Research article

Characteristics of Transformation of Traditional Upland Farming System in Cambodia: A Case Study of Snuol Commune, Kratie Province

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Abstract The main objective of this study is to compare the characteristics between the local farmers who conduct traditional upland farming without chemical fertilizer and the local farmers who depend on chemical fertilizer. The results of the analysis are summarized as follows. 1) According to the results of Multiple Correspondence Analysis, it was clear that the preference divisions of the local farmers who depend on chemical fertilizer were "Gender", "Age", "Family number", "Duration of residence", "Irrigation facility" and "Multiple cropping" as important characteristics for the classification. 2) The results from the Biological and Chemical Technology Method indicated that chemical fertilizers were applied intensively in farmlands with low soil fertility. Therefore, it was considered that the contribution of the current capital, such as chemical fertilizer, was not effectively conducted. 3) In the research site, the estimated value of technical efficiency showed the existence of technical inefficiency in upland farming systems.

Keywords traditional farming system, chemical fertilizer, biological and chemical technology, production function

INTRODUCTION

In Cambodia the amounts of applying agricultural chemicals, such as chemical fertilizer and pesticide, have rapidly been increasing in recently years (Fujimoto and Miyaura, 1966). Although it contributed to increase the agricultural productivity, the amounts of applying agricultural chemicals caused environmental disruptions, such as soil and water quality degradation, and decreased land productivity in the long term. Based on the above mentioned backgrounds, the main objective of this study is to compare the characteristics between the local farmers who conduct traditional upland farming without chemical fertilizer and the local farmers who depend on chemical fertilizer. At first, the approach was to clarify the characteristics of the local farmers who depend on chemical fertilizer through evaluating factor inputs by the estimated production function based on the Biological and Chemical Technology Method. In addition, the technical efficiency is evaluated by the estimated stochastic frontier production function.

METHODOLOGY

The research site is the Snuol Commune, Kratie Province. The research site is a well-known area where a variety of upland crops are produced in Cambodia. The urgent expansion of a variety of upland crop production creates an issue of environmental disruptions, such as soil and water quality degradation, and decreases land productivity by the amounts of agricultural chemicals which are applied. In addition, in this site, the Institute of Environmental Rehabilitation and Conservation carried out the project "study on sustained utilization of the natural resource" (3/2015 – 4/2016). The first problem is to clarify the characteristic of the farm household using agricultural chemicals. The second problem is to clarify factor input structures by estimated the production function that was based on the Biological and Chemical technology (Egaitu and Shigeno, 1983). In addition, the third problem is to clarify technical efficiency by estimating the stochastic frontier production function.

Kratie Province is located in the northeastern part, where development is the slowest, in Cambodia, and the compared difference with other areas is large. In Snuol village, Snuol district, Kratié Province, 170,000 ha, equal to 65%, is used in the total area, 260,000 ha is forest, and 14,000 ha, equal to 5%, is used as agricultural land. The questionnaire survey was entitled "Baseline investigation for sustainable rural development in Snuol village, Snuol district, Kratié Province (2011, April)". The target area of the questionnaire survey consisted of six villages: Kbal Snuol, Thpong, Snuol Kert, Snuol Lech, Kathdai and Prek Kdey. The numbers of useful responses received per area are as follows: Kbal Snuol Village: 46 respondents (25.0% of the total respondents), Thpong Village: 42 respondents (22.8%), Snuol Kert Village: 23 respondents (12.5%), Snuol Lech Village: 33 respondents (17.9%), Kathdai Village: 21 respondents (11.4%) and Prek Kdey Village: 19 respondents (10.3%). There were 184 respondents in total.

RESULTS AND DISCUSSION

Table 1 shows the respondent profiles. Almost 51% were "male" and about 48% were "female." About the age of the respondents, the majority of respondents were between the ages of "More than 50 years" (41.0%), followed by "40-49" years (27.5%) and "30-39" years (18.0%). The lowest percentage was aged "Less than 20 years" old. About the number of family members, the majority of respondents had a family number of "3-5" people (55.0%), followed by "6-8" people (34.3%) and "Less than 2 people" (5.3%). The lowest percentage was "More than 10 people." About the residing number of years, the majority of respondents had resided in the area "More than 41 years" (54.7%), followed by "36-40" years (9.4%) and "31-35" years (8.8%). The lowest percentage was "Less than 20 years" old.

Table 1 Demographic Information of Respondents

Gender			Age			Numbers of family persons			Family living years in this village		
	numbers of responses			numbers of responses			numbers of responses			numbers of responses	
	(n)	(%)		(n)	(%)		(n)	(%)		(n)	(%)
Male	95	51.6	Less than 20 years	2	1.1	Less than 2 persons	9	5.3	Less than 2 years	1	0.6
Female	89	48.4	20 - 29 years	22	12.4	3-5	93	55.0	3-5	6	3.5
			30 - 39 years	32	18.0	6-8	58	34.3	6-10	3	1.8
			40 - 49 years	49	27.5	9-10	5	3.0	11-15	5	2.9
			More than 50 years	73	41.0	More than 10	4	2.4	16-20	13	7.6
									21-25	9	5.3
									26-30	9	5.3
									31-35	15	8.8
									36-40	16	9.4
									More than 41 years	93	54.7
Total	184	100.0	Total	178	100.0	Total	169	100.0	Total	170	100.0

Source:Survey Data

Table 2 shows the using of the chemical fertilizer and the organic fertilizer becoming the core of the BC technology with land. About using chemical fertilizer, almost 76% were "No" and about 27% were "Yes." About using chemical pesticide, almost 64% were "Yes" and about 36% were "No". About using organic fertilizer, almost 50% were "No" and about 50% were "Yes." About using organic pesticide, almost 97% were "No" and about 3% were "Yes". The inhabitants continue Cambodian-style traditional lifestyle depending on natural resources.

Table 2 Using of the chemical fertilizer and the organic fertilizer

Using chemical fertilizer	numbers of responses		Using chemical pesticide	numbers of responses		Using organic fertilizer	numbers of responses		Using organic pesticide	numbers of responses	
	(n)	(%)		(n)	(%)		(n)	(%)		(n)	(%)
Yes	37	23.6	Yes	98	64.5	Yes	78	49.7	Yes	4	2.6
No	120	76.4	No	54	35.5	No	79	50.3	No	152	97.4
Total	157	100.0	Total	152	100.0	Total	157	100.0	Total	156	100.0

Source:Survey Data

In the Snuol District, Kratie Province, this area uses a high level of chemical fertilizer and pesticide. However, there are many local farmers which apply fertilizers without knowing the usage of appropriate chemical fertilizers and pesticides. Using an attribute from Table 1, this part clarifies the characteristic of the local farmers using the chemical fertilizer and the local farmers not using chemical fertilizer. In this analysis, Multiple Correspondence Analysis was employed. According to the results of Multiple Correspondence Analysis, it was clear that the preference divisions of the local farmers who depend on chemical fertilizer were "Gender", "Age", "Family number", "Duration of residence", "Irrigation facility" and "Multiple cropping" as important characteristics for the classification.

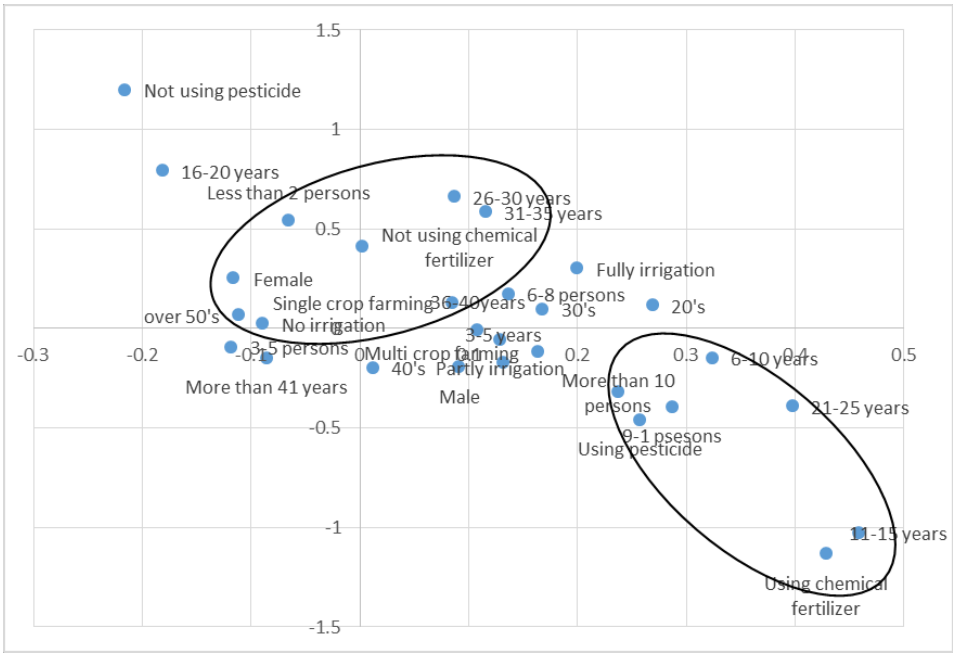

Fig.1 The result of Answer Pattern for using of chemical fertilizer and organic fertilizer by Correspondence Analysis

Figure 1 shows the result of the answer pattern for "Not using chemical fertilizer", as well as "Using chemical fertilizer". The answer pattern of "Using chemical fertilizer" is similar to the answer pattern of family number of 9-10 persons, more than 10 persons, duration of residence of 6-10 years, 11-15 years, 16-20 years, and using pesticide. Also, the answer pattern of "Not using chemical fertilizer" is similar to the answer pattern of female, aged more than 50 years old, family number of less than two persons, duration of residence of 26-30 years, 31-35 years, irrigation not improved, and single-crop farming.

BC process production technology functional model for the estimation is shown by Model 1 and Model 2.

Model 1: $Yn = AX1^{\alpha}X2^{\beta}$
Model 2: $Yn = AX2^{\beta}$

Where Yn is the average annual income from agricultural activity (riel), X1 is the total chemical fertilizer inputs, and X2 is the upland area (ha). At the same time, A, α, β is the estimation parameter. The estimation sample is the unit of the farm. Model 1 is the farmers using chemical fertilizers, and Model 2 is the farmers not using chemical fertilizers. The estimated parameter introduces a dummy variable of OID and VDn. OID is organic input dummy (input: 1, no input: 0) and VDn is village dummy, n is each village (Thpong: 1, Snuol Kert: 2, Snuol Lech: 3, Kathdai: 4, Prek Kdey: 5). The ordinary least squares (OLS) method was employed in the estimation of regression model.

Table 3 Estimation results of BC process production technology function

Chemical Input : Model 1 (N=33)							Non Chemical Input : Model 2 (N=86)		
Variable				Coefficient	t-value		Coefficient	t-value	
Constant			: C	12.44	23.77	***	14.39	76.92	***
Chemical Input	kg	X1	: α	0.42	5.59	***			
Upland and Paddy field	Area (ha)	X2	: β	0.54	3.44	***	0.61	5.99	***
Organic Input	Dummy	OD1	: γ	-0.43	-0.15		-0.10	-0.61	
Thpong	Dummy	VD1	: δ	1.09	2.72	***	0.34	1.23	
Snuol Kert	Dummy	VD2	: ε	0.38	0.60		0.53	1.92	*
Snuol Lech	Dummy	VD3	: ζ	0.68	1.62	*	0.22	0.81	
Kathdai	Dummy	VD4	: η	0.79	1.66	*	0.51	1.75	*
Prek Kdey	Dummy	VD5	: θ	1.15	1.90	**	-0.11	-0.30	
R2				0.68			0.46		
Adj.R2				0.57			0.42		
F-value				6.28			9.65		
p-value				0.00			0.00		

*Note:***1% level of significance,**5% level of significance,*10% level of significance*
Source:Survey Data

In Table 3, the estimation results are shown of the BC process production technology function of upland farming systems in the research-site area.

Estimation results of Model 1 and Model 2 are as follows. According to the measuring results of Model 1, indicating the farmer using the chemical fertilizer inputs, the value of production elasticity of chemical fertilizer inputs (α) is 0.3596. Moreover, the value of production elasticity of the land area (β) is 0.6060. The statistical significances of the value of α, β are satisfactory. Adjusted R-squared as statistical goodness-of-fit shows 0.6190. In the estimation results of Model 1, no statistical significance is recognized of the estimation parameter of the organic input dummy (OID) (γ) and village dummy of Snuol Lech (VD2) (ε). The value of α+β is 0.9656. BC process production technology in Model 1 has diminishing returns to scale. Furthermore, the value of α/β shows 0.5933. This means that the land use

and the chemical fertilizer inputs saving technology have been applied in BC process production technology.

According to the measuring results of Model 2 indicating the farmers not using the chemical fertilizer inputs, the value of production elasticity of the land area (β) are 0.6123. The statistical significance of the value of β is satisfactory. Adjusted R-squared as statistical goodness-of-fit shows 0.4413. In the estimation results of Model 1, the statistical significance is not recognized of the estimation parameter of the organic input dummy (OID) (γ) and village dummy of Thpong (VD1)(δ), Snuol Lech (VD3)(ζ) and Prek Kdey (VD5)(θ).

From these estimation results, observation facts of the BC process production technology function are as follows.

First observation fact, the BC process production technology have diminishing returns to scale ($\alpha+\beta<0$).

Second observation fact, when examining routine charge wealth (α) and land area (β), element contribution for the production of the element was not a high value.

Third observation fact is related to the value of land area (β). The values of β are mode 1:0.541 and mode 2:0.612. The contribution degrees of the land as the agricultural production inputs are more than 0.5 with both models. With the value of β being high, regardless of having chemical fertilizer in use or not, farmers performed the agricultural production which depended on the land. Regarding the value of land area (β), even if the land's fertile soil under the present conditions was a high level, in such condition of land area, the current inputs were intensively utilized. Therefore, element contribution of current inputs to production became a low level. It gradually strengthens a tendency as the productivity of the land is a low level. This tendency occurs if the soil fertility is a low level and soil erosion is a high level.

Fourth observation fact did not recognize a statistically significant recurrence relation in the organic input dummy (OID) (γ). This means that the introduction of the sustainable farming system based on natural resource circulation for the purpose of a decrease in chemical fertilizer and the decrease in chemical pesticide is difficult.

At first the estimation of the technical efficiency is as follows. Difference of the technology efficiency defines the residual from the actual value and estimated value. Difference of the technology efficiency is as follows with the index. Difference of technology efficiency index of the average annual income from an agricultural activity base:

EFFICIENCY = (income actual value / income estimated value) × 100

This means that EFFICIENCY is the technology efficiency of a high level in the time over 100, and the technology efficiency is a low level in times fewer than 100.

Table 4 The results of estimated of EFFICENCY

Using chemical fertilizer			Using chemical pesticide			Using organic fertilizer			Using organic pesticide		
	numbers of responses			numbers of responses			numbers of responses			numbers of responses	
	(n)	(%)		(n)	(%)		(n)	(%)		(n)	(%)
Yes	37	23.6	Yes	98	64.5	Yes	78	49.7	Yes	4	2.6
No	120	76.4	No	54	35.5	No	79	50.3	No	152	97.4
Total	157	100.0	Total	152	100.0	Total	157	100.0	Total	156	100.0

Source:Survey Data

In Table 4, the results of the estimated EFFICIENCY by analysis of variance (Multiple Range Tests: Modified LSD (Bonferroni) test with a significance level 0.05), in the villages Kbal Snuol,

Thpong, Snuol Kert, Snuol Lech, Kathdai, and Prek Kdey, the difference of the mean of the index of EFFICIENCY is not confirmed statistically.

Therefore, it confirms the influence that EFFICIENCY gives to agriculture income (Y: the average annual income from agricultural activity (riel)). The results of the regression model by estimation are as follows.

［Using chemical fertilizer of farmer］

$Y = -233{,}717 + 55{,}438.94$ EFFICIENCY $\quad \overline{R^2} = 0.6377$

［Non-using chemical fertilizer of farmer］

$Y = -1{,}357{,}258 + 48{,}388.51$ EFFICIENCY $\quad \overline{R^2} = 0.7671$

With both farmers using chemical fertilizers and those which do not, EFFICIENCY shows that it has a positive influence on agriculture income. It also shows that the existence of the technical inefficiency has a negative influence on agriculture income at the same time. The growth of technical efficiency of farm productivity rises and realizes an increase in agriculture income.

CONCLUSION

The main objectives of this study are tp clarify the character of the upland farming system in Snuol village, Snuol district, Kratié Province. The first objective is to clarify the characteristic of the farm households using agricultural chemicals. The second is to clarify factor input structures by estimating the production function that was based on the Biological and Chemical technology. In addition, the third objective is to clarify technical efficiency by estimated the stochastic frontier production function.

The results of this analysis are summarized as follows.

According to the results of Multiple Correspondence Analysis, it will be clear for the preference of the farm household using the agricultural chemicals, the divisions of “Gender,“ “Age,“ “Family number,“ “Duration of residence,“ “Irrigation facility“ and “Multiple cropping“, as important characteristics for the classification.

The Biological and Chemical technology process is a condition of the diminishing returns to scale. The technology process intensively utilizes the agricultural chemicals in farms with low soil fertility. Therefore, contribution to the current capital such as chemical fertilizer is not high. Under the traditional cultivation method, depending on soil fertility, the upland farming system of the productivity has been realized by lands using chemicals and the agricultural chemicals saving production technology.

The estimated value of the technical efficiency shows existence of the technical inefficiency in upland farming systems of the research site.

As a result of the analysis, in the future, introduction of the environmental preservation farming systems are necessary for the sustainable development of the upland farming system.

Toward realization of the environmental preservation farming systems, it is suggested that agricultural education be part of life-skill education and networking for promoting sustainable agriculture.

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