Determinants of Adoption of Crop Diversification by Smallholder Rubber Producers in Southern Thailand: Implications on Natural Resource Conservation

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ABSTRACT

There is little empirical evidence regarding the local and internal drivers of diversification in rubber farming systems and crop diversification affecting the decisions of households in undertaking resource conservation measures. This study aimed to analyze the determinants of crop diversification and their effect on natural resource conservation. Primary data were collected from 200 farm households using a structured questionnaire. Descriptive statistics, logistic regression, and multiple regression were used to analyze the data. The results indicated that 70 percent of the sampled farmers have diversified their farming systems. Logistic regression analysis indicated a significant influence of several factors on the adoption of crop diversification by farmers: lack of water, attendance at agricultural training, rubber price fluctuations, savings, and schooling period. Multiple regression analysis, performed to explore the impact of crop diversification on natural resource conservation at the farm household level, revealed that diversified farming systems have a positive influence on natural resource conservation practices along with the other significant influencing factors of: attendance at agricultural training, schooling period, lack of water, and poor soil fertility. This study has practical implications for the present and future of crop diversification and natural resource conservation promotion in rubber farming systems.

Keywords: rubber diversification, rubber farming system, influencing factors

บทคัดย่อ

เนื่องจากการศึกษาปัจจัยที่มีอิทธิพลต่อความหลากหลายของพืช และอิทธิพลของความหลากหลายของพืชนั้นต่อการอนุรักษ์ทรัพยากรธรรมชาติในระบบการทำสวนยางพารายังมีน้อย การศึกษานี้จึงมีวัตถุประสงค์เพื่อวิเคราะห์ปัจจัยที่กำหนดความหลากหลายของพืช และผลจากความหลากหลายของพืชต่อการอนุรักษ์ทรัพยากรธรรมชาติ โดยการใช้ข้อมูลปฐมภูมิที่ได้จากการเก็บข้อมูลเกษตรกลุ่มตัวอย่าง 200 ตัวอย่างโดยใช้แบบสอบถามเชิงโครงสร้าง และวิเคราะห์ข้อมูลโดยใช้สถิติเชิงพรรณนา การวิเคราะห์การถดถอยโลจิสติก และการวิเคราะห์การถดถอยพหุเชิงเส้นตรง ผลการศึกษาพบว่าร้อยละ 70 ของเกษตรกรกลุ่มตัวอย่างมีการปลูกพืชมากกว่า 1 ชนิดในระบบการทำสวนยางพารา โดยผลการวิเคราะห์การถดถอย โลจิสติกระบุถึงปัจจัยที่ส่งผลต่อความหลากหลายของพืชในระบบการทำสวน

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ยางพารา คือ ปัญหาความไม่เพียงพอของน้ำในการผลิตทางการเกษตร การเข้าร่วมฝึกอบรมทางการเกษตร ความผันผวนของราคายางพารา เงินออม และระดับการศึกษา ในขณะที่การวิเคราะห์การถดถอยพหุเชิงเส้นตรงเพื่อทดสอบอิทธิพลของความหลากหลายของพืชต่อการอนุรักษ์ทรัพยากรธรรมชาติ พบว่า ระบบการทำสวนยางพาราที่มีความหลากหลายมีความอิทธิพลส่งเสริมการอนุรักษ์ทรัพยากรธรรมชาติ นอกจากนี้ยังมีปัจจัยอื่นที่สนับสนุนให้มีการอนุรักษ์ทรัพยากรธรรมชาติในระบบการทำสวนยางพารา คือ การเข้าร่วมฝึกอบรมทางการเกษตร ระดับการศึกษา การขาดแคลนน้ำในการผลิตทางการเกษตร ดินที่ไม่มีความอุดมสมบูรณ์ ซึ่งผลที่ได้จากการศึกษาสามารถนำไปใช้กำหนดแนวทางในการส่งเสริมความหลากหลายของพืช และการอนุรักษ์ทรัพยากรธรรมชาติในระบบการทำสวนยางพาราต่อไป

คำสำคัญ: ความหลากหลายของสวนยาง ระบบการทำสวนยางพารา ปัจจัยที่มีอิทธิพล

INTRODUCTION

Diversification in agriculture by shifting from specialized cropping and monoculture to various crop and animal production is a very common process in the humid tropics (Ruthenberg, 1971; Harwood, 1979). Diversification is recognized for its role to spur sustainable growth in the rural sector, and the extent of its sustainability effects and the gains in the more complete utilization of resources in a diversified form is more visible than in a monocrop production system (Barghouti, Kane, Sorby, & Ali, 2004). Increased diversity of crop or animal species is a strategy frequently associated with sustainability (Hansen, 1996; Ellis, 2000). Diversification helps to minimize the technical and economic risks associated with monoculture (Kasem & Thapa, 2011). On-farm diversification also thrives upon strategic complementarities among activities, such as integration among different crops, crop-livestock integration, and the like (Barrett, Reardon, & Webb, 2001). Farming systems in Southeast Asian countries are undergoing significant transformations in response to challenges and opportunities arising out of globalization and the consequent economic integration (Sunderlin, 1997; Sikor, 2004). Especially, there is a transition from subsistence production based on shifting cultivation to commercial production. Cramb (2007) elaborated that with the growth in population and with the improvement of rural infrastructure, shifting cultivators in Southeast Asia have substantially incorporated tree crops such as rubber, coffee, and cocoa in their farming systems, and thus, have been moving beyond subsistence production with at least partial engagement in global commodity markets.

Thailand is no exception to these trends in diversification and integration. The country's rubber sector is currently the world's largest producer and exporter of natural rubber, and intends to sustain this leading position, while providing sufficient livelihood to small-scale production systems (less than 4 ha on average), as the dominant form of rubber production in Thailand (Longpichai, 2011). Over the last two decades, many researchers have tried to capture the increased diversity of rubber-based farming systems through classification schemes based on cropping systems. Klongsripun (1994) classified rubber farming systems according to the very principle of integrated systems. Along the same line, Thungwa (1998) classified three types of smallholding rubber-based farming systems on the number of cash crops associated with rubber. This was consistent with Kjonchaikun (1995) who classified according to the types of crops that are useful in supplementing the income of smallholding farms as rubber intercropping systems. Nair (1985) referred to rubber agroforestry farming systems to develop his classification of rubber farming systems in Thailand. Somboonsuke, Shivakoti, and Demaine (2001) hypothesized that the emergence of various rubber farming systems among smallholders in Thailand was in response to, and an adjustment strategy against the adverse effects of the 1997 economic crisis. They classified rubber farming systems according to socioeconomic activity and agro-ecozone. Despite such empirical evidence regarding diversification, the internal and local drivers behind such diversification remain largely unknown.

In addition, it has been also recognized that rubber monoculture has negative environmental implications, such as decreased soil quality and rapid soil erosion (Asian Development Bank [ADB], 1997). Damaging effects could also result from the unbalanced use of fertilizers, eventual exhaustion of the natural soil condition, and possible contamination of runoff water (Asian Development Bank, 1997). In Thailand specifically, some researchers have studied the impacts of rubber production on the environment. The main negative externalities from rubber production are associated with land degradation. The use of chemical fertilizers and pesticides has destroyed the bio-diversity of the eco-systems and the coexistence of flora and fauna leading to land degradation (Kaiyoorawong & Yangdee, 2006). Nusang (2006) found that there are also cases of land degradation in rubber plantations because farmers have grown a monoculture crop for a long time. Rural people, including rubber farmers, most often depend heavily upon natural resources for their livelihoods. The long term sustainable use of such resources depends on the local people's knowledge, management, and ability to maintain and utilize these resources, and this applies especially to the soil. Therefore, it is reasonable to know about farmers' practices of natural resource conservation. And yet, the possible effects of crop diversifications on the decisions of the farm households in undertaking resource conservation measures are not known.

Owing to such research gaps, this study first analyzes the factors influencing crop diversification. Then, an estimation is made regarding the implications of crop diversification patterns on resource use. Success in the establishment and documentation of such a relationship would pave the way for targeted and problem-driven policy and provide support towards development of the sector. For assessing the options for, and impacts of rural development policies, this study proposes to identify variables to determine crop diversification patterns and also to investigate how natural resource conservation is affected by crop diversification patterns. For the estimation of the factors affecting investment in natural resource conservation, variables representing farm characteristics are often included, such as location, slope, soil type, etc. (Overmars & Verburg, 2006). However, for the purpose of this study, variables representing physical characteristics of farms were not collected, as this study is interested in the implications of crop diversification portfolios upon the decisions made by households to invest in resource conservation measures. The study examines whether the cluster variables affect such implementation of resource conservation measures, while recognizing some shortcomings. The findings of this study are expected to make valuable contributions towards the formulation and effective implementation of policies regarding crop diversification and natural resource conservation and thus eventually would play an important role in the sustainability of rubber farming systems in Thailand and elsewhere.

LITERATURE REVIEW

Determinants of people's attitude towards the adoption of new technologies or practices, such as crop diversification, have been discussed through scholarly publications for a long time. The classical theory of diffusion of innovations takes into account the important roles played by societal norms and values, the characteristics of individuals, as well as the different traits of the concerned innovations, in people's adoption of any new technology or practice (Rogers, 1995). Many empirical studies have attempted to expand the dimensions of this theory by incorporating the role of the policy and environmental factors that may influence the decision-making process in the adoption of new and innovative technologies (Ervin & Ervin, 1982; Rasul & Thapa, 2004). Mainstream economists throughout time have emphasized the important role played by economic factors in the adoption of innovations by farmers. Apart from these economic factors, Ellis (2000) found the resources and assets available at the farmers' disposal also play very influential roles. Ellis went on to conclude that small farmers' decisions to adopt an innovation are guided by a risk minimizing strategy as they are quite vulnerable to risks arising out of natural and anthropogenic uncertainties. The degree of such uncertainty is greater in developing countries as the farmers in these countries tend to have a very low level of access to basic information regarding prices, supply, demand, and alternative opportunities (Anderson, 2003). Due to such inherent uncertainties, farmers in developing countries are vulnerable to various risks that may affect the severity of the eventual loss of assets and income; therefore, farmers always find it difficult to entirely shift from their conventional way of farming practices to any newly introduced agricultural practices (Anderson, 2003). In addition, the decision by farmers to adopt any new technology or practice is also influenced to a greater degree by their skills and scientific knowledge regarding plants, soils, animals, and machines (Schultz, 1964). In general, people who are relatively well educated and resourceful tend to adopt innovations more than those who are less educated (Lapar & Ehui, 2004). However, Lipton (1968) and Binswanger and McIntire (1987) stated that even though knowledge and skills are relevant, these are not the only factors influencing the decision-making process of farmers. According to them, even though a farmer is knowledgeable and skilled, it may still be difficult for a poor farmer to procure improved seeds and fertilizers, and to have access to the irrigation system required for commercial agriculture owing to some structural constraints imposed by policies and institutions. The socio-economic characteristics of the target population may have a substantial effect on the process of their decision making for the adoption of new technologies, when information pertaining to such new technologies becomes available (Rasul, Thapa, & Zoebisch, 2004; Knowler & Bradshaw, 2007). Hossain, Lewis, Bose, and Chowdhury (2003) and Quoc, Tivet, Khamxaykhay, Keodouangsy, and Seguy (2006) stated that the economic status of the farmers also plays a very crucial role in their decision to adopt new technologies. Extension services, provided either through formal or informal means, also play a crucial role in the promotion of new agricultural technologies, because of the direct contact with the concerned farmers (Calub, Tanje, & Phouyyavong, 2005; Oladele, 2005; Thapa & Rattanasuteerakul, 2011). Rogers (1995) was of the opinion that the degree of trialing of any new technology influences its extent of adoption. Besides, the labor intensiveness of such new technologies (De Graaff et al., 2008) play crucial roles in the farmers' decision making process in the adoption of such new technologies. De Graaff et al. (2008) also stated that in developing countries, the continued use of conservation practices for both soil and water is primarily driven by the actual profitability of and the labor requirements for the farming operations.

METHODOLOGY

Study area

This study was conducted in Songkhla province of Southern Thailand, an area that plays a vital role in terms of both rubber production and marketing. The province has many important rubber plantation areas which host various existing rubber farming systems, a developed rubber industry, and many important rubber organizations such as the Rubber Research Institute of Thailand and the Office of Central Rubber Market. Songkhla has a total land area of 739,388.80 hectares, of which rubber plantations cover 332,378.24 hectares or about 45 percent of the total area (Longpichai, 2011).

While occupying the highest percentage of the area of the province, rubber plantations show various types of rubber-based farming systems in varying topographic, land use and biodiversity, and socio-economic characteristics.

From the viewpoint of the number of crops being cultivated in rubber-based farming systems, the cropping patterns in the study area appeared highly diversified. Upon grouping the 200 sample farm households, according to the identical crops grown, six cropping systems in rubber-based farming systems emerged in the study area (Table 1). Rubber-monoculture farming system, being practiced by around 30 percent of the farm households, is the dominant type of cropping system in the study area. The second important cropping system, with nearly 20 percent of the farm households, is diversified farming with rubber as the main crop in conjunction with fruit trees such as durian, rambutan, and mangosteen. With nearly 18 percent of the farm households, the rubber-rice farming system is the third most important cropping system and is followed by a rubber-livestock farming system, practiced by 12.5 percent of the farm households. A rubber-intercrop farming system with high value local vegetables and spices (e.g. peesa: *Gnetum gnemon;* torch ginger: *Nicolaia eliator*) and a rubber-integrated farming system where many combinations may be observed, such as rubber-fruit tree-livestock, rubber-rice-livestock and rubber-rice-fruit tree (rubber with more than one agricultural activities), are the next two systems, being practiced by 11 and 10 percent of the farm households, respectively.

Data collection and analysis

Initially, two districts of Songkhla province were purposively selected—Hat Yai and Rattaphum districts. Following this, two subdistricts under each district were purposively selected for the survey based on the criteria that each subdistrict should have a large number of smallholding farms involved in rubber production and that each subdistrict should have a variety of rubber-based farming systems. The study involved 200 farmers representing various types of rubber farming systems and was selected using simple random sampling in order to capture any variability among the different rubber farming systems. The field survey was conducted from January 2010 to May 2010 and focused on conducting a household survey using a structured questionnaire. Prior to the survey, the questionnaire was translated into the Thai language, pre-tested and subsequently revised. Five local graduates were recruited to administer the questionnaire survey. The household survey provided information on the farmers, their socio-economic characteristics, problems and constraints regarding production processes, and their adjustment capacity regarding the rubber-based farming systems. Furthermore, vital information regarding the natural resource conservation in their respective farming practices was also obtained.

In order to analyze the factors influencing crop diversification in the rubber farming systems, cropping patterns were classified into two main

Table 1 Cropping systems and crop diversification

Cropping pattern	No. of households	%
Rubber-monoculture farming system	59	29.5
Rubber-fruit tree farming system	39	19.5
Rubber-rice farming system	35	17.5
Rubber-livestock farming system	25	12.5
Rubber-intercrop farming system	22	11.0
Rubber-integrated farming system	20	10.0
Total	200	100.0

cropping systems—rubber-monoculture farming and a diversified rubber farming system including rubber-intercrop, rubber-rice, rubber-fruit tree, rubber livestock and rubber-integrated farming systems. With ‘adoption of a diversified rubber farming system’ as a dichotomous or binary dependent variable with the option of either ‘adoption’ or ‘non-adoption (monoculture)’, logistic regression was considered to be the most appropriate analytical tool in order to ascertain factors determining adoption. For facilitating data analysis, a value of 1.0 was assigned to the adopters of diversified rubber farmers, and 0.0 to the non-adopters or rubber monoculture famers.

Farmers practicing each type of rubber farming system also were considered for the analysis of the effect of crop diversification patterns on natural resource conservation. The farmers opined that there are eight natural resource conservation practices in the study area. For determining the overall range of natural resource conservation adopted, as required for multivariate regression analysis, at first, for the eight natural resource conservations adopted, a score of 1.0 was assigned to practices adopted by farmers and 0.0 to practices not adopted. It followed by the aggregation of all the scores and division by eight that a composite index of adoption could be obtained. This index was considered as the dependent variable. As seen from Table 2, the practicing of natural resources conservation through the use of organic fertilizer and use of chemical fertilizer as per recommendations are popular among farmers in the study area. Saving water in agricultural activities is the most popular natural resource practice in the study area while the least is the practice of integrated pest management. Terrace practice is also quite rare as farmers in the study area have experienced very little soil erosion.

Model specification

Model I: Adoption of crop diversification

The model of the logistic regression characterizing the adoption of diversified farming by the farmers is specified by Equation 1:

$$\ln(odds(even)) = \ln\left[\frac{prob(even)}{1-prob(even)}\right] \quad (1)$$

$$= b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k$$

Here, 1 to k represent the independent variables (X) and b_0 is a constant. The output indicated that the “b coefficient” column represents the parameter estimates of the variables. The odds ratio represents the factor for any given independent variable, by the amount by which the odds (event) change in response to a single unit change that occurs for the independent variable. Altogether, 14 independent variables were included in the model (Table 3).

Table 2 Natural resource conservation practices considered in construction the index of adoption

Natural resource conservation practices	No. of household adopting	% adopting
Saving water in agricultural activities	171	85.5
Use of chemical fertilizer as per recommendation	166	83.0
Use of organic fertilizer	164	82.0
Use of pesticide/herbicide as per recommendation	131	65.5
Reserved water sources construction	119	59.5
Reduction in dumped sewage into natural water sources	116	58.0
Terrace practicing	70	35.0
Integrated pest management practicing	30	15.0

Table 3 Analysis of the maximum likelihood estimates for the factor affecting the adoption of crop diversification

	Coefficient	Wald stat	Odds ratio
Age (yr)	0.023	1.011	1.023
Gender (dummy)	-0.260	0.277	0.771
Schooling period (yr)	0.201	4.602*	1.223
Family labor (person)	0.316	2.606	1.372
Land holding size (hectare)	0.055	3.790	1.056
Lack of water (dummy)	-3.108	11.177**	0.045
Poor soil fertility (dummy)	-0.968	2.313	0.380
Attendance at agricultural training (dummy)	1.398	9.161**	4.045
Saving (baht)	0.001	5.144*	1.001
Debt (baht)	0.000	0 .215	1.000
Credit (dummy)	0.739	2.468	2.094
Amount of household income (baht)	0.000	1.224	1.000
Variation of rubber price (%)	0.016	7.774**	1.016
Contact with extension workers (time/year)	0.391	2.442	1.479
Constant	-4.826	9.598	0.008
-2log-likelihood	132.469		
Cox & Snell R^2	0.424		
Nagelkerke R^2	0.603		
Prediction rate	86%		

33 baht = 1 US dollar (2010)
**p* < .05; ***p* < .01

Model II: Impact of crop diversification on natural resource conservation

The model of the multiple regression characterizing the impact of crop diversification on natural resource conservation is specified by Equation 2:

$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k \qquad (2)$$

Here, Y represents the adoption of natural resource conservation practices and is the dependent variable, while b_0 represents the intercept and $b_1,b_2,\ldots,b_k$ represent the coefficients of the independent variables $X_1,X_2,\ldots,X_k$. Fourteen independent variables with no co-linearity were included in this regression model. These variables are: age (X_1), gender (X_2), schooling period (X_3), family labor (X_4), land holding size (X_5), lack of water (X_6), poor soil fertility (X_7), attendance at agricultural training (X_8), saving (X_9), debt (X_{10}), credit (X_{11}), amount of farm income (X_{12}), and contact with extension workers (X_{13}). In addition, one dummy variable representing the diversified rubber farming system (X_{14}) was also included in order to identify the impact of crop diversification on natural resource conservation practicing.

RESULTS AND DISCUSSION

Determinants of crop diversification patterns

Table 3 shows the results of logistic regression on which variables would affect the adoption of diversified rubber farming system. The prediction ratios for each cluster were 86 percent.

The Nagelkerke R^2 value (0.603) indicated that 60.3 percent of the variance can be explained by the logistic model. The results of the analysis indicated that the adoption of diversified rubber farming system has been significantly dependent on the farmers' problems related to insufficient water supply. Farmers' problems regarding the lack of water have had a negative effect on the adoption of a diversified rubber farming system. Water availability refers to the sufficiency of water for the plantation, as perceived by the farmers (Muangkaew & Shivakoti, 2005). In the humid tropics, rubber yields stagnate or increase marginally under an augmented supply of water. However, with diversified systems including intercropping and crop associations with rubber, water becomes an important resource in increasing the yields of the accompanying crops.

Farmers' participation in agricultural training programs has a positive influence over their adoption of diversified farming system. The Office of Rubber Replanting Aid Fund plays a vital role in rubber production in Thailand. Most of the rubber farmers participate in the replanting program initiated by this organization. This program supports the initial budget for planting. The extension officers from this office make periodic audit visits to the farms to verify the proper use of funds. Where the visiting extension officers discover some irregularities or some sort of difficulties at farm level, then direct instructions are given to the farmers to address the problem. In such cases, the farmers concerned are obliged to correct the outcomes before they can receive the next payment. In addition, this organization encourages farmers to practice rubber-intercropping by providing an economic allowance to the participating small-scale farmers in the form of low interest loans, training, and knowledge. These loans are provided for implementing intercropping such as different tree species, pineapple, watermelon, sweet corn, and rice and animal husbandry activities such as raising chickens, goats, or pigs on their farmland. Moreover, several agricultural training programs are also provided by other related extension agencies such as those on crop production, especially fruit trees and livestock production. These training programs have encouraged the farmers with the necessary information on sufficiency economy which generally aimed at sustainable agricultural systems, specifically the integrated farming and organic farming systems. This highlights the very influential and important role of agricultural training in successfully influencing the farmers to adopt a diversified rubber farming system.

Price fluctuation also positively influence farmers to adopt a diversified farming system. Rubber prices are beyond the farmers' control and are very vulnerable to reductions (Kaiyoorawong & Yangdee, 2006). Price fluctuates in the local market because of an over- supply of production, inefficiency of local product markets, and insufficient price insurance policies (Somboonsuke, 2001). The high percentage of rubber price fluctuation in the last five years has led to the adoption of diversified rubber farming systems. This is consistent with the findings of Simien and Penot (2011) that diversification through agroforestry practices is an adapted alternative to overcome the fluctuations in rubber prices.

The analysis shows that the amount of saving has a positive effect on the adoption of a diversified farming system. This is consistent with the findings of other studies which revealed that the economic status of the farmers also plays a vital role influencing their decision to adopt new technologies (Hossain et al., 2003; Quoc et al., 2006). Saving is an important contributing factor in improving the farming activities, especially to assist in accessing capital for diversifying farming activities through further investment, for extra expenditure and production costs, and as a buffer to possible cash flow disruptions (Hocking, 2003; Shivakoti & Shrestha, 2005). Finally, the results indicated the positive influence of the schooling period on the adoption of a diversified rubber farming system.

This is consistent with the empirical findings that individuals who are relatively well-educated and resourceful adopt more innovation in farm production than less-educated people (Lapar & Ehui, 2004).and they tend to diversify more of their farm production (Thapa & Rattanasuteerakul, 2011).

Factors affecting natural resource conservation

Lastly, this study attempted to determine whether farming system diversification affects the decisions by households to undertake resource conservation measures. The results show that out of the 14 variables considered, five—namely, attendance at agricultural training, lack of water, farm type (diversified and monoculture farming systems), poor soil fertility, and schooling period significantly explained the model (Table 4), accounting for almost 70 percent of the variation in practicing natural resource conservation. A sensible direction of the relationships between the significant independent and dependent variables was found with natural resource conservation practice increasing with an increase in these five independent variables (Table 5).

The farmers facing the problems of poor soil fertility and lack of water seem to practice natural resource conservation more, which is quite logical behavior. As far as the rubber farmers' views on soil fertility are concerned and the trends being observed over the last five years, the decline of soil fertility has occurred for different reasons and has varied among farmers. Most of the farmers identified the continuous use of chemical fertilizers over a long period as the most important reason for the decrease in soil fertility and also for making the soil hard. Overuse of herbicide for rubber plantations has been mentioned as another reason contributing to the

Table 4 Summary of regression models

Model	R	R^2	Adjusted R^2	Standard error of the estimate
1	0.642[a]	0.413	0.410	0.08917
2	0.724[b]	0.525	0.520	0.08041
3	0.781[c]	0.609	0.603	0.07309
4	0.814[d]	0.662	0.655	0.06817
5	0.821[e]	0.673	0.665	0.06716

Remark: a. Predictor: (Constant), attendance in agricultural training
b. Predictors: (Constant), attendance in agricultural training, lack of water
c. Predictors: (Constant), attendance in agricultural training, lack of water, farm type
d. Predictors: (Constant), attendance in agricultural training, lack of water, farm type, poor soil fertility
e. Predictors: (Constant), attendance in agricultural training, lack of water, farm type, poor soil fertility, schooling period

Table 5 Coefficients of independents variables included in regression model

Variables	Un-standardized coefficients		Standardized coefficients (beta)	*t*	*p*
	B	Standard error			
Attendance in agricultural training	0.065	0.012	0.277	5.291	0.000
Lack of water	0.076	0.016	0.222	4.862	0.000
Farm type	0.085	0.013	0.335	6.627	0.000
Poor soil fertility	0.082	0.017	0.229	4.814	0.000
Schooling period	0.004	0.001	0.126	2.621	0.009
Constant	0.518	0.011		48.416	0.000

destruction of soil fertility. However, the farmers facing decreasing soil fertility have now been following a trend of reduced use of chemical fertilizers and at the same time have also started using organic fertilizers. Farmers have also used chemical fertilizers and herbicides according to the manufacturers' recommendations in order to increase soil fertility. Along the same line, farmers facing the problem of lack of water in rubber farming systems have coped with this problem by saving water from agricultural activities and the construction of water retention facilities. Most of the rubber farmers reported water to be very important where they have been growing other crops with rubber especially, rice and fruit trees.

Agricultural training and education has also played an important role in contributing to the practice of natural resource conservation. Various related organizations have promoted the practices of soil fertility conservation and efficient water management for agricultural production in the study area. Extension workers also have played vital roles in providing the farmers with necessary knowledge of and training in natural resource conservation. Empirical evidence suggests that extension services, provided through formal or informal ways, also are crucial for the promotion and subsequent adoption of any new agricultural technologies among farmers (Calub et al., 2005; Oladele, 2005; Thapa & Rattanasuteerakul, 2011). It is evident that farmers participating more in agricultural training acquire more knowledge and develop new skills than those who participated less. In the study area, farmers practicing natural resource conservation significantly outnumbered farmers who are not practicing it, in the frequency of participation in agricultural training and thus have opened up more opportunities for themselves to acquire and expand their knowledge and technical know-how on farm production, eventually motivating these farmers to practice natural resource conservation. In general, resourceful individuals and those relatively well-educated adopt more innovations in farm production than less-educated people (Lapar & Ehui, 2004). This is consistent with the findings of the current study which revealed the positive influence of the schooling period on the adoption of natural resource conservation practices.

Finally, the results indicated the influence of farm type on the adoption of natural resource conservation practices, especially the natural resource conservation through the use of organic fertilizer and the construction of reserved water sources. A diversified rubber farming system has a positive effect on practicing natural resource conservation. The study area, a part of the southern Thailand, is considered to be the rubber bowl of the country, where most of the farmers have been traditionally growing only rubber using a lot of herbicides and inorganic fertilizers. Since 1997, with the implementation of the crop diversification program, this situation has gradually improved in different parts of the country including the study area. Even though farmers practicing both rubber monoculture and diversified rubber farming systems are still using inorganic fertilizers and herbicides, at the same time some of the rubber monoculture farmers and nearly 75 percent of the diversified farmers are also using organic fertilizers. Although not very impressive, this can be considered a substantial change compared with the use of only inorganic fertilizers in the past. However, the majority of the rubber monoculture farmers are still using only inorganic fertilizers as they still believe that they can get higher crop yields this way. Diversified rubber farmers are using organic fertilizer more than rubber monoculture farmers as these farmers generally produce organic fertilizers mostly as by-products from their agricultural production. Diversified rubber farmers are also applying farmyard manure where cattle and poultry manure are the major sources of farmyard manure where farmers rear cattle and poultry on farm. Fermented liquid bio-fertilizer is derived from by-products such as vegetables and fruits etc. with molasses. In addition, as diversified rubber farming systems need enough water on a continuous basis and to cope with drought damage, these diversified farmers have constructed water storage facilities.

CONCLUSIONS AND RECOMENDATION

The results of this study further strengthen the theoretical foundation laid down by Rogers (1995) and Ellis (2000) and the findings of several other studies reviewed above. The results of this study also indicated an overwhelming majority of rubber monoculture farmers in the study area could not shift to crop diversification partly because of the lack of water. Thus, the provision of water source management, both better management for irrigation systems and the promotion of the construction of water storage facilities should be implemented by government to encourage farmers to adopt similar practices in their various agricultural activities. Apart from the biophysical conditions discussed above, the findings of this study also prove that knowledge gained from school and training programs can influence and enable farmers to enhance their capability for crop diversification. Farmers, in general, being traditionally engaged in farming, lack the skills and knowledge for growing crops that they have not grown before. This calls for serious effort to be put into capability building for crop diversification aiming at promoting the cultivation of crops that have not been grown to date by the farmers. In view of this, the government has carried out capability strengthening programs in the study area. While capability strengthening activities such as training programs are essential for the effective promotion of any crop diversification program, such activities should be tuned to the crop diversification packages, so that there is a provision in the appropriate packages for training programs and awareness building as part of the consideration of the suitability of crop diversification in different areas. This can only make such programs attractive to the farmers.

Regarding the effect of crop diversification on natural resource conservation, the findings of this study also indicated the dependence of natural resource conservation practice on several factors that are consistent with the theories of Rogers and the findings of several other studies reviewed above. As also indicated by the results of this study, farmers in the study area adopt natural resource conservation because of the status of the natural resources in the study area such as poor soil fertility and the lack of water. The findings of the study revealed that the adoption of natural resource conservation practices are dependent on training programs. Therefore, the promotion of a natural resource conservation program should be developed and implemented together with a crop diversification promotion program. In view of the proven contribution of farm type or diversified farming system to improving soil structure and fertility by using organic fertilizer, this can certainly be considered as a positive change in the pursuit of sustainable agricultural development. However, the long-run effect of the accelerated use of inorganic fertilizers on soil fertility and environmental quality still remains a question that needs to be answered.

REFERENCES

Anderson, J. R. (2003). Risk in rural development: Challenges for mangers and policy makers. *Agricultural Systems, 75*, 161–197.

Asian Development Bank. (1997). *Reevaluation of the rubber rehabilitation expansion project in Bangladesh*. Reevaluation Study No. 28.

Barghouti, S., Kane, S., Sorby, K., & Ali, M. (2004). *Agricultural diversification for poor: guidelines for practitioners*. Agricultural and Rural Development Discussion Paper1, Agriculture and Rural Development Department, World Bank.

Barrett, C. B., Reardon, T., & Webb, P. (2001). Non farm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. *Food Policy, 26*(4), 315–331.

Binswanger, H. P., & McIntire, J. (1987). Behavior and material determinants of production relations in land abundant tropical agriculture. *Economic Development and Cultural Change, 36*, 73–99.

Calub, B. M., Tanje, D., & Phouyyavong, K. (2005). *Promotion of soybean as a cash crop: Determinants and possible impacts*. LSUAFRP Field Report No. 05/09, NAFRI Vientiane Lao PDR.

Cramb, R. A. (2007). *Land and longhouse: Agrarian transformation in the uplands of Sarawak*. Copenhagen: NIAS Press.

De Graaff, J., Amsalu, A., Bodnar, F., Kessler, A., Posthumus, H., & Tenge, A. (2008). Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. *Applied Geography, 28*, 271–280.

Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics, 51*, 289–302.

Ervin, C. A., & Ervin, D. E. (1982). Factors affecting the use of soil conservation practices: Hypotheses, evidence and policy implications. *Land Economics, 58*, 277–292.

Hansen, J. W. (1996). Is agricultural sustainability a useful concept? *Agricultural Systems, 50*, 117–143.

Harwood, R. (1979). *Small farm development: Understanding and improving farming systems in the humid tropics*. Boulder, CO, USA: Westview Press.

Hocking, G. (2003). Oxfam Great Britain and sustainable livelihoods in the UK. *Community Development Journal, 38*, 235–242.

Hossain, M., Lewis, D., Bose, M. L., & Chowdhury, A. (2003). *Rice research, technological progress, and impact on poor: The Bangladesh case*. International Food Policy Research Institute New York, USA.

Kaiyoorawong, S., & Yangdee, B. (2006). *Rights of rubber farmers in Thailand under free trade*, Thailand. Retrieved from http://www.wrm.org.uy/countries /Thailand/Rights_of_rubber_farmers _in_ Thailand.pdf

Kasem, S., & Thapa, G. B. (2011). Crop diversification in Thailand: Status, determinants, and effects on income and use of inputs. *Land Use Policy, 28*, 618–628.

Kjonchaikun, P. (1995). *The supplement income of small holders in Thailand*. Surat Thani Rubber Research Center, Thailand.

Klongsripun, S. (1994). *The rubber multicrop and intercrop system*. Songkhla Rubber Research Centre, Thailand.

Knowler, D., & Bradshaw, B. (2007). Farmer's adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy, 32*, 25–48.

Lapar, M. L. A., & Ehui, S.K. (2004). Factors affecting adoption of dual-purpose forage in the Philippine uplands. *Agricultural Systems, 81*, 95–104.

Lipton, M. (1968). The theory of the optimizing peasant. *Journal of Development Studies, 4*, 327–351.

Longpichai, O. (2011). *Assessing sustainability of smallholding rubber-based farmimg system: Application of a sustainable livelihood approach in Southern Thailand* (Unpublished doctoral dissertation). Asian Institute of Technology, Thailand.

Muangkaew, T., & Shivakoti, P. G. (2005). Effect of livelihood assets on rice productivity: A case study of rice based farming in Southern Thailand. *Journal of International Society for Southeast Asian Agricultural Science, 11*, 63–83.

Nair, K. R. (1985). *Classification of agro-forestry system*. Ministry of Agriculture and Cooperative.

Nusang, R. (2006). *The socio-economic adjustment of rubber smallholders in small holding* *rubber-rice farming system in Khao Chaison, Amphoe Khao Chaison, Changwat Phatthalung* (Unpublished master's thesis). Prince of Songkla University, Songkhla.

Oladele, O. I. (2005). A profit analysis of propensity to discontinue adoption of agriculture technology among farmers in Southwestern Nigeria. *Journal of Central European Agriculture, 6*, 249–254.

Overmars, K. P., & Verburg, P. H. (2006). Multilevel modeling of land use from field to village level in the Philippines. *Agricultural Systems, 89*, 435–456.

Quoc, H. T., Tivet, F., Khamxaykhay, C., Keodouangsy, C., & Seguy, L. (2006). In *Issues concerning the adoption of direct seeding mulch-base cropping systems in Southern Xayabury, Lao PDR*. National Agriculture and Forestry Research Institute, Vientiane.

Rasul, G., & Thapa, G. B. (2004). Shifting cultivation in the mountains of south and Southeast Asia: Regional patterns and factors influencing the change. *Land Degradation & Development, 14*, 495–508.

Rasul, G., Thapa, G. B., & Zoebisch, M. A. (2004). Determinants of land-use changes in the Chittagong Hill Tracts of Bangladesh. *Applied Geography, 24*, 217–240.

Rogers, M. E. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press.

Ruthenberg, H. (1971). *Farming systems in the tropics*. London: Oxford University Press.

Schultz, T. W. (1964). *Transforming traditional agriculture*. New Haven: Yale University Press.

Shivakoti, G. P., & Shrestha, S. G. (2005). Analysis of livelihood asset pentagon to assess the performance of irrigation system: Part I-analytical framework. *Water International, 30*, 356–362.

Sikor, T. (2004). The commons in transition: Agrarian and environmental change in Central and Eastern Europe. *Environmental Management, 34*, 270–280.

Simien, A., & Penot, E. (2011). Current evolution of smallholder rubber-based farming systems in Southern Thailand. *Journal of Sustainable Forestry, 30*(3), 247–260.

Somboonsuke, B. (2001). Recent evolution of rubber-based farming systems in Southern Thailand. *Kasetsart Journal: Social Sciences, 22*, 61–74.

Somboonsuke, B., Shivakoti, G. P., & Demaine, H. (2001). Agricultural sustainability through empowerment of rubber smallholders in Thailand. *Asia-Pacific Journal of Rural Development, 11*, 65–89.

Sunderlin, W. D. (1997). *Shifting cultivation and deforestation in Indonesia: Steps towards overcoming confusion in debate*. Rural Development Forestry Network Paper, 21b, ODI, London.

Thapa, G. B., & Rattanasuteerakul, K. (2011). Adoption and extend of organic vegetable farming in Mahasarakham province, Thailand. *Applied Geography, 31*, 201–209.

Thungwa, S. (1998). *Possibility of sustainable agricultural development in Para Rubber Base Agrarian System, Changwat Songkhla and Changwat Satun*. Prince of Songkla University, Songkhla.