rice-rice-melon rotation	29.6	33.6	32.1	24.0

Source: Field survey data and calculation by the author

Information from the FGD of adopter farmers provides similar findings. The farmers rank the sesame-rice-rice rotation first, the soy bean-rice-rice rotation second, and the rice-rice-melon rotation last. The risk in growing melon is very high as the product has to be consumed

fresh and the technologies to process or store melons for a long time are not available. Again, the market constraints come in.

4 Conclusion

Key findings

The economic analysis of the selected SLM models in the study sites in Vietnam contributes some insight into the adoption of SLM models. The studied agroforestry systems in Da Bac, Hoa Binh province are not financially attractive to farmers as their net returns are low. Many farmers adopt these SLM models as a measure to restore their land fertility after many years growing cassava or maize and they cannot continue this practice because the land is severely degraded. The environmental benefits of the SLM models in terms of reducing soil erosion and restoring land productivity are significant. The off-site benefits of the adoption of the agroforestry models in terms of saved removal and dumping cost of sediment downstream are significant, about VND 300,000–320,000 per hectare per year, almost the same or more than the payments for forest environmental service programs in Vietnam.

The SLM models in Hai Lang district, Quang Tri province are intercropping and rotation with legume crops with increased use of organic mulching and manure. These sustainable land management models bring a higher net return than the prevailing non-SLM model, the cassava mono-cropping that is very popular in the district. They are very financially attractive to farmers. The important constraints to the adoption of these SLM models are lack of organic mulching materials and difficulties in selling products.

For Can Tho province, the studied SLM models are the rotation between rice and upland crops, namely sesame, maize and melon. They are financially attractive, with a much higher net return than the corresponding triple-rice rotation. The fragmented and uncompetitive market for upland crop products is the most important constraint to the adoption of this SLM model. The farmers find it difficult to sell their upland crop products. This prevents farmers to make the shift from triple rice cropping to the upland crop rotation.

To conclude, the net returns from the SLM models are context-specific, varying across their types applied in the regions. There exist SLM models that are financially attractive to farmers. Meanwhile, there also exist other SLM models that are not profitable from the private point of view, but they would bring about significant environmental off-site benefits, positive externalities to society. To promote the adoption of SLM models, policies to internalize those external benefits are needed.

Recommendations

A common recommendation for all three study sites is that it is of vital importance to develop markets for products. Farmers are very responsive to the market. Low development or lack of outlet markets for SLM models hinders the adoption, and farmers often bear the consequences of price fall and get a little share of the benefits of price rise. The policy to encourage cooperation between farmers and agribusiness firms should be developed.

To promote the adoption of the SLM models in the upland district of Da Bac, the implementation of the payments for forest environmental service programs is crucial because these SLM models bring off-site effects to lowlands. Furthermore, this is really in line with the Vietnam Government's Decree 99 on the Policy for Payment for Forest Environmental Services: farmers adopting agroforestry system must be paid for the ecological service they provide.

For Hai Lang district in Central Coast and Can Tho in the Mekong Delta, in addition to market development for SLM products, it is necessary to find measures to change farmers' traditional ways of farming and to enhance their agribusiness knowledge, making them be able to deal with risks in the adoption of SLM models.

References

1. Guong, V. T., Khoi, C. M. and Dung, N. M (2010), Soil organic matter quality and nitrogen supplying capacity in continuously triple rice and rice-upland crop rotation systems, *Scientific Journal of Can Tho University*, 16b, 147–154.
2. MARD (Ministry of Agriculture and Rural Development) (2006), Vietnam National Report on the UNCCD Implementation 2006, Ministry of Agriculture and Rural Development, Hanoi, Vietnam.
3. MONRE (Ministry of Natural Resources and Environment) (2012), National strategy for environmental protection until 2020 and vision toward 2030, Hanoi, Vietnam.
4. Pannell, D. J., Llewellyn, R. S., and Corbeels, M. (2014), The farm-level economics of conservation agriculture for resource-poor farmers, *Agriculture, Ecosystems and Environment.* 187(1), 52–64.
5. Quyet, V. M., Bao, L. Q., Frossard, E. and Vlek P.L.G. (2014), Socioeconomic and biophysical determinants of land degradation in Vietnam: An integrated causal analysis at the national level, *Land Use Policy*, 36, 605–617.
6. Toan, P. V., Sebesvari. Z., Bläsing, M., Rosendahl, I. and Renaud, F. G. (2013), Pesticide management and their residues in sediments and surface and drinking water in the Mekong Delta, Vietnam, *Sci Total Environ,* 2013 May 1; 452–453, 28–39. doi: 10.1016/j.scitotenv.2013.02.026. Epub 2013 Mar 15.
7. Viet, N. Q., Thuan, L. D., Nam, N. N. (2014), Initial establishment of soil degradation map proposed by WOCAT at communes in Ha Lang District, Quang Tri Province, *Journal of Science and Technology, Hue University,*1 (1), 124–134.
8. VNFOREST (2016), Forest Protection Management and Desertification combating in period 2011–2015 and orientation 2016–2020.
9. World Bank (2006), *Sustainable Land Management,* Washington DC, USA.
10. World Bank (2008), *Sustainable land management sourcebook,* Washington DC, USA.
11. Young, A., Menz. K., Muraya. P. and Smith. C. (1998), SCUAF Version 4: A model to estimate soil changes under agriculture, agroforestry and forestry, *ACIAR Technical Reports Series*, 41, 49.