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Investigation of rubber-based intercropping system in Southern Thailand

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ABSTRACT

The objectives were: to investigate the differences in the socio-economic characteristics of rubber farmers who operate either a rubber mono-cropping system (RMCS) or a rubber-based intercropping system (RBIS), to identify RMCS farmer's attitudes toward RBIS, to determine the decision-making factors influencing the adoption of RBIS, and to examine the different types of intercrop available. The study areas were in Kaopra sub-district, Songkhla province and Tamod sub-district, Phattalung province, Thailand, since in these areas there is already some practice of RBIS. The findings revealed that the size of the rubber tapping area is a significant factor in the adoption of either RMCS or RBIS. The significant factors positively influencing RMCS farmers toward adopting RBIS were: members in the household, level of RBIS knowledge, attendance at an RBIS workshop, and rubber growing experience. The study's findings suggest that rubber intercropping tutorials are a driving force behind the adoption of RBIS. Whilst, it would seem to be a good idea to promote the expansion of the RBIS area in the future, this will be quite difficult to achieve in practice if left to happen naturally and there should be positive measures adopted to promote this expansion.

Introduction

Rubber is a perennial plant grown traditionally as an important cash crop which generates income as well as having a fundamental influence on the way of life for many rural people in Thailand, particularly in the south of the country. Furthermore, Thailand has been the world's largest rubber producer and exporter since 1991. The price of rubber has generally increased due to world demand and the expansion of the world economy. Additionally, China, which is Thailand's most important rubber trading partner, is demanding more natural rubber mainly for use in the manufacture of tires. This has made rubber production more attractive and has led farmers to plant more rubber as confirmed by the Office of Agricultural Economics. Between 2006 and 2013, the average area of agricultural land devoted to rubber plantations increased from 14.37 million rai to 22.18 million rai.

Based on movements in the rubber price at The Hat Yai Central Rubber Market, the average price of Rib Smoked Sheet-3 (RSS3) was THB 30/kg in 2002. Over the next decade there was a gradually increasing trend as shown in Figure 1, culminating in the highest average price for RSS3 of THB 146/kg. recorded in February 2011. The percentage growth in the RSS3 price between 2002 and 2011 was approximately 15 percent per year (Charernjiratragul, Satsue, & Romyen, 2015). Since then, however, the price of RSS3 has fallen sharply to approximately one third of its highest value, standing at THB 54.20/kg in October 2014

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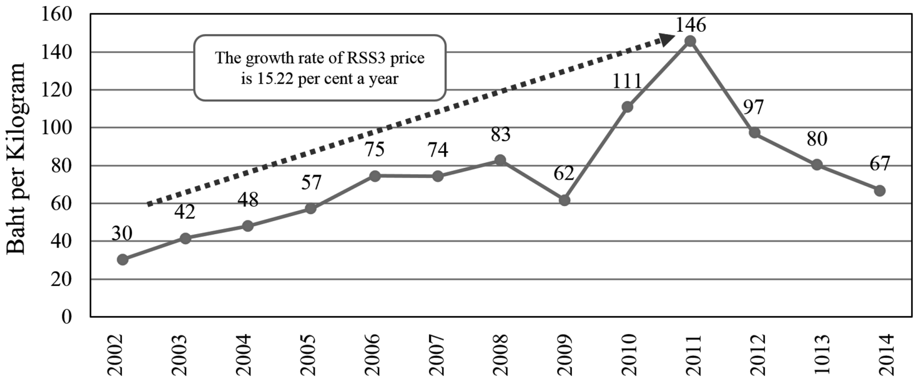

Figure 1 Average price of RSS3 at The Hat Yai Central Rubber Market between 2002 and 2014 (Rubber Research Institution of Thailand, 2014).
Note: The percentage growth rate has been calculated using the exponential curve, $Y = ab^T$.
Source: Charernjiratragul et al. (2015)

(Rubber Research Institution of Thailand, 2014). The reason for this fall is that the supply of natural rubber has outpaced demand by industry sources. Moreover, this rubber surplus could increase further as some tire-producing countries, such as China, the USA, Japan, and countries in Europe reduce their domestic tire production.

In fact, the determination of rubber prices depends substantially on the world spot and future markets such as the Tokyo Commodity Exchange (TOCOM), the Singapore Commodity Exchange (SICOM), and the Future Exchange of Thailand (AFET). Additionally, many countries including Vietnam, Lao People's Democratic Republic, Myanmar, Cambodia, and Pakistan also trade in the global rubber market. The Thai government is therefore unable to either control or influence rubber prices and Thailand has little bargaining power in the face of movements in rubber prices even though it is the largest rubber producer in the world.

In common with other commodity prices, rubber prices within domestic markets in Thailand tend to fluctuate over time since these prices result partly from cyclical movements in the world market influenced by both demand and supply. The emergence of unstable prices for rubber inevitably affects rubber planters since rubber prices are the major determinant of household incomes and livelihoods, particularly for smallholders producing predominantly rubber. Most rubber planters in Thailand have traditionally practiced a rubber mono-cropping system (RMCS) so they are prone to suffer because of fluctuations in the rubber price and uncertainty about the level of their earnings. In order to reduce the risks associated with price fluctuations and to improve efficiency at the farm level, operating a rubber-based intercropping system (RBIS) seems to offer an alternative method of practicing agriculture which could diversify crop production and enable farmers to earn extra income (Rodrigo, 1997, 2001; Tournebize & Sinoquet, 1995). Therefore, the objectives of this paper were: (1) to investigate the differences in socio-economic characteristics between rubber farmers who operate either RMCS or RBIS; (2) to identify the attitude of mono-cropping rubber farmers toward RBIS; (3) to determine the decision-making factors that influence the use of RMCS; and (4) to examine the variety of crops which mono-cropping rubber farmers are interested in growing using RBIS.

Literature Review

RBIS Situation

Since the industrial revolution in the 1950s, natural rubber has been one of the raw materials needed in industry. The demand for natural rubber in industrialized countries generated a rubber boom and the high price of rubber enticed farmers to cultivate latex-producing trees (Joshi et al., 2002). Large areas of primary forests have been converted into rubber plantation using a mono-cropping system practiced by smallholder farmers, particularly in Southeast Asia. Deforestation has rapidly taken place over the past decades in many part of Indonesia such as Jambi province, Sumatra, Indonesia (Ekadinata, Widayati, & Vincent, 2004; Feintrenie & Levang, 2009). Similarly, the Chinese central government sees natural rubber as an essential product and critically important to national security (Yi, Canono, Chen, & Swetnam, 2014). Consequently, 20 years ago in Xishuangbanna, Southwest China, primary forests have been replaced at a remarkable rate by monoculture rubber plantations (Li & Yuan, 2008; Qiu, 2009; Ziegler, Fox, & Jianchu, 2009). In Thailand, most rubber farmers use RMCS, whereas practicing RBIS is rare, with the latter estimated at around 2 percent of all rubber farmers in both Songkhla and Phattalung provinces (Charernjiratragul et al., 2015). Somboonsuke, Wetayaprasit, Chernchom, and Pacheerat (2011) reported that a rubber agroforestry system is an alternative form of agriculture to complement biological integrity, crop diversity, and financial stability. RBIS can be divided into three main systems: (1) intercropping rubber-food crop system, (2) rubber-fruit crop system, and (3) rubber-timber species system. The conversion of natural forests to rubber monoculture plantations brings many unfavorable circumstances such as a loss of extra revenues generated from other mixed plants and species and a loss of ecological integrity.

Economic Advantages of RBIS

RBIS has tremendous beneficial aspects. A survey by Joshi et al. (2002) found that smallholder rubber farmers generated approximately 70 percent of the total household income from RBIS. This additional income was created from a range of added crop mixtures to rubber, such as fruit trees, timber trees, and medicinal plants. Penot and Sunario (1997) compared the economic performance between rubber agroforestry systems (RAS) and a monoculture rubber system (MRS) in West Kalimantan, Indonesia. The results showed that the RAS returns were higher than for MRS because adoption of RAS provided additional economic and environmental advantages. Consistent with this report, Chambon (2001) found that rubber agroforests performed considerably better than an appropriate rubber farming approach. Rubber farmers often perceive these rubber agroforests as their 'rubber bank' in which secondary products can be gained such as fruit, timber, building, and handicraft materials. Wulan, Budidarsono, and Joshi (2008) summarized the economic performance of RAS in Sanggau district, Kalimantan, Indonesia and indicated that all the RAS implementations had positive indicators, resulting in RAS 1 Low Maintenance having an NPV of IDR 10,087,000/ha and an IRR of 21 percent; and RAS 2 Associated Trees having an NPV of IDR 18,316,000/ha, and an IRR of 26.32 percent. In contrast, the MRS delivered a lower NPV of IDR 8,045,000/ha, and an IRR of 17.84 percent.

Environmental Advantages of RBIS

From a global climate change perspective, forest is evidently one of the most important sources for the capture and secure storage of carbon dioxide or carbon sequestration, through absorption by root systems and tree trunks. Current, Scheer, Harting, Zamoran, and Ulland (2010) offered guidance on carbon sequestration credits for local landowners who are able to reduce carbon dioxide emissions. To earn extra revenue from these carbon credits, the landowner can determine whether or not to enroll their land in carbon sequestration. These transactions can be handled via the Chicago Climate Exchange (CCX), where there is a tradable market in carbon credits. Chiarawipa, Patkhaw, Keawdoung, and Prommee (2012) computed the carbon offset in rubber plantation in Songkhla province, Thailand over a 25-year period based on a biomass allometric equation and soil organic carbon, using an approximate polynomial model involving rubber age and carbon stock. They found total carbon storage from 50.68 to 193.72 M^3ha. The potential net revenue of the contract was USD 573.39/ha. Furthermore, Charenjiratragul et al. (2015) estimated the total additional income from RBIS in Songkhla and Patthalung provinces, Thailand at USD 775.10/ha.

RBIS can produce and make available for harvest not only additional products for consumption by the household or by sale in markets, but also it can contribute environmental advantages. Jungle rubber as the initial form of RBIS supply essentially functions as a form of biodiversity conservation, soil conservation, watershed protection, and carbon sequestration. The economic and environmental advantages of RBIS adoption may be much higher than from RMCS. RBIS is supposed to be an alternative approach for rubber smallholder agriculture so it can become sustainable. Therefore, investigation of the RBIS predicament and of the driving factors behind RBIS adoption are necessary to enhance the expansion of RBIS for rubber farmers.

Methods

The study areas purposefully selected were the Kaopra sub-district, Songkhla province and the Tamod sub-district, Phattalung province because both these areas are in Southern Thailand, where rubber farmers already practice according to the RBIS criteria.

Data Collection

1) To investigate differences in socio-economic characteristics, the key informants (21 RBIS farmers and 31 RMCS farmers) were personally interviewed using structured questionnaires in which questions investigated the socio-economic aspects of rubber farmers, practical approaches to rubber plantation, rubber plantation system details as well as the costs and revenues associated with rubber plantations. An independent sample t-test was used to test for significant differences in the sample variables, made up of: age, number of members in a household, the labor force in a family, household income, household expenditure, household debt, area of agricultural land, area of land devoted to rubber, area devoted to orchards, experience in growing rubber, and finally the area of land on which rubber tapping takes place.

2) To determine the opinions of the mono-cropping rubber farmers regarding RBIS, 400 RMCS farmers as recommended by a pilot study were individually interviewed. Based on accidental sampling, those samples were normally distributed across the two study areas. Then, their opinions were gathered using a Likert scale measuring technique (a rating scale varying from: 1 to 5, covering the range from low to high importance attributed by the respondents to each factor included in the survey).

3) To explore the decision-making factors influencing the use of RBIS, binary logistic regression was employed, with the dependent parameters in this study being defined as dichotomous variables:

$$Y_i \begin{cases} 1 & \text{if RMCS planters decide to operate RBIS in the next 5 years} \\ 0 & \text{otherwise} \end{cases}$$

The logistic regression analysis model used in this study is shown in Equation (1):

$$\text{Prob}(Y=1) = \frac{1}{1+e^{-\mu}} \quad (1)$$

where μ is the vector of the predictors, or a multiple logistic regression which can be substituted by. $\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k$

where $\beta_0$is an intercept parameter, $\beta_1 \ldots \beta_n$ are the coefficients of the predictors, X is the vector of explanatory variables, and e is the base for natural logarithms.

The probability of no event (Y = 0) can be estimated as shown in Equation (2):

$$\text{Prob}(Y=0) = 1 - \text{Prob}(Y=1) = \frac{1+e^{-\mu}}{1+e^{-\mu}} - \frac{1}{1+e^{-\mu}} = \frac{e^{-\mu}}{1+e^{-\mu}} \quad (2)$$

Within the logistic model, the odds refer to the ratio of the probability of occurrence to that of non-occurrence and indicate how likely something will occur or otherwise. The odds ratios can be interpreted as the effect of a one unit change in X to the predicted odds ratio with the other variables held constant (Halloran, 2013). Theoretically, the logistic model quantifies the effect of a predictor in terms of a log-odds ratio, which can be expressed by taking the logarithm function as per Equation (3) according to Hailpern and Visintainer (2003).

$$log\left[\frac{Prob(Y=1)}{1-Prob(Y=1)}\right] = exp\ e^{\mu} = \mu$$

$$\text{logit } Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k \quad (3)$$

The logistic regression analysis employs a maximum likelihood estimation (MLE), which runs an iterative procedure for finding the maximum likelihood to effectively obtain estimated models along with the number of parameters relative to the observations being potentially high (Hautsch, Okhrin, & Alexander, 2014). In this study, the decision to convert from RMCS to RBIS within the next 5 years was defined as a binary choice. Table 1 illustrates the explanatory variables which were the decision-making factors consisting of the eight factors previously mentioned.

The multiple logistic regression can be written as:

$$\text{logit } Y = \beta_0 + \beta_1(\text{RUB\_MEM}) + \beta_2(\text{SECOC}) + \beta_3(\text{RUBLAND}) + \beta_4(\text{INTERC}) + \beta_5(\text{RUB\_EXP}) + \beta_6(\text{RRAF}) + \beta_7(\text{KNOWLEG}) + \beta_8(\text{ATTEND})$$

4) To investigate the variety of inter-crops grown on rubber land, the crops were divided into three categories: (1) perennial plants, (2) fruit trees, and (3) home-grown vegetables. A multinomial logistic regression was then used to predict the probability of a categorically distributed dependent variable, given a set of the same independent variables as illustrated in Table 1.

$$Y_i \begin{cases} 1.\ \text{Perennial plants} \\ 2.\ \text{Fruit trees} \\ 3.\ \text{Home} - \text{grown vegetables} \end{cases}$$

The multinomial logistic regression can be stated as:

$$\log\left[\frac{P(\text{group i})}{P(\text{group k})}\right] = \beta_0 + \beta_1(\text{RUB\_MEM}) + \beta_2(\text{SECOC}) + \beta_3(\text{RUBLAND}) + \beta_4(\text{INTEC}) + \beta_5(\text{RUB\_LAND}) + \beta_6(\text{RRAF}) + \beta_7(\text{KNOWLEG}) + \beta_8(\text{ATTEND})$$

Results

Difference in Socio-economic Characteristics Between RBIS and RMCS Planters

The mean values of the socio-economic aspects were investigated using an independent sample t-test to establish if there were significant differences between the characteristics of the RBIS and RMCS farmers. The results (Table 2) showed that only the average land holdings devoted to rubber tapping by RBIS and RMCS farmers (6.05 and 9.10 rai per family, respectively) were significantly different ($p = .040$), which implies that the RMCS farmers owned more agricultural land than the RBIS farmers.

Therefore, the RBIS farmers needed alternative sources of income based on intercropping, thereby gaining more

Table 1
Definition of variables

Variable	Label
logit Y	Dependent variable (takes the value 1 if the respondent intends to operate RBIS in next 5 years, 0 if the respondent decides against intercropping)
RUB_MEM	Household members (number of people)
SECOC	Extra occupation (dummy variable where 1 refers to having an alternative occupation and 0 is no alternative occupation)
RUBLAND	Rubber land area (rai)
INTERC	Practice intercropping (dummy variable where 1 refers to conducting intercropping and 0 is not conducting intercropping)
RUB_EXP	Years' experience of growing rubber
RRAF	Member of Rubber Replanting Aid Fund (RRAF) (Dummy variable where 1 refers to being a member of RRAF and 0 is not being a member.
KNOWLEG	Rubber intercropping knowledge (scale variable: 1–5, from low to high knowledge)
ATTEND	Attendance at a rubber intercropping tutorial (Dummy variable where 1 refers to having attended a tutorial and 0 is not having attended one.)

Table 2
Difference in socio-economic characteristics of RBIS and RMCS farmers

Socio-economic characteristic	Mean		t	p
	RBIS (N = 21)	RMCS (N = 31)		
Age (years)	50.26	52.35	−0.560	(.578)NS
Members of household (people)	4.57	4.10	1.042	(.104)NS
Labor force of family (people)	3.52	2.94	1.349	(.184)NS
Household income (THB per month)	24,214.00	25,487.00	−0.417	(.679)NS
Household expenditure (THB per month)	16,595.00	17,414.00	−0.327	(.745)NS
Household debt (THB per family)	164,761.00	143,226.00	0.345	(.732)NS
Agricultural land (rai per family)	20.19	21.34	−0.295	(.769)NS
Rubber land (rai per family)	15.90	18.71	−0.835	(.407)NS
Orchard (rai per family)	3.05	1.81	1.159	(.252)NS
Experience in rubber farming (years)	22.52	21.90	0.182	(.856)NS
Rubber tapping area (rai per family)	6.05	9.10	−2.105	(.040)**

Note: ** significance at the $p < .05$ level, NS is non-significant

yield and a higher return per area. Penot and Sunario (1997) considered the introduction of the rubber agroforestry system (RAS) as a means of improving rubber productivity. The RAS provides a higher return per area than the traditional system of cultivating rubber. Generally, the RBIS approach seems to be more appropriate for smallholders, even though the number of farmers who actually use RBIS is small and in Kaopra sub-district, Songkhla province and in Tamod sub-district, Phattalung province, there are only 21 farmers employing RBIS.

Investigation of Attitudes of RMCS Farmers Toward RBIS

In order to examine the attitudes of RMCS farmers regarding the adoption of the RBIS approach in the next 5 years, three key factors related to economic, social, and environmental advantages, were studied. It was clear that most of the 400 participants have positive perceptions of RBIS, with mean scores ranging from 3.56 to 4.35 (out of a possible 5) across all items. Table 3 shows that the participants appreciated that practicing RBIS can bring many advantages because rubber is not the only crop harvested—other trees, yielding timber or fruit can be grown as inter-crops well as other annual crops. Consequently, farmers adopting RBIS will acquire a positive economic and social advantage, such as wood to be used by their household (3.69 scale average), more efficient use of agricultural land (3.75), more alternative income sources (3.68) and the extension of collaboration with other local rubber civic groups (3.63). Wulan et al. (2008) compared farm budgets under RMCS and RBIS, and their findings revealed that a diversified RBIS approach clearly provides better economic and environmental performance. In addition, rubber farmers often view rubber agroforestry as their "rubber bank" (Chambon, 2001; Feintrenie & Levang, 2009).

Table 3
Attitudes of RMCS farmers toward the RBIS approach

Item	Mean
Economic advantages: practicing the RBIS approach can gain	
- wood for use in the household	3.69
- more efficient use of agricultural land	3.75
- more alternative income sources	3.68
Social advantages: practicing the RBIS approach can gain	
- extension of collaboration with other local rubber civic groups	3.63
- consultation and exchange of experience about the RBIS approach	3.66
Environmental advantages: practicing the RBIS approach can achieve	
- improvement of soil fertility by mulching with a large variety of leaves	3.70
- reduction of soil erosion	3.91
- reduction of phenomena associated with global warming	4.35

Note: a scale average of 3.50–4.50 is defined as a positive attitude

Moreover, the rubber farmers were interested in the environmental advantages which can be achieved using RBIS, such as reduction of soil erosion (3.91 scale average), more effective groundwater absorption by maximizing the tree root system (3.85), and particularly reducing phenomena associated with global warming (4.35). Nowadays, these farmers are more aware of global climate change because they have personally experienced phenomena associated with global warming. Practicing rubber cultivation can reduce global warming since rubber plantations have been determined as a potential source of CO_2 absorption. In other countries, the role of trees in reducing atmospheric carbon has been recognized. For example, in the USA, Current et al. (2010) noted in a guide to carbon sequestration credits published in Minnesota that local landowners are able to reduce global climate change as well as gain additional income through a carbon sequestration project. Chiarawipa et al. (2012) computed the carbon stock rate of rubber plantations and estimated the net income based on carbon credits accrued to landowners in Thailand. Similarly, Charernjiratragul et al. (2015) estimated that based on a sequestration rate of carbon stock during a 28-year period at a rate of 5.48 t/ha and a net income of USD 775.10/ha, rubber trees provided USD 655.87/ha while in other timber trees it was USD 119.25/ha.

Decision-Making Factors Influencing the Adoption of the RBIS Approach

From the 400 RMCS farmers interviewed, 345 (86.25%) intended to convert to RBIS instead of RMCS within the next 5 years. Table 4 shows the estimated results of the logit model including parameter estimates.

Table 4
Decision-making factors influencing the adoption of the RBIS approach within the next 5 years

Explanatory variable	Coef.	Robust S.E.	z	p	Marginal effect
RUB_MEM	0.221	0.136	2.02	.043**	0.041
SECOC	0.266	0.312	1.12	.265 NS	0.049
RUBLAND	0.006	0.011	0.59	.554 NS	0.002
INTERC	0.024	0.028	−0.83	.407 NS	0.004
RUB_EXP	0.018	0.010	−1.79	.074*	0.004
RRAF	0.229	0.341	0.85	.397 NS	0.042
KNOWLEG	0.332	0.202	2.29	.022**	0.061
ATTEND	0.619	0.558	2.07	.039**	0.114
Constant	0.464	0.352	−0.83	.407 NS	

Note: * significant at the .10 level, ** significant at the .05 level, NS not significant

Table 5
Crop types selected by intended adopters of RBIS

Type of crop	n = 345	Percentage
Perennial plants	199	57.7
Fruit trees	106	30.7
Homegrown vegetables	40	11.6

These resulting equation based on a 90 percent confidence interval is shown below with the terms defined and discussed in the subsequent text.

$$\text{LOGIT}\quad Y = 0.221(\text{RUB\_MEM}) + 0.018(\text{RUB\_EXP}) + 0.332(\text{KNOWLEG}) + 0.619(\text{ATTEND})$$

The rubber experience variable (RUB_EXP) correlates with an increasing tendency to adopt the RBIS approach (ME = 0.004) since experienced RMCS farmers have accumulated a lot of knowledge regarding agriculture. This longer experience might cause them to adopt RBIS. In addition, they have inevitably suffered fluctuations in the rubber price over the decades, and therefore they understand well the market mechanisms of the global rubber market. Operating an RBIS approach might improve their household wealth.

The rubber intercropping knowledge variable (KNOWLEG) is also a factor which increases the likelihood of the adoption of the RBIS approach (ME = 0.061). RMCS farmers are able to obtain training in rubber intercropping which is organized by local civic groups, the Rubber Replanting Aid Fund, or other government agencies. Generally, rubber farmers (based on their perception or habit) have tended to view RBIS as an obstacle to the management of their rubber plantations. However, acquiring more knowledge about rubber intercropping can alter such attitudes. In fact, RBIS is not a new agricultural concept in the Kaopra sub-district, of Songkhla province or in the Tamod sub-district of Phattalung province; nevertheless, this concept has not hitherto been a common practice.

Similarly, variable for attendance at a rubber intercropping tutorial (ATTEND) is positively correlated with the intention to adopt RBIS and shows the largest magnitude effect (ME = 0.114). It is evident that attendance at a rubber intercropping tutorial directly provides new information and promotes this ides to those who attend.

Categorization of Types of Crop for Rubber Intercropping

To calculate the probabilities of the adoption of crop different types for rubber intercropping, a multinomial logistic regression model was applied to predict preferences between different types of crops based on three crop comparisons: (1) perennial plants versus homegrown vegetables, (2) fruit trees versus homegrown vegetables, and (3) perennial plants versus fruit trees. Table 5 shows the number of farmers preferring each crop together with their respective percentages. In summary, the cultivation of perennial plants such as Iron Wood, Eagle Wood, and Champak was the most popular model (57.7%), followed by fruit trees and homegrown vegetables at 30.7 percent and 11.6 percent, respectively.

Multinomial logistic regression uses maximum likelihood estimation to compute the probabilities of adoption of the crop different types. The explanatory variables Rub_MEM, SECOC, RUBLAND, INTERC, RUB_EXP, RRAF, KNOWLEG and ATTEND were analyzed. Table 6 shows the relevant decision-making factors influencing the adoption of RBIS as detailed below.

Table 6
Factors affecting the decision to choose crop type for rubber intercropping

Explanatory variable	Model[1]: perennial plants *vs.* homegrown vegetables			Model[2]: fruit trees *vs.* homegrown vegetables			Model[3]: perennial plants *vs.*fruit trees		
	Coef.	Sig	Exp(B)	Coef.	Sig	Exp(B)	Coef.	Sig	Exp(B)
Rub_MEM	0.170	.381	1.185	0.865	.409	1.181	0.003	.978	1.003
SECOC	−0.336	.368	0.715	0.167	.649	0.836	−0.157	.541	0.855
RUBLAND	0.015	.425	1.015	−0.179	.309	1.020	−0.005	.671	0.995
INTERC	−0.010	.810	0.990	0.020	.892	1.006	−0.016	.590	0.984
RUB_EXP	0.015	.401	1.015	−0.002	.928	0.998	0.017	.166	1.017
RRAF	1.050	.005***	2.858	0.631	.109	1.879	0.420	.143	1.521
KNOWLEG	0.180	.392	1.197	−0.278	.221	0.757	0.458	.002***	1.581
ATTEND	0.238	.565	1.269	−0.280	.538	0.755	0.519	.082*	1.680
Constant	−0.355	.666		0.865	.309		0.034	.034**	

Note: Model[1, 2]: homegrown vegetables is the reference category and in Model[3] fruit trees is the reference category. * significant at the .10 level, ** significant at the .05 level, *** significant at the .01 level, NS not significant

Model 1: perennial plants versus homegrown vegetables

Being a member of the RRAF was significant in choosing perennial plants as against homegrown vegetables (exp = 2.858). In 2013, the RRAF promoted corporate social responsibility (CSR) for the expansion of green areas in rubber plantations projects with a budget of THB 1.5 million over the six southern provinces of Thailand. Many perennial plants such as Iron Wood, Mahogany, *Shorea roxburghii*, and *Tectona grandis* were distributed. Consequently, rubber farmers who are members of the RRAF, tend to grow perennial plants rather than homegrown vegetables. Those farmers who grow perennial plants are also likely to earn higher incomes from the variety of plants which they grow.

Model 2: fruit trees versus. homegrown vegetables

Interestingly, there were no significant differences between fruit trees and homegrown vegetables because the cultivation of either type of crop is often subject to market failure. The problems associated with the production and marketing of these types of crops are therefore similar.

Model 3: perennial plants 2 versus fruit trees

The rubber intercropping knowledge variable (KNOWLEG) and attendance at a rubber intercropping tutorial variable (ATTEND) appear to be important factors in the adoption of the RBIS approach and in this comparison, the exp (B) values of these two variables were 1.581 and 1.680, respectively, indicating that rubber farmers with more knowledge and those who have attended an RBIS tutorial are more likely to select perennial plants for the reasons mentioned above under Model 1.

Conclusion and Recommendation

From the results of the independent sample t-test conducted to test the effect of socio-economic factors on the adoption of RBIS and RMCS practiced on farmers in the study areas (Tamot and Khaoprasub districts), it can be seen that only the size of the rubber tapping area produced any significant difference ($p = .040$), with the average area per household under RBIS being 6.05 rai and under RMCS being 9.10 rai. The RMCS farmers can earn higher income from their larger farm area than the RBIS farmers, therefore they are less attracted to plant multiple crops, whereas, RBIS farmers are under greater pressure to increase their income.

However, it can be seen from the results of the attitude survey that the RMCS farmers participating in this study are positively inclined towards RBIS as a means of diversifying their agricultural production and enhancing their wealth. Monitoring the attitude of rubber farmers is one of the most important steps toward achieving wider use of RBIS and the results of the attitude survey indicate that most farmers currently operating under RMCS are interested in adopting the RBIS approach. The results revealed that they have positive attitudes with regard to all 11 issues covering the economic, social, and environmental dimensions with an average level ranking between 3.56 and 4.35 out of a possible score of 5.

The responses from the farmers show a particular concern to mitigate the effects of climate change by planting trees or expanding green areas through intercropping their rubber plantations.

Based on the logit model, the key decision-making factors affecting the adoption of the RBIS approach in the next 5 years are the number of household members (RUB_MEM), their rubber growing experience (RUB_EXP), their knowledge of rubber intercropping (KNOWLEG), and their attendance at a rubber intercropping tutorial (ATTEND) with the involvement of a local civic group in these latter two variables being notable, though other government agencies are important factors in encouraging rubber farmers to adopt the RBIS approach.

Based on the results of the multinomial logistic regression, there is considerable variety in the types of perennial plants considered suitable for intercropping, including Iron Wood, Eagle Wood, and Champak. Consistently, the RRAF promoted CSR projects that expanded green areas in rubber plantations by growing these perennial plants. Certain kinds of fruit trees, (Durian, Champedak, Santol) and Lantern trees are possible cash crops for rubber-based intercropping. However, one important lesson learned from the RBIS practice was that fast-growing trees, such as Mega neem and Mahogany are not practically suitable. Fruit trees such as Pummelo, Longkong, and Mangosteen (in dry areas), Mango, Rambutan, and Longan are also unsuitable because these have negative impacts on the production of rubber (Charernjiratragul et al., 2015). A combination of rubber intercropping knowledge (KNOWLEG) and attendance at rubber intercropping training sessions (ATTEND) will ensure that farmers obtain the maximum benefit from planting perennial trees as intercrops in their rubber.

The findings of this study suggest that rubber farmers have a positive attitude toward RBIS and this should be promoted as a means of expanding green areas in rubber plantations in the future. However, a change toward the widespread adoption of RBIS is unlikely to happen naturally and will be quite difficult to achieve unless positive measures are taken. In fact, RMCS farmers are still a majority in Thailand nowadays because of two main reasons. First, as a result of governmental policies initially aimed at raising the export levels of rubber products over the past decades, the government and particularly the Office of the Rubber Replanting Aid Fund (RRAF), strictly imposed an intensive rubber mono-cropping system. In addition, the rubber farmers themselves lack the motivation, enthusiasm, and driving force to implement RBIS, with some of them seeming to have incorrect knowledge regarding RBIS such as the increased competition between plants for fertilizer or the many plant diseases caused by fungi as a result of the increased relative humidity resulting from practicing RBIS. Nevertheless, to promote RBIS, existing government measures in which the RRAF has allowed farmers to plant a maximum of 15 intercrop tree species per rai have been launched since 2008. Therefore, in order to promote the expansion of the RBIS area, decisive action needs to be taken and measures adopted to drive this change.

Conflict of Interest

There is no conflict of interest.

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