Characterising Farmers' Adoption Factors of Cleanliness Levels of Vegetable Farming Systems

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ABSTRACT

'Clean and safe' agricultural products are an important issue among consumers, farmers and governments. Many developing countries develop their produce at various points along the 'clean' continuum based on four different production practices related to the use of synthetic chemicals. Organic farming is applied to technologies which do not use chemicals or synthetic fertilisers during production or processing. Safe-use and pesticide-free practices lie between organic and conventional practices, and are possible steps when converting conventional farms to organic farms. The four farming systems are also viewed as a series of 'clean and safe' farming systems, with conventional vegetable (CV) being the least 'clean and safe', safe-use vegetable (SUV) being more 'clean and safe', pesticide free vegetable (PFV) more so again, and organic vegetable (OV) being the most 'clean and safe' system. The main purpose of this paper is to investigate factors affecting the adoption of 'clean and safe' farming systems in northern Thailand. To examine the patterns of adoption based on this continuum notion regarding cleanliness level, we used an ordered logistic regression. Farm-level data on vegetable production were collected from random samples of farms using these technologies in northern Thailand. The results of the analysis of farming system adoption show that the important significant factors are membership of farmers' groups, proportion of female family members working on the farm, location, NGO financial sources, and ownership of freehold land. Thus, in developing more 'clean and safe' farming systems and practices the above factors need to be considered.

Key words: Cleanliness, Organic, Pesticide-free, Safe-use, Vegetable

INTRODUCTION

Food safety has been an important issue in agricultural production. Thailand has adopted a range of levels of 'clean and safe' farming systems from safe-use chemical, pesticide-free and no chemical to environmentally friendly practices notably organic. 'Clean and safe' food market demand continues to increase (Vanit-Anunchai and Schmidt, 2005; Johnson et al., 2008), but lack of 'clean and safe' produce of good quality and in sufficient variety is constraining development of the 'clean and safe' vegetable industry (Kramol et al., 2005; Posri et al., 2007; Lorlowhakarn et al., 2008).

Although rice is the most important crop in Thailand based on consumption, production and income, vegetable crops are also significant as an alternative source of household income and are considered to be essential goods particularly in the North. When food safety issues are considered, vegetables are subject to a high risk from chemical contamination because of production practices and consumption behaviour (Vanit-Anunchai, 2006; Posri et al., 2007).

There are various stages of conversion from the heavily dependent use of chemicals to no use of chemicals. The range of 'clean and safe' vegetable farming practices can be seen as a clean continuum (McCoy and Parlevliet, 2000) (Figure 1). The clean continuum ranges from production practices that allow the use of high chemical inputs, safe-chemical, pesticide-free to no chemical use with environmental friendly practices (organic). The ideal of the 'clean and safe' produce system is the organic vegetable (OV) method that allows the use of organic substitutes such as alternative fertilisers and herbal pesticides rather than synthetic chemicals. Safe-use and pesticide-free farming are intermediate practices between the organic and conventional farming. A pesticide-free vegetable (PFV) farming system is considered a step taken before organic practice since its systems tend to have similar concepts to organic farming systems. However, the pesticide-free method is more relaxed than OV. It allows the use of synthetic fertilisers to improve farmers' ability to enhance vegetable yields. The safe-use vegetable (SUV) farming system allows the use of synthetic or artificial chemical fertilisers, insecticides, fungicides and herbicides provided the practices strictly follow the system's guidelines. Produce from this system is normally tested for safe levels of chemical residues. This farming practice follows the Good Agricultural Practice developed by the Departments of Agriculture and Agricultural Extension as a production guideline (Salakpetch 2007). Conventional vegetable (CV) farms are mainstream farming practices that conform to the standard, dominant farming approach (Kristiansen et al., 2006).

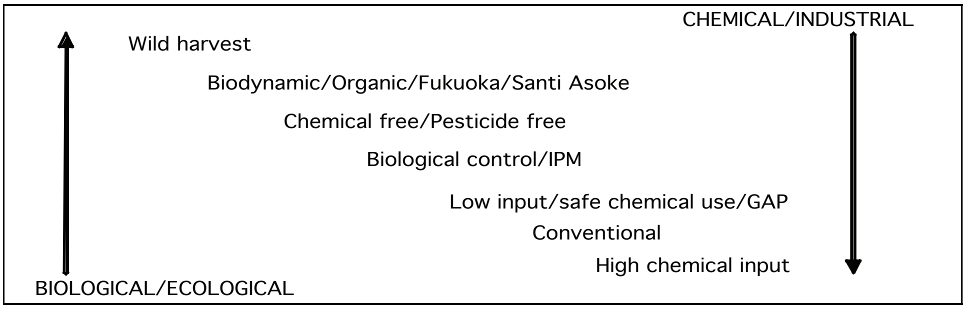

Figure 1. The range of 'clean and safe' farming systems in Thailand.
Source: Adapted from McCoy and Parlevliet (2000)

In this paper, factors influencing the adoption of 'clean and safe' practices were analysed using ordered logit. Vegetable farmers were categorised into four groups based on their based on their level of synthetic chemical use: OV, PFV, SUV and CV. Objectives were to identify factors affecting adoption in different vegetable farming systems at different cleanliness levels.

METHODOLOGY

The decision of farmers in choosing certain 'clean and safe' vegetable farming systems is made for their own reasons based on their skills, knowledge, motivation, resources and access to necessary information and support. Without a form of interval scale, the OV farming system is considered to be the cleanest and the PFV farming system is considered less clean than OV farming system but cleaner than the SUV farming system. The CV farming system is considered to be the least clean system (Figure 2). The ordered logit model estimated in this study follows Greene (2008) and Hill et al. (2008).

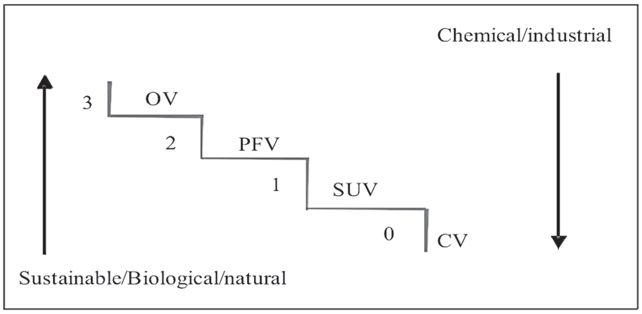

Figure 2. Cleanliness range of 'clean and safe' farming systems according to use of chemicals in farming methods.

The ordered logit model is expressed as:

$$d_{ij}^{*} = z_{ij}'\alpha + w_{ij} \qquad i = 1,...N \quad ; \qquad j = 0, 1, 2, 3 \tag{1}$$

The d_{ij}^{*} is unobserved; however it corresponds to the dependent variable *d*, defined as:

$$d = \begin{cases} 3 = \text{OV} & \text{if } d_i^* > \mu_3 \\ 2 = \text{PFV} & \text{if } \mu_2 < d_i^* \leq \mu_3 \\ 1 = \text{SUV} & \text{if } \mu_1 < d_i^* \leq \mu_2 \\ 0 = \text{CV} & \text{if } d_i^* \leq \mu_1 \end{cases} \tag{2}$$

The μ s are unknown threshold parameters to be estimated with α . The decision to choose any particular farming system depends on factor *z* and unobserved factor w_{ij}. The probabilities of adopting individual farming systems are defined as:

$$\begin{aligned} &\text{Prob}(d = 0|\text{z}) = \Phi(-z'\alpha) \\ &\text{Prob}(d = 1|\text{z}) = \Phi(\mu_1 - z'\alpha) - \Phi(-z'\alpha) \\ &\text{Prob}(d = 2|\text{z}) = \Phi(\mu_2 - z'\alpha) - \Phi(\mu_1 - z'\alpha) \\ &\text{Prob}(d = 3|\text{z}) = 1 - \Phi(\mu_2 - z'\alpha) \end{aligned} \tag{3}$$

where Prob ($d = j$) is the probability of ordered choices j

d is the dependent variable (*j*: 3=OV, 2=PFV, 1=SUV and 0=CV),

z are the explanatory variables including variable sets in resource availability, information accessibility, management, innovation properties, and special concerns and farmer perceptions (Box 1),

α are the model parameters,

N is the number of choice occasions,

J is the number of ordered choices (4), and

Φ is the logistic cumulative distribution function.

Accordingly, the marginal effect can be derived as follows:

$$\begin{aligned} &\frac{\partial\,\text{Prob}(d = 0|\text{z})}{\partial \text{z}} = -\Phi(z'\alpha)\,\alpha, \\ &\frac{\partial\,\text{Prob}(d = 1|\text{z})}{\partial \text{z}} = [\Phi(-z'\alpha) - \Phi(\mu - z'\alpha)\alpha], \\ &\frac{\partial\,\text{Prob}(d = 2|\text{z})}{\partial \text{z}} = [\Phi(\mu_1 - z'\alpha)\alpha - \Phi(\mu_2 - z'\alpha)\alpha], \\ &\frac{\partial\,\text{Prob}(d = 3|\text{z})}{\partial \text{z}} = \Phi(\mu_2 - z'\alpha)\,\alpha. \end{aligned} \tag{4}$$

The ordered logit analyses were carried out using the 'ologit' function in *Limdep* 9.

Box 1. Explanatory factor included in the ordered logit model.

Resource availability:	**Management factors:**
Vegetable farm experience	Sub-temperate vegetables
Education of farmer working on farm	Financial source: government project
Average age of family members working on vegetable farm	Financial source: other projects
Political role and position of farmer	Member of clean and safe group
Number of household members	Training in alternative substances
Proportion of females working on vegetable farm	Use of direct marketing
Land holding	**Innovation properties:**
Vegetable area	Number of vegetables
Soil condition	**Special concerns/perceptions:**
Water source	Farmer perception on production of OV
High land	Farmer perception on demand for CV produce
Household asset	Farmer perception: agricultural chemicals effect on the environment
Financial source: own savings	
Off-farm income	Farmer perception: agricultural chemicals effect on health
Own freehold or free access to some land	
Information accessibility:	Household members aged ≤ 5 and students
Information sources: mass communication	Food security: at least do farming with other rice crops
Information sources: internal	

RESULTS AND DISCUSSION

The results of the estimated parameters of coefficients, marginal effects, odds ratios and *t* statistics are provided in Table 1. The chi-squared test from the estimation was highly significant, with a power of correct prediction of 71.9% for the whole model. The power of prediction for individual farming systems were 86.6, 67.5, 53.8 and 77.9% for CV, SUV, PFV and OV farms, respectively. The power of correct prediction of adoption in the PFV and SUV farming systems is quite low, and about 45% of PFV farms are predicted to be SUV and OV farms. About 20.4% of SUV farms are predicted to be PFV farms, and 10.2 % are predicted to be CV farms.

Sixteen factors of the 30 factors were found to significantly influence farmer adoption of cleanliness vegetable methods. The variables related to resource availability, management factors, innovation properties and special concern play an important role in farmers' adoption decisions. But the information accessibility variables were not significant.

Table 1. Significantly estimated parameters of farmer adoption of cleanliness level.

Variable	Coefficient	Std Error	Odds ratios	Marginal effects			
				CV rank =0	SUV rank =1	PFV rank =2	OV rank =3
Resource availability:							
Vegetable farm experience	-0.027	0.011b	0.973	0.0018	0.0048	-0.0047	-0.0019
Average age of family members working on vegetable farm	0.075	0.018a	1.078	-0.0052	-0.0135	0.0134	0.0053
Political role and position of farmer	0.40	0.31*	1.492	-0.0254	-0.0743	0.0686	0.0312
Proportion of females working on vegetable farm	2.40	0.77[a]	11.077	-0.1667	-0.4310	0.4276	0.1702
Vegetable area	-0.221	0.050[a]	0.801	0.0153	0.0397	-0.0394	-0.0157
Highland	2.41	0.48[a]	11.167	-0.1451	-0.3910	0.2901	0.2460
Household asset	-0.00050	0.00038*	0.999	0.0000	0.0001	-0.0001	0.000
Off-farm income	-0.58	0.27[b]	0.560	0.0409	0.1019	-0.1019	-0.0408
Own freehold or free access to some land	1.99	0.36[a]	7.352	-0.2056	-0.2278	0.3235	0.11
Management factors:							
Financial source: government project	-0.49	0.29[c]	0.612	0.0389	0.0807	-0.0888	-0.0308
Financial source: other projects	1.92	0.41[a]	6.841	-0.0871	-0.3418	0.1995	0.2294
Member of clean and safe group	3.91	0.38[a]	49.797	-0.5540	-0.1124	0.4768	0.1896
Training in alternative substances	0.76	0.28[a]	2.136	-0.0460	-0.1415	0.1246	0.0628
Innovation properties:							
Number of vegetables	0.142	0.036[a]	1.152	-0.0098	-0.0254	0.0252	0.010
Special concerns/perceptions:							
Farmer perception on production of OV	-0.40	0.25*	0.668	0.0284	0.0715	-0.0715	-0.0284
Food security: at least do farming with other rice crops	0.76	0.28[a]	2.150	-0.0498	-0.1390	0.1297	0.0592
Threshold parameters for index							
μ_1	2.66	0.18[a]					
μ_2	5.00	0.23[a]					
Log likelihood function	-292.2333	Restricted log likelihood					-521.6815
Degrees of freedom	30	Chi squared					458.8964
Prob [χ^2 > value]	.0000000	McFadden Pseudo R-squared					.4398243
Power of correct prediction	Total 71.9		CV 86.6		SUV 67.5	PFV 53.8	OV 77.9

Note: a, b, and c denote significant using a two-tailed *t* test at 1, 5, and 10% levels, respectively.

The odds ratios indicate that being a member of a farmers' group is the factor with the highest probability of influencing farmers' decisions to adopt a cleaner level of vegetable farming. Other important factors that have a high probability of influencing the adoption of a higher level of cleanliness were found to be farm location, proportion of females working on farms, land ownership (own and extended family freehold land), financial support from NGO projects, co-existing vegetable and rice production, and training in alternative substances. Other factors such as the farmer's age and the number of vegetables produced were found to have a slight probability of increasing adoption. On the other hands, vegetable farm area is more likely to influence farmers to practise a lower-level 'clean and safe' farming system (i.e. more likely to be CV), and farmers with longer vegetable farming experience tended not to adopt higher levels of 'clean and safe' methods.

The magnitudes of the marginal effects indicate the probability that farmer decision-making about practising the four farming systems is based on their ranks. At the mean value, the fact that farmers are members of 'clean and safe' groups shows that probabilities of practising CV and SUV farming systems are reduced by about 0.529 and 0.126, respectively, but increased about 0.471 and 0.184, respectively, for PFV and OV farming systems. The proportion of females working on the farm also highly affected the probability of adoption of a more 'clean and safe' farming system. A one percent increase in the proportion of females working on the farm is associated with decreased probabilities of farmers practising CV and SUV farming by 0.164 and 0.431, respectively, and increased for PFV and OV farming by 0.425 and 0.170, respectively. Farming vegetables in highland areas and having financial support from other projects such as those provided by NGOs also show quite large marginal effects on the probability of abandoning CV and SUV farming systems and turning to PFV and OV farming systems.

The index of thresholds parameters is significant and this may indicate the ordinal condition of OV, PFV, SUV and CV farming systems as assumed to represent their cleanliness from chemical contamination. This result is also related to answers from the survey that CV farmers were willing to convert their farming practice to SUV rather than PFV and OV, while SUV farmers tended to change their farms to OV systems.

Notably, CV and SUV systems would be adopted by those farmers who have high off-farm income and large vegetable areas. CV and SUV farmers who have long-term vegetable farm experience and receive support from governments seem to be influenced by these factors to remain operating CV and SUV farms. On the other hand, PFV farms would tend to be adopted by those farmers who are members of ‘clean and safe’ farmers’ groups, have a high proportion of females working on their farms, own freehold land, and farm vegetables in a highland area. Location in a highland area is also a significant factor for OV farms. Besides location, OV farms tend to be run by farmers who receive financial support from non-government projects, are members of ‘clean and safe’ farmers’ groups and are mainly female.

The results from this study have shown important findings that farmers’ groups or organisations may be used as the main target to transfer information and other types of support including financial and training support. Wollni et al. (2010) found that participation in farmer-based groups in Honduras encourages farmers to adopt related organic practices, filling an important gap in providing farmers with input information and technical assistance. Farmers’ organisations and networks were also found to play an important role in agri-food chains (Vellema and Danse, 2007). Results from the current study also suggest that assistance provided on ‘clean and safe’ practices through farmer-based groups has a positive effect on adoption. Developing the capacity of farmer groups could be increased to support the development of ‘clean and safe’ technologies. Moreover, the knowledge that, should the newly adopted vegetable production venture fail, the farmers still had their rice crop for their own consumption, played a significant role in their decision about whether or not to adopt ‘clean and safe’ farming practices.

CONCLUSION

In this paper, the four vegetable farming systems were considered as ordered categories in terms of a ‘clean’ continuum. The OV farming system was ranked as the ‘cleanest’, followed in descending order of ‘cleanliness’ by PFV, SUV and CV. The ordered logit model had shown a potential for ordering between the farming systems that is implied by the ‘clean’ continuum. The power of prediction of ordered logit is high with threshold parameters significantly indicated ordinal choices condition.

Factors that were found to influence farmers to practise higher levels of cleanliness were membership of farmers’ groups, proportion of female members working on the farm, location, NGO financial sources, and ownership of freehold land. Farmers tend to remain practising CV farms when they have high off-farm income and vegetable farms in highland areas. SUV farmers who remain practising SUV farming have quite similar characteristics to those farmers practising CV farms. Conversely, PFV farmers were mostly members of ‘clean and safe’ farmers’ groups. Financial support from non-government projects and location in a highland area were important characters for OV farms.

The implication that can be made from the overall results is that farmers’ groups or organisations may be used as the main target to transfer information and other types of support including financial and training support. Developing the capacity of farmer groups could also be increased to support the development of ‘clean and safe’ technologies.

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