A Practice Model for Sustainable Agriculture Assessment: A Case Study of the Sustainable Cultivation of Thai Hom Mali (Jasmine) Rice in Thailand

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Abstract

The purpose of this study was to indicate the sustainability of Thai Hom Mali Rice (Jasmine rice) cultivation in Thailand. Which the study had statistical samples from the most intensive cultivation provinces, as Phayao (Northern region), Sisaket (Northeastern), Chachoengsao (Central region) and Nakhonsithammarat (Southern region). Two indicators had were assigned to assess the sustainable cultivation of Thai's farmers, namely as Sustainability in Cultivation Practices (SCP), and the Composite Sustainability Indicators (CSI). Indicators of each region had performed by this study. The findings revealed that where the northeastern region had the highest values of SCP and level of CSI level in the country. than other regions of Thailand. Besides, the independent variables of SCP, in particularly production costs, chemical and fertilizer utilization, the risk of weeds and pest, were found to be the significantly common variables in the most of regions of THMR cultivation.

Key Words: Thai Hom Mali (Jasmine) Rice/ Sustainability in Cultivation Practices/ Soil Preservation Model/ Increasing Production Model/ Prevention Production Model/ Composite Sustainability Indicators

1. Introduction

The 3 pillars as economic, social, and environmental are highlighted for the SD (sustainable development) concept. Several action programs for SD, has called for countries, international and non-governmental organizations to develop indices for the SD (CSD, 2006; Parris, 2003). These indices should be statistical formulations which could purposively be used to define the directions and trends, as well as the earlier warning for the situations of economic, social and environmental of the countries (Hammond, 1995). As well, since the Rio Earth Summit, there has been a mutual efforts to formulate indicators to approach the sustainable development situation, such as Sustainable Society Index, Human Development Index, Environmental Sustainability Index and some indicators was adopted for SA (Sustainable agriculture), such as Framework for the Evaluation of Sustainable Land Management. Land Quality Indicators and Environmental Sustainability Index for agricultural systems. However, the mentioned indicators have performed a variety of indicators which mostly aimed at the interests of such studies. Which have not so much address the interactions of the socio-economic and environmental factors in agriculture system and the sustainable situations of area. Therefore, it might be worth less to approach sustainable practice manners, in particular rice cultivations. Hence, the concept-proof-model on the development of indicators of sustainable agricultural practices, as the dependent variables on socio-economic and environment factors of area were adopted by this study. In the case study of Thai Hom Mali (Jasmine) Rice (hereafter called THMR) production systems of Thailand.

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2. Methodology

2.1 Data sampling

The purposive sampling was justified from the databases (1995-2007) of Office of Agricultural Economics. In which, jasmine rice of Dawk Mali 105 and RD 15 varieties was found to be in the most cultivated area. The cultivation area distributed to all regions of Thailand, as in Northern region of 17 provinces, North-eastern region of 19 provinces, Central region of 26 provinces, and Southern region of 14 provinces. Then, the 5 provinces with the most cultivation area of each regions was selected and have the head officers (Province agriculture extension Office) interviews. After that, several villages in each justified area were visited and had pre-feasibility assessment to qualify as study area. At last, i) Thung–ruangthong (TRT): the sub district in Phayao province of Northern region, ii) Du (DU): the sub district in Sisaket province of North-eastern region, iii) Bangkha (BK): the sub district in Chachoengsao province of Central region, and iv) Nariang (NR): the sub district in Nakhonsithammarat province of Southern region, were selected.

2.2 Indicators to analyze of sustainability

• The indicators in this study was initiatorily designed from the recommendations of various studies, such as Hammond (1995), Rainer (2000), Booysen (2002), Saisana (2005) and OECD handbook (Nardo, 2008). The 2 indicator values, i) the Sustainability in Cultivation Practices or model (hereafter called SCP or SCM in holistic view of model) and ii) Composite Sustainability Indicators (hereafter called CSI) were determined to be used for sustainable agriculture assessment of THMR cultivation.

• SCP, based on whether farmers followed the guidelines of sustainability in cultivation practices or not(Guideline methods,2009). SCP had mainly been depended on 3 practices in THMR cultivation as, i) the soil preservation practices or model(SP-P or SP-M) which considered from crop rotation, soil mulching, and non- rice stubble burning, ii) the increasing production practices or model (IP-P or IP-M)) which considered from seed selection, organic fertilizer utilization, and seed immunization; and iii) the prevention production (or product protection) practices or model (PP-P or PP-M)) which considered from non-chemical fungicide utilization, non-chemical insecticide utilization, and non-chemical herbicide utilization

• CSI aimed at the assessment of sustainability level of THMR cultivation. It was assessed through the THMR-farmer attitudes in the following the guideline practices, which composed of i) the Soil Preservation Model (SP-M) through the soil preservation indices (SP-IN) which resulted from of crop rotation indicator (CR-I), soil mulching indicator (SM-I), and non- rice stubble burning indicator (NRSB-I), ii) the Increasing Production Model (IP-M), through the increasing production indices (IP-IN) which resulted from seed selection indicator (SS-I), Organic fertilizer use indicator (OFU-I), and seed immunization indicator (SI-I), and iii) the Prevention Production Model (hereafter PP-M) through the prevention production indices (PP-IN) which resulted from non-chemical fungicide use indicator (NCFU-I), non- chemical insecticide use indicator (NCIU-I), and non-chemical herbicide use indicator (NCHU-I). All of the indices are then at last aggregate to be the Composite sustainability indicator (CSI). (Figure 1).

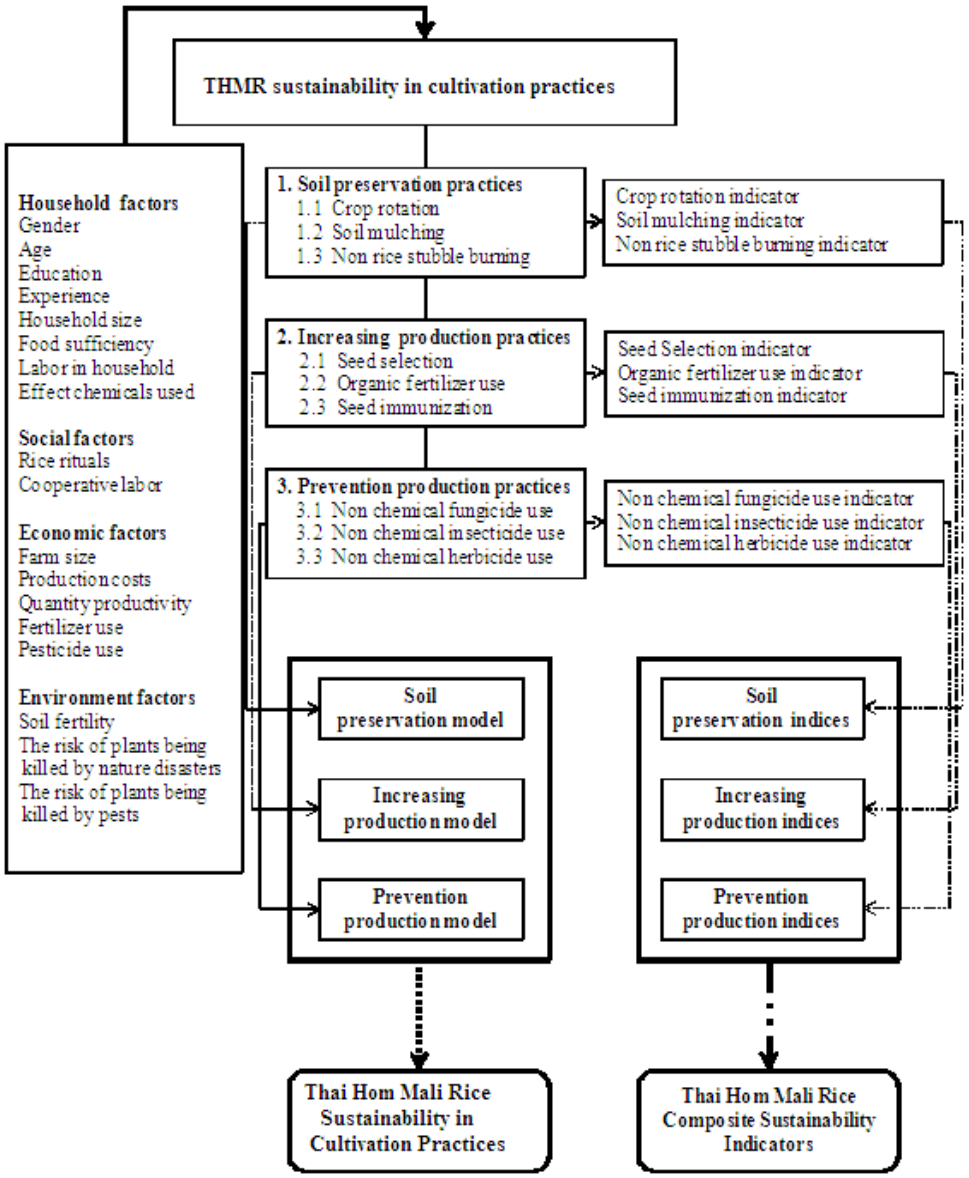

Figure 1:. Illustrated conceptual framework of the study

2.3 The sampling size

Taro Yamane formula (Yamane, 1973) was used to determine the sampling size. Three hundreds fifty eight (385) THMR households were calculated to be the minimum of sample size, with the acceptance of error at 0.05. As well, the study selected 460 household for this study. Which separately sampled 136 households in TRT, 136 in DU, 65 in BK and 123 in NR (or all of THMR cultivation households available in this area).

2.4 The variables of the study

The variables factors, which concerned sustainable practices and sustainability level of THMR had extracted from the previous studies, and gathered into the group of household, social, economics and environment factors, as shown in Table 1.

Table 1: The influence variables on rice cultivation practice of the previous studies.

Variables	Descriptions	Previous studies (Significance)	References
Household factors			
GEN	Household head's sex	+ (Male)	Marenya, 2007.
AGE	Household head's age	- (Young)	Gockowski, 2004 & Somda,2002
EDU	Household head's education	+ (Higher than primary school)	Peipukiew, 2007 & Bozoglu, 2007.
EXP	Farming experience in years	+ (High)	Illukpitiya, 2004 & Rahman, 2003.
HS	Total number in household	+ (Large)	Thangata,2003.
FOSC	Food sufficiency	+ (High percent)	Poudel, 2009.
LIH	Total labor in household	+ (More labor)	Feleke, 2006.
ECI	Effect of chemical inputs i - HCE (Herbicide effected) - ICE(Insecticide effected) - BCE(Both effectsed	+ (Effected)	Pumnumkem,2007 & Atreya, 2007
Social factors			
RR	Rice rituals CURT (Cultivation ritual) WSRT(Worship ritual) HVRT(Harvest ritual) CBRT (Celebration ritual)	+ (Continued)	Mangsuwan, 2000.
CPTL	Cooperative labors BFGR (Before growing) AFGR (After growing) BOGR(Both)	+ (Exchanged)	Grisanaputi,1985.
Economic factors			
FRS	Farm size in rai	- (Small)	Lohr, 2002 & Treewannakul, 2000.
PDTC	Product cost per rai	- (Low)	Mokkamakkul, 2006 & Berg, 2002.
QP	Quantity of Product per rai	+ (More paddy)	Saka, 2005 & Charuphong, 2000.
FTZU	Fertilizer use per rai	- (Low use)	Goldar,2004
PTCU	Pesticide use per rai	- (Low use)	Sa-ardying, 2001.
Environmental factors			
SOFY	Soil fertility i.e. low and moderate	+ (Moderate level)	Rahman, 2007 & Isgin, 2008 & Binam, 2004.
NDSR	Natural disaster	- (Low risk)	Qianwen, 2007.
PR	Product's risk to pests i.e. WER(Weeds risk) ANR(Animals risk) DIR(Diseases risk) INR(Insects risk)	- (Low risk)	Mariyono, 2007 & Kipkoech, 2008.
THMR-CSI	Amount of years in following the THMR-CSI		UNEP-HDI (2005), Yale -university- EPI (2010), NESDB- SDI (2006), CDO-PQLI (2004).

The magnitudes or values of independent and dependent variables had been rated into number, point, dummy values, and scaling as nominal, ratio, interval and percentage scale as Table 2 and 3.

Table 2: Types and scales of independent variables

Variables	Descriptions	Types of value	Scale
GEN	Gender	Dummy (0 if male, 1 if female)	Nominal
AGE	Age	Year	Ratio
EDU	Education	Dummy (0 if primary, 1 if upper primary)	Nominal
EXP	Experience	Year	Ratio
HS	Household	Number of member in household	Ratio
FOSC	Food sufficiency	Percentage	Ratio
LIH	Labor in household	Number of labor in household	Ratio
ECI	Effect of chemical inputs		Nominal
HCE	Herbicide effected	Dummy (0 if no, 1 if yes)	
ICE	Insecticide effected	Dummy (0 if no, 1 if yes)	
BOE	Both effected	Dummy (0 if no, 1 if yes)	
RR	Rice rituals		Nominal
CURT	Cultivation ritual	Dummy (0 if no, 1 if yes)	
WSRT	Worship ritual	Dummy (0 if no, 1 if yes)	
HVRT	Harvest ritual	Dummy (0 if no, 1 if yes)	
CBRT	Celebration ritual	Dummy (0 if no, 1 if yes)	
CPTL	Cooperative labors		Nominal
BFGR	Before growing	Dummy (0 if no, 1 if yes)	
AFGR	After growing	Dummy (0 if no, 1 if yes)	
BOGR	Both before and after	Dummy (0 if no, 1 if yes)	
FRS	Farm size	Rai (1 hectare = 6.25 rai)	Ratio
PDTC	Production costs	Bath per rai	Ratio
QP	Quantity productivity	Kilogram per rai	Ratio
FTZU	Fertilizer use	Kilogram per rai	Ratio
PTCU	Pesticide use	Kilogram per rai	Ratio
SOFY	Soil fertility	Dummy (0 if low, 1 if moderate)	Nominal
NDR	Natural disasters	1, lowest; 2, low; 3, moderate; 4, High; 5, Highest	Interval
PR	Product risk to pests	All indicated by	Interval
WER	Weeds risk	Never = 0	
ANR	Animals risk	Lowest = 1	
DIR	Diseases risk	Low = 2	
INR	Insects risk	Moderate = 3	
		High = 4	
		Highest = 5	

Table 3: Types and scales of dependent variables

Variables	Description	Types of value	Scale
THMR-SCP	THMR Sustainability in Cultivation Practices	Average in year to follow THMR-CSP	Ratio
SP-P - CR - SM - NRS	Soil preservative practice Crop rotation Soil mulching Non rice stubble burning	All indicated by Lowest = 1 Low = 2 Moderate = 3 High = 4 Highest = 5	Interval
IP-P - SS - OFU - SI	Increasing production practices Seed selection Organic fertilizer use Seed immunization	All indicated by Lowest = 1 Low = 2 Moderate = 3 High = 4 Highest = 5	Interval
PP-P - NCFU - NCIU - NCHU	Prevention production practices Non chemical fungicide use Non chemical insecticide use Non chemical herbicide use	All indicated by Lowest = 1 Low = 2 Moderate = 3 High = 4 Highest = 5	Interval

The study questionnaires were precisely designed to cover all of the above variables. However, the certainty of qualify questionnaires, pretest had conducted in study area, as well as the 12 experts in social and sustainability study were asked to comment on this questionnaire.

2.5 Data analysis methodology

The first index (THMR-SCP), Logistic regression method was conducted through 3 steps. Which the first step, univariate analysis by Chi-square statistics had been used to screen the significantly independent variables. Then, the second step, multivariate analysis by Binary Logistic Regression as Wald statistic

$$\text{Wald} = \left[\frac{B}{S.E}\right]^2$$

where B is the estimated coefficients and S.E. is the standard errors of the individual regression coefficients), was used to identify such independent variables that had significant association ($P \leq 0.05$) with dependent variables (Practice model). At the third step, Fitting model by Log likelihood (LL) function was taken. The difference between -2LL for the full model and -2LL for the null model had compared, the decreasing in -2LL of full model mean the good fitting model, which then followed by Hosmer and Lemeshow Test, if chi-square test were not significant at $P > 0.05$ that mean good fitting model, and finally finished the last test with Omnibus Tests of Model Coefficients. If chi-square test is significant at $P < 0.05$, that mean good fitting model. After that, transforming significant variables to probability, which the Logit (P) (logistic regression model) by the equation of

$$\text{Logit}(P) = \log\left[\frac{P}{1-P}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n$$

Where: P_i is the probability that the dependent variable (Y) is 1 (follow THMR-CSP), and Q_i (or $1\text{-}P_i$) is the probability that the dependent variable(Y) is 0 (or not follow THMR-CSP), while β_0 is the intercept, and β_1 , β_2 ,…. B_n are the

coefficients, as X_1, X_2 … X_n measure the contribution of independent factors to the variations in P.

As well, the second index (CSI), the collected data was normalized by equation of

$$\text{Indicator}(\ I) = \left[\frac{\text{Actual value}}{\text{Maximum value}}\right] \times 100 \ ,$$

where Actual value is the amount of years in THMR-CSP, and Maximum value is equal to 5 years period . Then Indices aggregated all indicators in such model into indices by arithmetic average as:

$$\text{Indices}(I_n) = \frac{\text{Indicator}_1 + \text{Indicator}_2 + \text{Indicator}_3}{\text{Number of Indicators}}$$

.

At last, aggregated all indices into composite indicators by arithmetic average as :

$$\text{Composite Indicators(Ci)} = \frac{\text{Indices}_1 + \text{Indices}_2 + \text{Indices}_3}{\text{Number of Indices}}$$

3. Results

3.1 Sustainability in THMR cultivation practices

3.1.1 Background values of Sustainability in Cultivation Practices (THMR-SCP)

The highest THMR-SCP point (value) was in the northeastern region (DU), the THMR-farmers there followed the methods for THMR-SCP more than the other regions of Thailand (Table 4)

Table 4: THMR sustainability in cultivation practices (THMR-SCP).

	CR	SM	NRSB	SP-P	SS	OFU	SI	IP-P	NCFU	NICU	NCHU	PP-P	THMR SCP value
TRT	0.14	3.82	4.34	**8.30**	4.67	2.74	0.07	**7.49**	4.07	0.66	2.07	**6.81**	**22.6**
DU	1.00	4.54	3.51	**9.05**	3.22	4.35	0.10	**7.67**	4.88	3.96	2.76	**11.60**	**28.32**
BK	1.54	4.92	3.95	**10.41**	5.00	1.55	0.05	**6.60**	4.26	3.02	1.17	**8.45**	**25.46**
NR	0.07	4.09	3.95	**8.11**	4.90	1.02	0.10	**6.02**	4.70	2.48	3.00	**10.18**	**24.31**

Remark: Some households had never practice (0 point) in crop rotation, seed immunization and non-chemical herbicide use, so the average point of some parameters performed the values below 1.

3.1.2 Screening the significance variables in SCM

SCM (Sustainability in Cultivation Model) was SCP indicator, but in the perceivably holistic views of sustainability cultivation on soil preservation (SP-M), increasing production(IP-M) and product prevention(PP-M), not had the view points separated into such single practices as crop rotation, soil mulching etc. Which a large number of variables showed correlations with sustainability in SP-M, IP-M and PP-M. The common variables (more than 5 correlations) were performed by AGE, EXP, FOSC, HVRT, FRS, PDTC, QP, FTZU, PTCU, WER, ANR, DIR, INR.

Table 5: The significant variables in Cultivated Sustainability Model (CSM)

Models/ Regions/ Variables	Soil preservation model **(SP-M)**				Increasing product model **(IP-M)**				Prevention production model **(PP-M)**			
	N	NS	C	S	N	NS	C	S	N	NS	C	S
Total significance	17	11	6	11	14	13	9	9	11	9	12	12
GEN				*	*	*				*		
AGE	*	*					*		*	*	*	
EDU	*				*	*						
EXP	*	*		*	*	*	*	*		*		*
HS		*				*		*			*	
FOSC	*		*	*		*	*	*	*	*	*	*
LIH						*		*			*	
ECI												
HCE		*				*						*
ICE												
BOE												
RR												
CURT												
WSRT												
HVRT	*		*		*		*		*		*	
CBRT												
CPT												
BFGR				*								*
AFGR												
BOGR	*				*		*					
FRS	*	*			*	*	*		*	*		*
PDTC	*	*		*	*	*	*	*	*	*	*	*
QP	*	*	*	*	*	*	*		*	*	*	
FTZU	*	*		*	*	*	*	*	*	*	*	*
PTCU	*	*		*	*	*		*	*	*	*	*
SOFY	*											
NDR	*				*							*
PR												
WER	*		*	*	*			*	*		*	*
ANR	*	*		*							*	*
DIR	*		*	*	*			*	*		*	
INR	*	*	*		*	*			*			*

Remark * was significance, N(North), NS(Northeastern), C(Central), S(Southern)

3.1.3 Significant association of variables and SCM (SP-M, IP-M,PP-M)

By multivariate analysis, through the example of SP-M in the northern region (Table 6). The Wald statistics indicated the strong evidence of positive effect of PDTC, ANR, DIR and negative effect of FTZU. Also the Likelihood Ratio Test showed that the attained model was a significant fit of data .To determine the value of Odds Ratio, it appeared that the estimated odds for the soil preservation was 5.058 times per each point of ANR. In addition, the estimated odds for the soil preservation was 2 times per point of DIR. While the effects of FTZU and PDTC were slightly different to the practice of soil preservation. These results suggest that the probability in

practicing the soil preservation increased when ANR and DIR increased.

As well as, in the north-eastern region, the evidence of positive effect was only AGE and others show negative. In particular, the positive effects on QP was only in central and WER was only in the southern region (Table 6).

Table 6: Soil Preservation Model (SP-M)

Independent variables in significance ($P \leq 0.05$) by Wald statistic												
Variables	North			North-eastern			Central			Southern		
	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)
PDTC	5.548	0.019	1.001									
FTZU	5.990	0.014	0.962									
ANR	10.445	0.001	5.058	5.404	0.020	0.654						
DIR	8.542	0.003	1.981				4.157	0.041	0.489			
AGE				5.139	0.023	1.049						
EXP				4.902	0.027	0.928						
PTCU				4.904	0.027	0.064				5.745	0.017	0.205
QP							13.213	0.000	1.026			
WER							4.637	0.031	0.382	9.178	0.002	1.598
Constant	6.369	0.012	0.022	1.403	0.236	2.988	2.667	0.102	0.037	1.259	0.262	0.601
Goodness of fit model												
Methods	North			North-eastern			Central			Southern		
	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test
-2Log likelihood	150.718	113.044	37.674	181.864	162.401	19.463	76.703	32.726	43.977	141.014	136.082	4.932
	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.
Omnibus	37.674	4	0.000	19.463	4	0.001	43.977	3	0.000	4.932	1	0.026
Hosmer	15.334	8	0.051	13.033	8	0.111	6.232	7	0.513	2.990	2	0.224
Cox	24.20			13.30			39.60			39.00		
Predicted	75.70	79.40		61.0	69.90		72.30	84.60		74.00	74.00	
Independent variables in significance ($P \leq 0.05$) by Wald statistic												
Variables	North			North-eastern			Central			Southern		
	B	S.E		B	S.E		B	S.E	Exp(B)	B	S.E	
PDTC	0.001	0.001										
FTZU	-0.039	0.016										
ANR	1.621	0.502										
DIR	0.684	0.234					-0.716	0.351				
AGE				0.048	0.021							
EXP				-0.075	0.034							
PTCU				-2.748	1.241					-1.586	0.662	
ANR				-0.424	0.183							
QP							0.026	0.007				
WER							-0.962	0.447		0.469	0.155	
Constant	-3.821	1.514		1.095	0.924		-3.300	2.021		-0.509	0.453	

Remark: Wald test is the ratio of B to S.E squared; Exp(B) is odds ratio for related of two groups of variables; χ^2 test is chi square test; Omnibus = Omnibus test, Hosmer = Hosmer and Lemeshow test,Cox = Percentage of Cox & Snell R^2, Predicted = Percentage correctly predicted

B is the estimated regression coefficients; S.E is the standard errors.

As mentioned in methodology, then the study transformed significant variables to probability, by the Logit (P) . For example in northern region as

$$\text{Logit(P)} = \log\left[\frac{P_{sp\text{-}M}}{Q_{sp-M}}\right] = -3.821 + (0.001 \times PDTC) + (-0.039 \times FTZU) + (1.621 \times ANR) + (0.684 \times DIR)$$

Where is the probability that THMR-farmers have follow in soil preservation practices, is the probability that THMR-farmers have not follow in soil preservation model. Therefore, $P_{SP\text{-}M}$ = 0.65 , or followed in soil preservation practice. As well, (1- 0.65) = 0.35 or not followed in soil preservation practice. Probabilities for other regions are shown in Table 9.

As well as , through the increasing production model(IP-M) and production protection model(PP-M) had shown in table 7 and 8, with the summary of probability values of farmers in whether following the SCP or not, had presented in table 9.

Table 7: Increasing production model (IP-M)

Independent variables in significance (P ≤ 0.05) by Wald statistic												
Variables	Northern			North-eastern			Central			Southern		
	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)
GEN	4.388	0.036	3.168									
BOGR	6.097	0.014	2.738									
QP	5.933	0.015	1.007									
FTZU	4.448	0.035	1.029	8.712	0.003	1.038	3.840	0.050	1.039			
WER	3.979	0.046	1.438									
PDTC				8.896	0.003	0.998	6.712	0.010	0.998			
FOSC							7.868	0.005	1.054			
LIH										4.841	0.028	1.722
Constant	17.184	0.000	0.002	2.049	0.152	3.194	0.197	0.657	0.509	13.098	0.000	0.093
Goodness of fit model												
Methods	Northern			North-eastern			Central			Southern		
	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test
-2Log likelihood	187.476	153.582	33.894	185.584	168.556	17.028	81.806	62.443	19.348	141.014	136.082	4.932
	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.
Omnibus	33.894	5	0.000	17.028	2	0.000	19.348	3	0.000	4.932	1	0.026
Hosmer	12.211	8	0.142	3.279	8	0.916	5.769	7	0.567	2.990	2	0.224
Cox	21.10			11.8			25.70			39.00		
Predicted	54.40	72.10		57.40	63.20		67.70	76.90		74	74	
Variables	Northern			North-eastern			Central			Southern		
	B	S.E		B	S.E		B	S.E		B	S.E	
GEN	1.153	0.551										
BOGR	1.007	0.408										
QP	0.007	0.003										
FTZU	0.029	0.014		0.038	0.013		0.038	0.019				
WER	0.364	0.182										
PDTC				-0.002	0.001		-0.002	0.001				
FOSC							0.052	0.019				
LIH										0.543	0.247	
Constant	-6.495	1.567		1.161	0.811		-0.676	1.524		-2.379	0.657	

Remark: B is the estimated regression coefficients; S.E is the standard errors.

Table 8: Prevention production model (PP-M)

Independent variables in significance (P ≤ 0.05) by Wald statistic												
Variables	Northern			North-eastern			Central			Southern		
	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)	Wald	Sig.	Exp(B)
FRS	13.591	0.000	0.929									
FTZU	4.747	0.029	0.962							6.244	0.012	1.081
PTCU	24.280	0.000	0.256							18.632	0.000	0.002
WER	6.439	0.011	1.911							6.378	0.012	1.590
DIR	7.074	0.008	0.538									
INR	5.148	0.023	1.718									
GEN				4.440	0.035	2.276						
FOSC				6.621	0.010	1.025	5.833	0.016	1.045			
HS							4.340	0.037	1.489			
ANR							5.283	0.022	1.830			
NDR										7.375	0.007	1.572
Constant	1.976	0.160	10.521	4.510	0.034	0.302	7.242	0.007	0.026	5.553	0.018	0.160
Goodness of fit model												
Methods	Northern			North-eastern			Central			Southern		
	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test	Null model	Full model	χ^2 test
-2Log likelihood	183.535	114.706	68.829	175.351	160.804	14.547	83.201	67.259	15.942	163.612	117.964	45.648
	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.	χ^2 test	d.f.	Sig.
Omnibus	68.829	6	0.000	14.547	2	0.001	15.942	3	0.001	45.648	4	0.000
Hosmer	4.094	8	0.849	4.432	7	0.729	1.997	7	0.960	9.338	8	0.315
Cox	39.70			10.10		31.70				31.00		
Predicted	59.60	82.4		65.40	71.30	66.20	70.80			61.80	77.20	

Table 8 (con't)

Variables	Northern		North-eastern		Central		Southern	
	B	S.E	B	S.E	B	S.E	B	S.E
FRS	-0.073	0.020						
FTZU	-0.038	0.018					0.078	0.031
PTCU	-1.363	0.277					-6.377	1.477
WER	0.647	0.255					0.464	0.184
DIR	-0.620	0.233						
INR	0.541	0.239						
GEN			0.822	0.390				
FOSC			0.025	0.010	0.044	0.018		
HS					0.398	0.191		
ANR					0.604	0.263		
NDR							0.452	0.167
Constant	2.353	1.674	-1.196	0.563	-3.635	1.351	-1.834	0.778

Remark: B is the estimated regression coefficients; S.E is the standard errors.

Table 9: Probability values of sustainability in cultivation practices (SCP)

Models and Practices		Northern	North-eastern	Central	Southern	Average
SP-M	Followed	0.65	0.62	0.86	0.63	0.69
	Not Followed	0.35	0.38	0.14	0.37	0.31
IP-M	Followed	0.74	0.61	0.42	0.25	0.51
	Not Followed	0.26	0.39	0.58	0.75	0.49
PP-M	Followed	0.26	0.74	0.73	0.67	0.60
	Not Followed	0.74	0.26	0.27	0.33	0.40
Average	Followed	0.55	0.66	0.67	0.52	0.60
	Not Followed	0.45	0.34	0.33	0.48	0.40

3.4 Composite sustainability indicators (CSI) values

The value of THMR-CSI was normalized and aggregated to be a single value of THMR-CSI by arithmetic average, as shown in Table10. The level of THMR - sustainable Cultivation in the northern region was 50.21, and was the lowest value among 4 regions. In this region, most of the sustainable practices was not followed or followed in lower values when compared with other regions, excepted non-rice stubble burning. The northeastern region resulted in the highest value of THMR– sustainable cultivation at 65.36. Where most of sustainable practices had well followed than other regions

Table 10: Values of THMR-CSI (Composite Sustainability Indicators)

Indices		Northern		North-eastern		Central		Southern	
		Normalizing Value	Indices (Aggregation)	Normalizing Value	Indices (Aggregation)	Normalizing Value	Indices (Aggregation)	Normalizing Value	Indics (Aggregation)
SP-I (Soil preservation indices)	Crop rotation (CR)	2.79	55.34	20.0	60.34	30.77	69.44	1.30	54.04
	Soil mulching (SM)	76.47		90.74		98.46		81.79	
	Non rice stubble burning (NRSB)	86.76		70.29		79.08		79.02	
IP-I (Increasing production indices)	Seed selection (SS)	93.38	49.90	64.41	51.81	100.00	44.00	98.05	40.11
	Organic fertilizer use (OFU)	54.85		87.00		31.08		20.33	
	Seed immunization (SI)	1.47		2.06		0.92		1.95	
PP-I (Prevention production indices)	Non chemical fungicide use (NCFU)	81.47	45.39	98.09	84.56	85.23	56.31	93.98	67.86
	Non chemical insecticide use (NCIU)	13.24		96.47		60.31		49.59	
	Non chemical herbicide use (NCHU)	41.47		59.12		23.38		60.00	
THMR-CSI (Average CSI for all area = 56.54)			50.21		65.36		56.58		54.00

4. DISCUSSION

4.1 Performance of common variables

From Table 6, 7, 8, the common variables (at least 3 regions found) were PDTC, FTZU, PTCU, WER and ANR. Which had been shown in Table 11 and could be described as followed,

Table 11: The common variables found in most region of cultivation

Common Variables of Sustainable practices models	Northern	North-eastern	Central	Southern
SP-M	(+)PDTC (-)FTZU (+)ANR	(-)PTCU (-)ANR	(-)WER	(-)PTCU (+)WER
IP-M	(+)FTZU (+)WER	(-)PDTC (+)FTZU	(-)PDTC (+)FTZU	
PP-M	(-)FTZU (-)PTCU (+)WER		(+)ANR	(+)FTZU (-)PTCU (+)WER

In the view point of production cost(PDTC), as known the production cost of SCP had higher than the conventional cultivation practices (Berg, 2002; Mokkamakkul, 2006 and Chaisanchompoo,2006), Which confirmed the mentioned studies by the THMR cultivation in the northern region, where the high production costs was the farmers who followed soil preservation practices. It was noted that farmers were willingness to pay, in particular for the new technologies in soil preservative practices that they believed to be the major factor in increasing production. While in the northeastern and central regions, production cost had the significant negative correlation with the increasing production practice. There, THMR-farmers accepted and followed in increasing production practices, such as organic rice growing practice. No correlation of production cost in the southern region, this might be the farmers here did not earn their key household income from rice cultivation. Hence, the land for rice cultivation was only the excess land from their actual land-use for income, which was mainly on para-rubber plant, grassland etc. So, they did not invest much in land.

In the view point of fertilizer use (FTZU), as the positive significance of rice production with fertilizer inputs (Thomya, 2001), and experiences in chemical fertilizer use (Bekele, 2006) were previously found. The results of this study was in the same direction of previously studies, as the households of fertilizer use in the north, northeastern and central region had the positive significance on IP-M, while the negative significance on the SP-M and PP-M in the northern. But it was out of ordinary on the positive correlation of fertilizer use on PP-M in southern household. The note in field study defined that farmer in southern had their own concepts in practices for product prevention practice. They believed the higher chemical fertilizer input were better for the risk or prevention of product.

In the view point of pesticide use (PTCU), as significant correlation of higher IPM (integrated pest management) knowledge with the less pesticide usage (Feder, 2004), and non-significant amount of agro-chemicals with the level of technical efficiency (Oladeebo, 2007) in rice cultivation were investigated. This study found negatively significant correlation of pesticide use in the northern farmers who followed on PP-M, and who followed SP-M in the northeastern, as well who followed SP-M and PP-M in the south. Meaningly, most THMR-farmer had been conscious on pesticide use, they used in only necessary practices, such as in the northern for field crab and stem-borer worm demolisher. But, in the southern, most THMR-farmers grew rice only for household consumption, so they didn't prefer pesticide contamination in the rice for their household consumption.

In the view point of risk of rice killed by weeds(WER) and animals(ANR), that were sub-indicators of the risk of pest(PR). The risk of rice killed by weeds had positive correlation with IP-M and PP-M in northern region, with SP-M and PP-M in the south region and negative in central. The judgment of causes and magnitude of risk was considered through the experience and expectation of farmers. Consequently, the northern farmer believed the risks of weed originated from soil preservation and production prevention practices, so they followed IP-M and PP-M. While the south farmers judged and followed SP-M and PP-M, as well as the central judged and followed SP-M. But risk of animal that farmers in the northern judged and followed SP-M, while central on PP-M, in particular the farmer in northeastern did not judge and did not followed on SP-M for animal risk.

4.2 Thai Hom Mali Rice composite Indicator(THMR-CSI)

• In Table 10, performed that the average score of THMR-farmer was 56.54%. The lowest value (50.21 %) was the north region, as 54.00 % in the southern and 56.58 % in the central. While the highest value (65.36%) was the northeastern region. Though, this study was indicated only the situation of THMR cultivation level of Thailand. But it was just the proof-of-concept model study, whether the methodology was feasible or not. It need the further study for adjustment and calibration. However, at present, there were several composite indicators (CI) that can be applied for THMR cultivation which accepted in worldwide, such as i) the human development index (2005 HDI) (UNDP. 2007, ii) the Sustainable Development Index in Thailand (SDI2006) (NESDB,2006), iii) the Physical Quality of Life Index (PQLI) (CDO, 2004), etc., as concluded in Table 12.

Table 12: Composite indicators (CI) indicated Thailand situation

CI	References	Values
2005 HDI	UNDP(2007)	Thailand had rank at 78 of 177 countries, scores as 0.781
2008 EPI	Yale & Columbia University(2008)	Thailand had rank at 67 of 163 countries, scores as 62.20 %
SDI (2006)	NESDB(2006)	Thailand had scored as 69.72 %
PQLI (2004)	CDO(2004)	Thailand had scored as 0.7567
THMR-CSI	This study	Thailand had average score 56.54%

5. Conclusion

This study found that 60% of THMR-farmers had followed the sustainability cultivation practices. The most common variables, that affect on sustainability in cultivation practices, were production cost, fertilizer use, pesticide use, weed and animal risks. Other 10 variables were also found significant in some regions. For example gender in the north and northeastern, age in the northeastern, farm size in the northern etc. Composite sustainability level, the northeastern region performed the highest level, followed by central, southern region and the lowest in the northern region of Thailand.

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