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Role of land tenure security and farm household characteristics on land use change in the Prasae Watershed, Thailand

Nareeluck Wannasai*, Rajendra P. Shrestha

Natural Resources Management Field of Study, School of Environmental Resources and Development, Asian Institute of Technology, P.O.Box 4, Klong Luang, Pathumthani 12120, Thailand

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Abstract

Land tenure and resource availability can play a critical role in the land use decision-making process, resulting in different types of land use changes. This paper investigates the role of land tenure security and farm household characteristics on land use change in the Prasae Watershed, Thailand, using GIS and farm-level data. Forest conversion to annual crops and subsequently to perennial crops was a typical land use change during 1982–2004. Tenure insecurity is found to be associated with deforestation and forest encroachment. Insecure landholders adopt perennial crops in order to acquire basic land use rights and entitlement to subsequent legal registration, while more secure land tenure is seen to have economic advantages for production and long-term investment. Although land tenure security can act as a crucial factor in land use decision making, farmers opt for different land use options based on characteristics such as farm size and available labor. To advance the economic well-being of insecure and temporary landholders and support forest conservation, this report concludes that an effective policy should aim to improve both farm productivity and land quality while protecting the remaining forest.

Keywords: Land use change; GIS; Land tenure security; Household characteristics; Driving forces; Thailand

Introduction

Land use is continuously changing under the influence of humans and nature, resulting in a variety of local and global impacts (UNEP, 2000; Walker et al., 2002). Managing natural resources and controlling the environmental impacts associated with land use change requires an understanding of the underlying causes, which arise out of a complex interplay of biophysical and socioeconomic factors (Fox et al., 1994; Serneels and Lambin, 2001; Fox, 2002; Müller, 2003; Rasul et al., 2004). Among the various underlying socioeconomic factors affecting land use change, land tenure has been increasingly recognized as a critical element in eradicating poverty, promoting social equality, developing sustainable agriculture and conserving natural resources. There is a general consensus that secure land tenure leads to incentives that promote investment and efficient use of resources (Arnold, 1983; Feder et al., 1986; Onchan, 1990; ILC, 2004) whereas a lack of access to land or a low return per area of land, leads to the expansion of agriculture into forested areas and the degradation of natural resources.

Deforestation and unsustainable land use have been well- recognized in Thailand as leading to the degradation of the environment and natural resources. One key to controlling this problem is to reduce the rate of undesirable land conversion and land use through appropriate policy intervention. For instance, the provision of land tenure to farmers can be an effective solution to a variety of issues such as land degradation, land conflicts and environmental problems. Possession of secure land documents, viz. land titles, has been shown to have a positive effect on sustaining profitable farming that is less destructive to the environment (Arnold, 1983; World bank, 1983; Ayalew et al., 2005). Studies suggest that the secure land document enhances access to credit, thereby increasing tenure security for investment in rural Thailand (Onchan and Feder, 1985;

*Corresponding author. Tel.: +662 524 6387; fax: +662 524 6431.
E-mail address: Nareeluck.Wannasai@ait.ac.th (N. Wannasai).

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Feder et al., 1986). However, that may not hold true in the case of every farmer. Limitations such as inadequate or fragmented farm size or a lack of labor can undermine profitability. Farmers may opt for the land use system most appropriate to their resource endowments, as suggested by several studies that argue the development of different land use patterns is an outcome of underlying driving factors (Fox et al., 1994; Chomitz and Gray, 1996; Molle and Srijantr, 1999). One of the key factors considered in these studies is land tenure, which has been characterized by dichotomies such as private land/public land, owner/tenant and with/without titles.

In Thailand, different institutions provide different types of land documents reflecting different levels of tenure security. To date, it is not well understood how different levels of land tenure security lead to different types of land use change. As the decision making process is a complex interplay of several factors, it is necessary to understand how land tenure and asset heterogeneity affect such processes resulting in different forms of land use change or modification.

The objective of this study, conducted in the Prasae watershed of Thailand, is to analyze changes in land use and examine the role of land tenure security in land use decision making and eventual land use change. Additional attention is paid to the relationship between security of land tenure and farm characteristics in determining the use of land. Although farm characteristics include several factors, the focus here is on the effect of farm size and farm labor on land use decision-making. Such an understanding can be valuable for formulating sound land use policy to contribute to sustainable natural resource management.

Study area

The Prasae watershed, covering 2137 km^2 and situated in the eastern region of Thailand (Fig. 1), was selected as the study area. The study area has undergone enormous land use change in the past with an increasing rate of crop cultivation. The area also has a wide variety of households with respect to security documents, e.g. secure land tenure on private lands, temporary land tenure in land reform and cooperative settlement areas, and insecure land tenure inside forest reserves.

The topography of the study area consists of flat plain and upland area with an elevation ranging from 5 to 120 m. The eastern and western part of the watershed are composed of high mountains extending from the north to the south and covered with evergreen and deciduous forest forming the head watershed area. The lower parts are filled with orchard and rubber plantation. The climate is tropical monsoon with an annual rainfall of 1200 mm to as much as 1700 mm in the eastern part of the watershed.

The total population is 0.08 million with an average population density of 37 persons/km^2. The average annual population growth during 1990–2004 was as low as 0.1%. Most households in the study area are small to medium-sized with an average household population of four. Agriculture is the mainstay of the majority of households.

The majority of forest conversion occurred during the 1970s and 1980s, coinciding with the rapid increase in overseas demand for certain crops, e.g. cassava (Saenjan, 1999). The current forest cover in the watershed is distributed in the protected zone of Khao Chamao–Khao Wong National Park. Degraded and disturbed forests, cleared for agricultural use and human settlements, are found on the high sloping areas. Some of the degraded areas were distributed to farmers under the land reform project (ALRO, 2003). These include areas of lowland tropical forest, a rare forest type in Thailand. The conversion of land use continues in lowland areas where paddy and field crops are being replaced by permanent fruit trees and rubber plantations.

Materials and methods

Sources of data

The basic data used in the study were

- Land use map of 1982 in hard copy format obtained from the Land Development Department (LDD), Ministry of Agriculture and Cooperatives of Thailand.
- One scene of Landsat TM data of November 30th, 2004 procured from the Geo-informatics and Space Technology Development Agency of Thailand.
- NRD2C village level database (*Kor Chor Chor Song Kor*) from the Community Development Department for the National Economic and Social Development Board and the Ministry of Interior of Thailand. The database contains socioeconomic information at the village level since 1985 and is updated every two years.
- Household survey data of 240 households in the area.

Land use change detection

The methodology used for detecting land use change in this study was as follows. The hardcopy land use map of 1982 was digitized in a Geographic Information System (GIS) using ArcView^{TM} software. Landsat TM data of 2004 was digitally classified using ENVI^{TM} version 3.5 software. The land use classification system suggested by Anderson et al. (1976) was followed in classifying the image with the help of ground-surveyed training data to prepare the land use map of 2004. In general, the first level of classification including forest, agriculture, urban, wetland, water and others was considered although for some classes, the second and third level classes were also considered in order to examine land use changes in relation to land tenureship. These classes included annual crops, rubber, orchard, other perennial crops, paddy and shrimp farm. The accuracy assessment of the classified image was carried out as proposed by Lillesand and Kiefer (2000), and an overall accuracy of 84% was achieved.

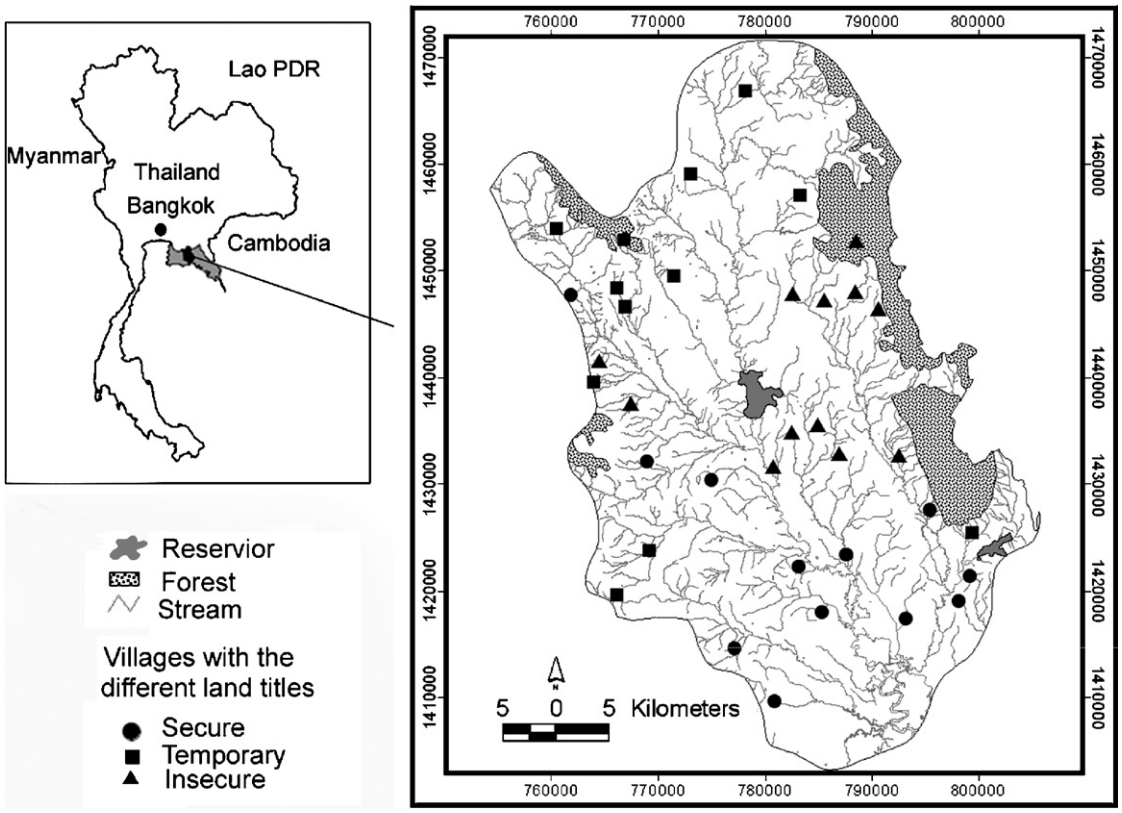

Fig. 1. Location of sampled villages with major land titles in the Prasae watershed, Thailand.

Two time series land use data maps were overlaid using GIS to detect land use changes. In this study, land use change refers to changes in land cover composition and land use pattern; for example, typical changes were changes from forest to agriculture or from land under annual crops to land under perennial crops.

Land tenure and socioeconomic assessment

A list of the current land tenure of 186 villages located in the study area was obtained from the NRD2C database. Farm households in the area hold various land certifications from several institutions. Three levels of land tenure security, namely secure, temporary and insecure, were classified from different types of land titles or certificates as follows:

(1) *Secure land tenure* refers to the possession of private land with land titles issued by the Department of Lands including title deed and N.S.3 K (*Nor Sor* 3 *Kor*). The landowners who hold this certificate possess unrestricted rights of sale, transfer and inheritance.
(2) *Temporary land tenure* refers to the possession of land with other forms of land document issued by respective departments. The Royal Forest Department issues S.T.K.1 (*Sor Tor Kor* 1) to illegal squatters. Some degraded forest areas were distributed to farmers for cultivation with land reform certificates S.P.K.4-01 (*Sor Por Kor* 4-01) by the Agricultural Land Reform Office. In addition, K.S.N.3 (*Kor Sor Nor* 3) and K.S.N.5 (*Kor Sor Nor* 5) were also issued to land holders by the Cooperative Promotion Department. All these land documents only provide the usufruct right for a farmer to use and inherit. In this study, about 19% of the households are under this type of tenure security.
(3) *Insecure land tenure* refers to the possession of land without recognized document or with only tax payment. The payment of tax indicates use of the land but does not entitle the user to long-term or permanent possession. In the study area, an estimated 15% of households reside inside the forest reserve area without legal land registration. Though informality of land titles does not necessarily mean insecure land tenure status, it is assumed in this study that farmers who occupy land without title suffer from a degree of uncertainty in matters of eviction and land disputes. They are also likely to have reduced credit access (Feder et al., 1986; Routray and Sahoo, 1995).

The information on land use change and land tenure category was used to select 36 villages using stratified random sampling (Fig. 1), from which a total of 240 households were randomly selected for conducting the household survey. A structured questionnaire survey was conducted for socioeconomic and land use data collection between March–June, 2005. The questionnaire comprised demographic data, farm characteristics, land tenure and

land use condition (both concurrently and at different dates in the past), family origin, migration history, farm input, production, income and credit. The collected socio-economic data were analyzed using SPSS™ software version 11. *F*-test and Chi-square tests were used to examine the relationship between the variables used. The Tobit model analysis was carried out using LIMDEP™ econometric software.

Results

Land use change

The land use change analysis indicated that agriculture has remained the dominant form of land use, occupying about 64.2% of the study area in 1982 and 87.9% in 2004 (Table 1). A significant increase was observed for perennial crops (rubber, orchard and other perennials such as oil palm and cashew nut), which increased from 10.2% to 57.1% of the area. The area under annual crops (field crops and paddy) decreased from 43.5% to 7.3%, whereas mixed land use on which both annuals and perennials are cultivated increased from 10.5% to 22.4%. A substantial decrease in the amount of forest area was observed from 33.2% in 1982 to 8.9% in 2004. This decrease is due directly to the increase in agricultural area. This indicates a continual transformation of land use over the last two decades in the study area.

Table 1
Land use allocation in 1982 and 2004

Land use type	1982	2004
	% of watershed area (213,764 ha)	
Forest	33.2	8.9
Agriculture	64.2	87.9
Annual crops	38.2	7.2
Annual crops–rubber	10.5	22.4
Rubber	8.2	35.0
Orchard	2.0	15.5
Other perennial crops	0	6.6
Paddy	5.3	0.1
Shrimp farm	0	1.1
Urban	0.7	1.6
Water	0.3	1.0
Wetland	1.5	0.4
Other	0.1	0.2

The matrix in Table 2 presents historical land use changes in the study area for 1982-2004. Most land conversion observed during the past two decades was mainly from forest to annual crops, and subsequently to perennials in the form of rubber plantations. About 75.7% of forest that existed in 1982 was lost to other uses by 2004, specifically to perennial crops (48.9%) such as rubber and to mixed annual and perennial crops (16%).

Mixed crops may be seen in newly cleared forest areas or on cultivated land at the end of the economic life of rubber trees. Newly cleared forest areas are initially planted with annual crops alone as farmers fear eviction by the authorities for encroachment. After one or two seasons, young rubber is intercropped with the annual crops as the farmers feel more secure in their use of the land. Alternatively, mixed cropping may appear after exhausted rubber trees cannot be tapped for latex, when the crop must be replanted. Annual crops are again intercropped with young rubber trees for a few years before the rubber crop attains full crown cover.

Land used solely for cultivating annual crops in 1982 had changed to mixed crop use consisting of annuals with rubber (33.5%) and perennial crops alone (53.3%) by 2004. In contrast, as much as 81% of the land used for perennial crops in 1982, rubber in particular, was found remaining in use in 2004. A further 17% had changed to mixed crop use of annual crops and rubber.

Paddy rice, a dominant subsistent crop in the area before 1970 and largely grown in the lower part of the watershed, was slowly replaced by other field crops, such as cassava, sugarcane and fruit trees (Bundprasirichot, 2000). Almost all (99%) of the rice area of 1982 had changed to other land uses, with a substantial proportion of that being 70% to perennial crops. Of the several underlying factors, agricultural policies and commodity prices were among the main factors behind these land use changes. In recent years, the cultivation pattern has been shifting away from annual crops to high-value crops, such as rubber and oil

Table 2
Land use change matrix from 1982 to 2004 shown as percentage change

1982	2004										
	Forest	Annual crops	Annual crops-rubber	Perennial crops	Paddy	Shrimp farm	Urban	Water	Wetland	Other	Total
Forest	24.3	10.3	16.0	48.9	0	0	0.6	0	0	0	100
Annual crops	1.7	9.1	33.5	53.3	0	0	0.9	1.6	0	0.1	100
Annual crops—rubber	0.5	1.1	16.4	80.1	0	0	0.4	1.5	0	0.1	100
Perennial crops	0.6	0.7	17.0	81.0	0	0	0.5	0.1	0	0.1	100
Paddy	0	3.4	14.6	69.8	1.4	7.1	3.2	0.3	0	0.2	100
Urban	0	0	0	0	0	0	94.7	1.6	0	3.7	100
Water	0	0	0	0	0	40.4	0.0	40.7	0	18.9	100
Wetland	0	0	0	0	0.3	40.4	9.1	8.6	24.6	17.0	100
Other	0	0	49.6	46.9	0	0	3.5	0	0	0	100

Table 3
Changes in land use in relation to land tenure security

Land tenure	Land use change (% of total household)**				
	Forest to perennial crops	Annual crops to perennial crops	Perennial crops (no change)	Annual crops (no change)	Perennial to annual crops
Secure to secure	0	3.4	17.3	2.1	0
Temporary to secure	0	0	3.0	0.4	0
Insecure to secure	0	1.3	4.2	1.3	0
Temporary to temporary	0	0	8.0	0.8	0.4
Insecure to temporary	0	0.8	21.5	3.8	0.4
Insecure to insecure	1.8	12.7	13.9	2.1	0.8
Total	1.8	18.2	67.9	10.5	1.6

** $P < 0.01$ (Chi-square = 61.47).

palm. The growing market for rubber, the demand for palm oil for bio-diesel production, and government subsidy for both crops encourage farmers toward substantive land conversion.

Perennial and annual crops are major categories of agricultural land use since the benefit of cultivating annuals with perennials is a quick return on investment during the gestation period of the perennial crops. Field observations show a typical farm household has as many as four alternatives of crop production: rubber, fruit tree, other perennial and annual crops. It was found that the division of land use in the study area accords with the proportions for each category employed by Pichón (1997) Predo (2003) and Baltenweck et al. (2004).

Land tenure security and land use change

Access to land is essential for farmers in order to make a living. Preliminary analysis of the field survey data indicated that 95% of surveyed households had their own land while 3% and 2% were full tenants and 'free users'—that is, farmers given permission to use the land by the owners—respectively. Of the total households who own land, 85% had invested in perennial crops as long-term investments, whereas 53% of land tenants and 60% of free users had invested in annual crops.

Farmers in the study area tended to invest in perennial crops. Irrespective of changes in their land tenure security status, 67.9% continued to grow perennials against 10.5% that continued to grow annual crops (Table 3). About one-fifth of the respondents were found to change their land use to perennial crops. 15.3% of households who held either temporary or insecure land tenure changed their land use to perennial crops compared to only 1.6% who changed to annual crops. There was a similar trend in those who held secure land tenure. Of these, 4.7% changed their land use to perennial crops while none changed to annual crops.

Insecure land tenure was found to be associated with the conversion of forest to cultivated areas of perennial crops. In the past, the majority of households were new settlers and forest conversion for agriculture was rather massive. The process is continuing although at a slower rate since most of the forests are designated as protected areas. Cultivation of annual crops, in particular, was the most common means of freely occupying forest land, with these areas gradually changing to perennial crops.

The reasons for cultivating perennial crops can vary with different kinds of land tenure security. Farm households with secure land tenure typically invest in perennials as longer term, higher-profit enterprises. Farm households granted temporary tenure security through possession of a land reform document, which in general only provides usufruct rights to the holders, nevertheless also feel secure enough to cultivate perennials. These farmers make land use decisions based not only on their existing right to use the land but also based on the expectation of being granted secure title in the future. Some households residing inside forest reserve areas and without any land titles at all have also planted perennial crops in order to make land registration claims. These areas are under the jurisdiction of the Royal Forest Department, and the intention is clearly to obtain land reform certificates of such cultivated lands. Presently, more than one-fourth of the total number of villages in the study area exist in the forest reserve area and could hinder forest conservation efforts. Such a strategy of using crops as a tool for obtaining land tenureship has been reported as a common practice in developing countries (Neef, 2001; Neef et al., 2004).

Land tenure security and land use decision making

Land use decision making is affected by several factors including tenure security and farm characteristics. The observed substantial changes in land use patterns in different tenure security categories in the study area suggested a link between land tenure security and land use decision making. As indicated in the previous section, the majority of farmers without legal land titles were responsible for land cover conversion, leading to deforestation. However, land use change also refers to the modification of land cover characteristics without changing overall classification (Turner et al., 1993) such as changes in land use from annual crops to perennial crops. Many

Table 4
Distribution of land use by land tenure security

Tenure security	Settlement duration* (y)	Farm size (ha)	Amount borrowed* (Baht)	Farm investment (Baht/HH)	Gross Benefit (Baht/HH)	Land use share (%)				
						Perennial crops				Annual crops
						Rubber	Fruit tree**	Other perennial crops*	Total	
Secure ($n = 91$)	36	5.0	143,866	52,867	220,693	48.5	31.0	4.3	83.8	16.1
Temporary ($n = 68$)	29	5.9	40,686	44,028	161,574	43.7	6.5	32.7	82.9	17.1
Insecure ($n = 66$)	26	4.8	85,162	41,563	168,607	57.6	17.8	12.6	88.0	12.0
Mean	31	5.2	95,463	46,900	187,655	49.7	19.7	15.3	84.7	15.2

*$P < 0.05$;
**$P < 0.01$; 1US$ = approx. 40 Thai Baht; n = number of observation; HH = household.

such instances of land use modifications were observed in the study area.

Though it is often argued that secure land tenure encourages long-term investment in certain resources, both titled and non-titled farmers tended to allocate more than 80% of their land to perennial crops (Table 4). This is not surprising considering that these settlers have been living in the area for more than 25 years and have adopted a variety of land use patterns. They feel secure in their rights, and this prompts them to invest in and maintain long-term use over the land. The high return of such long-term investment leads to a greater incentive to undertake investment. While the advantage of having land title documents was found to serve as collateral for increased access to credit, as also reported by Feder et al. (1986), that was not the sole determining factor for long-term investment in perennial crops.

In fact, farmers in this area generally engaged in more than one activity simultaneously on their farms such as mixed cropping with mostly commercial, but also a few subsistent, crops. For a typical farm, the average land use share was 50% of the farm area planted with rubber, 20% allocated to fruit trees, 15% to other perennial crops, e.g. cashew and oil palm, and 15% to annual crops, e.g. cassava, sugarcane, vegetables and rice. Each crop requires a different degree of crop management.

Among the alternative crops, rubber had the greatest share of farm area for all land tenure categories. This crop requires high initial investment but lower management cost at later stages. This can partly explain why insecure landholders occupying a relatively small area tended to claim the land with minimal costs of production as rubber plantation, similar to farmers in the Amazon frontier, where perennial crops dominate among non-titled farmers (Pichón, 1997). Though rubber was a major crop for all tenure categories, farm households with secure land tenure and the advantage of higher credit access for investment had a greater share of farm area cultivated with labor-intensive and relatively high-input crop, such as fruit trees. For temporary landowners with larger farm sizes (5.9 ha), cashew nut was one of the best choices of crop due to the fact that it requires limited investment. Mixed crops of cashew nut and rubber seemed to be a good strategy to achieve year-round income with low investment. Rubber can be harvested during the wet season and cashew nut in the dry season. Allocation of some areas for annual crops in case of all tenure categories was also observed since it provides a quick source of income to support immediate and short-term living expenses.

Given the type of crops grown in the area, it was evident that other factors than tenure security were involved in land use decision making since different crops require different degrees of resource availability and management practices. Farm characteristics such as farm size, labor, credit line and resource poverty are important factors influencing crop selection and allocation (Fox et al., 1994; Holden and Yohannes, 2002; Futemma and Brondizio, 2003; Baltenweck et al., 2004). In this study, farm characteristics, especially farm size and labor input were further investigated to comprehend their role in influencing land use allocation under different tenure security categories and their interaction with tenure security.

Farm household characteristics and land use decision making

The farm size in the study area ranged from less than 1 to 88 ha with an average size of 5.2 ha. Four categories of farm size, as marginal (<3 ha), small (3–6 ha), medium (6–9 ha) and large (>9 ha) were formed (Table 5). More than 80% of the surveyed households fall into the marginal and small categories. The trend toward small and marginal farm households appears to be increasing due to land fragmentation. Since farm labor per household is almost the same in all farm categories, there is an obvious advantage of increasing the labor to land ratio by decreasing the farm size. On average, the land use share of rubber was half the farm area while the share between farm sizes varied significantly. Marginal and small-scale

Table 5
Distribution of land use by farm size and farm labor

Farm size	Household (%)	Farm labor (person)	Labor to land ratio (person/ha)	Gross benefit* (Baht/ha)	Land use share (%)				
					Perennial crops*				Annual Crops*
					Rubber*	Fruit tree**	Other perennial crops*	Total*	
Marginal (<3 ha)	45.8	2.3	1.3	69,815	40.2	28.3	15.8	84.3	15.7
Small (3–5.9 ha)	35.1	2.5	0.5	42,329	59.4	14.7	17.3	91.4	8.6
Medium (6–9 ha)	8.9	2.4	0.3	33,630	55.5	8.9	10.8	75.2	24.7
Large (>9 ha)	10.2	2.7	0.1	41,030	54.4	7.7	10.3	72.4	27.6
Mean	45.8	2.4	0.4	54,218	49.7	19.7	15.3	84.7	15.2

*$P<0.05$;
**$P<0.01$, total surveyed households = 225.

farms also grow more labor-intensive crops, such as fruit trees, compared to the larger farms, which take advantage of greater labor availability. A similar finding has been reported by Rosset (1999). However, large farms showed a greater proportion of land use given over to annual crops requiring less labor. This can be explained partly by resource endowments and the nature of the market, supervision problems, imperfect credit markets and heterogeneity in farming skills (Feder, 1985; Eswaran and Kotwal, 1986). Though arguments remain concerning the relationship between farm size and productivity, the inverse relationship between farm size and gross benefit per unit area was observed in this study. This diminishing return per unit area with increased farm size is a result of limitations in credit, labor and market conditions (Assunção and Ghatak, 2003).

The availability of farm labor is an important factor in managing a farm of a given size. Most households in the study area had limited family labor. It was common to find only two people working in the farm. This limited the larger farms from to allocating more land for perennials (Fig. 2a). Large-scale farmers could sustain their land use with perennial crops whenever labor was available. Thus, the availability of farm labor was an important factor determining land use allocation; however, the farms in the study area did not totally rely on family labor, especially in the case of rubber. Since rubber production requires high labor during harvest, it was common practice to employ additional farm labor as sharecroppers when required. In sharecropping, landowners and sharecroppers shared both farm inputs and products at the rate of between 50–65% for landowners. Most sharecroppers were migrants from the northeastern region, landless people or local farmers with marginal land. Nevertheless, farmers who had marginal and small farms were likely to manage the farm on their own. Sharecropping was practiced more extensively in the case of medium- and large-scale farms.

The relationship between land tenure security and farm size is shown in Fig. 2b. Irrespective of land tenure category, the total share of perennial crops decreased with increasing farm size. This could be the consequence of the increasingly higher investment and management costs associated with farm expansion. However, farmers with insecure land tenure tended to have a higher percentage of their farm area under perennial crop cultivation in the hope of receiving land titles. Land use share for perennial crops also decreased for secure land tenure, but these farmers maintain a proportion of perennial crops on farms of extended size. This may be explained by the credit benefits available to secure land tenure farmers over other tenure regimes.

Determinants of land use allocation for perennial crops

Tobit analysis was employed to examine the relationship between land tenure, farm characteristics and land use allocation for perennial crops. Commonly used with probability or percentage data, the technique is useful to investigate the association of a censored continuous dependent variable with one or more independent variables (Long, 1997; Lesschen et al., 2005). It was appropriate for this study as land use share was censored with an upper limit of 100% and lower limit of 0% (Godoy et al., 1997; Predo, 2003; Baltenweck et al., 2004). Interpretation of the regression results stressed both the sign and statistically significant level of coefficients.

Table 6 shows that the regression analysis results support findings in the previous discussion on the effects of land tenure, farm size and labor on land use. The regression coefficients for all the variables were significant except for the amount of borrowings. The negative relationship between decisions to grow perennial or annual crops implies that farmers decide to grow less annual crops if they allocated more to perennial crops. Both dummy variables for land tenure security are positive, indicating that secure and temporary land tenure are both likely to have an influence on perennial crop investment. Similarly, the positive effects of settlement

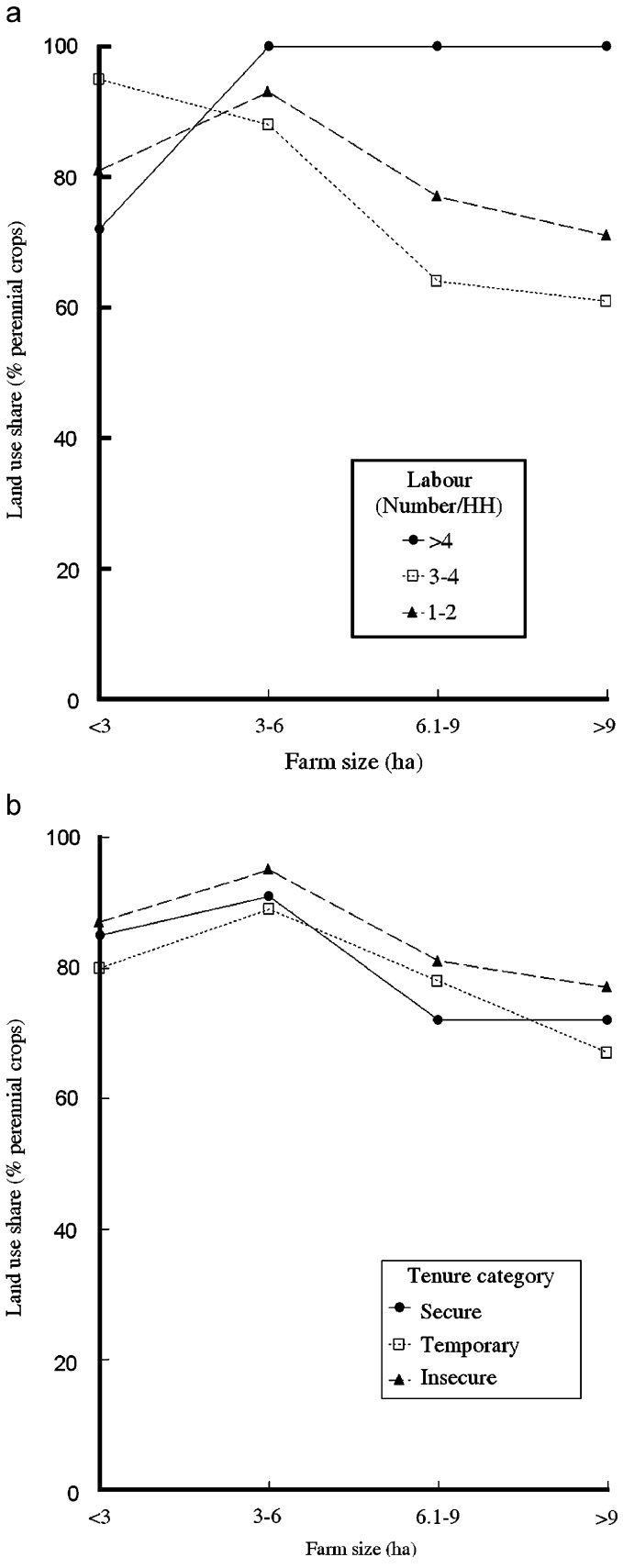

Fig. 2. Land use share with perennial crops as a function of (a) farm size and labor and (b) farm size and land tenure security.

Table 6
Tobit regression estimates for perennial crops growing decision

Variable	Coefficient	Standard error
Land use share with annual crops (%)	−1.17**	0.04
Secure land tenure (dummy)	41.81**	2.02
Temporary land tenure (dummy)	34.70**	2.13
Settlement inside forest reserve (dummy)	30.49**	2.27
Settlement duration (y)	0.44**	0.07
Cultivated area (ha)	−0.09*	0.03
Farm labor (person)	4.92**	1.04
Amount of borrowing (Baht/y)	5.36E–06	4.93E–06
Investment (Baht/y)	6.79E–05**	1.63E–05
Constant	14.63**	0.72

*$P<0.05$;
**$P<0.01$; 1US$ = approx. 40 Thai Baht.

duration and settlement inside forest reserve areas indicates that the longer the farmers have lived in the area, the more land they share for perennial crops, partly because of their assurance of continuing to use the land. Settlers inside the forest reserve with insecure tenure are likely to invest in tree crops similar to the other tenure regimes. Basic use rights are apparently sufficient to induce farmers to undertake investment, in expectation of acquiring legal status over the land they are cultivating.

Regarding farm characteristics, land use share with perennial crops showed a negative result relative to farm size, suggesting that the larger the acreage, the less the land use share of perennial crops. Conversely, increased availability of family labor leads to greater investment in perennials.

As anticipated, a positive relationship between investment and land use share in terms of the area under perennial crops was observed. However, while borrowing was found to be positively related with perennial land use, the amount of borrowing was not significant, thus suggesting that farm investment does not solely come from loans. Consequently, tenure security, investment, land and labor availability are all influential factors in the development of a particular land use pattern.

Discussion and implications

Land use changes in the Prasae watershed of Thailand are highly representative of both deforestation and land use modification throughout Southeast Asia, where farmers typically switch from shifting cultivation to cash crops and tree crop plantations (Long et al., 1999). A large-scale adoption of perennial crops as a "tree-crop zone" is mainly due to the demand for land registration, economic benefits, and resource availability. Lack of access to land in the case of landless settlers encourages forest conversion to perennial crops. This practice has been seen as an easy way of acquiring land, especially by some hungry land collectors, similar to other places in the world (Neef, 2001;

Brasselle et al., 2002). An estimated 80 to 100 million people in Southeast Asian countries reside in protected areas (Poffenberger, 1999) and of these 1.3 million households are in Thailand (MOAC and FINNIDA, 1993). Part of the problem of this on-going practice, which is likely to encourage further deforestation and degradation, is the policy of subsequently issuing titles to lands acquired through forest conversion. Under these circumstances, the issue is cyclically complex as access to land drives deforestation by planting trees to claim tenure over it, and further deforestation continues in order to acquire additional land.

Though investment in perennial crops is risky for non-titled farmers, they feel secure enough not to fear eviction or land conflicts with other landholders. This is partly due to the fact that most insecure farmers have paid land tax regularly to the local government. Though tax records only indicate that the taxpayer is a user of the land, they at least gain the right to use that land so long as tax has been paid. Moreover, landholders expect to obtain full rights in case of land registration or land distribution. The problem of land conflicts between landholders is also minimized since landholders have community-defined boundaries. This reflects a well-established customary tenure system that is cost-effective in ensuring secure tenure for landholders (Deininger and Feder, 1999).

The positive relationship between tenure security and investment in this study could be interpreted as a two-way relationship. The importance of land titles is found associated with credit access in order to gain higher income, which supports earlier arguments that land insecurity constrained credit access and productivity in several countries in Asia, South America and Africa (Feder and Nishio, 1999). In the study area, the opportunity to obtain institutional credit is not restricted to only landowners with collateral arrangement; the non-titled landholder can also obtain formal credit through group guarantee. However, the size of the loan available is smaller compared to those who use title deeds as collateral (It should be noted that temporary land title has recently been used as collateral for institutional loans under the Assets Capitalization Project established in 2004. However, this did not affect the results of survey data collected in 2005). Thus, households with secure and temporary tenure have greater opportunity to design a better land use system than those households with insecure tenure. In contrast, long-term investment could be found among insecure landholders, indicating that tenure security does not stimulate investment but rather is influenced by it. Econometric analysis suggests that insecure landholders go for long-term investment by planting perennial crops as a means to maintain their use rights on the land (Bruce, 1988; Brasselle et al., 2002).

Clearly, landholders prefer to own land officially; however, the social impact of having secured land tenure should be considered. Secure land tenure is always associated with property transfers to those who can make the best use of the land but it also facilitates land grabbing. In some villages, small farm holders easily lose their land to more powerful people. Almost the whole village land may belong to wealthy people, with the result that farmers become workers on their own farms. Such circumstances lead to a greater number of landless farmers with consequent social instability (Feder and Nishio, 1999), land fragmentation and natural resource degradation.

In addition to land tenure, the practice of cultivating mixed crops also requires adequate conditions for investment. Labor, for example, may be a greater requirement than cash in some cases (Harwood, 1995). Thus, it is inevitable to link farm resources with tenure through the economic advantage of different land tenure security. With a scarcity of land or labor, farmers may invest in less profitable crops appropriate to their resources. However, with less capital constraint, one can invest in crops that are more profitable with additional resources such as land rental or hired labor.

In order to improve the well- being of landholders and protect natural resources, policy makers should take an holistic approach. Lessons learnt from other parts of the world suggest that customary land tenure provides sufficient basic rights of land use (Migot-Adholla et al., 1991; Platteau, 1996). Land registration increases farmers' sense of security in their use of the land, but several issues have to be dealt with subsequently to reduce the risk of undesirable impacts (Feder and Nishio, 1999). Currently, the existing informal land right for insecure settlers is not critical regarding investment incentive, credit and economic benefits. However, the improvement of farm productivity and land resource conservation while protecting existing forest should be continued, partiuclarly with regard to protecting forest areas by restricting encroachment.

Whether land reform policy aimed at increasing tenure security of forest settlers favors or hinders forest conservation is still open to argument. Providing usufruct rights to forest encroachers neither reduces deforestation nor increases economic incentives (Wanapinit, 1987; Feder et al., 1988). Thus, a policy on land reform with effective monitoring should be applied with other policies on credit, agricultural improvement, subsidy and forest management. Owners can benefit from collateral arrangements using temporary documents for investment and encouraging land improvement. Since most reformed land areas are former degraded forest with low land quality, education programs could help improve farm productivity and prevent farmers from hunting for more land for production.

Land reform policy should consider the size of land required to make a sustainable living while providing land to the landless or even landholders. Given the limitation on land resources, the current plot size given under land reform programs was about adequate for small farm holders. In most developing countries, the majority of farmers are small-scale farmers; however, technology, subsidy or credit tends to favor farmers with larger landholdings. Hence, research and development into

small-farm friendly technology, subsidies, credit, and education based on the principles of self-sufficiency are crucial to any appropriate policy aimed at alleviating poverty and conserving natural resources.

Conclusion

Land use change is an important issue because of its impacts on the environment. Forest conversion to annual crops and subsequently to perennial crops is a typical land use change in the study area. The study revealed that factors like land tenure security, demand for land registration and resource availability are responsible for changes in land use. Forest encroachment and the plantation of perennials, e.g. rubber, were found associated with landholders who have insecure tenure and who seek to claim official land documents. Security is essential for investment incentives, credit access and productivity, but it is not the sole factor in decisions regarding the plantation of perennial crops. Land use decision making was also influenced by farm size and labor availability. Smaller sized farms tended to adopt labor-intensive perennial crops while larger farms had a greater share of land producing annual crops. Similarly, farmers with larger farm sizes but less labor to land ratio chose less labor-intensive annual crops and vice versa. To improve peoples' well- being while protecting the remaining forest, an effective policy should aim to (1) improve farm productivity and land quality in the case of land holders with insecure and temporary tenure; (2) provide usufruct rights and necessary support services to insecure land owners; and (3) establish a community-defined system, with government cooperation, as an alternative to ensuring land rights.

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References

Agricultural Land Reform Office (ALRO), 2003. List of area under land reform project in Thailand. Document No. 314. Ministry of Agriculture and Cooperatives, Thailand, 17pp. (in Thai).

Anderson, J.R., Hardy, E.E., Roach, J.T., Witmer, R.E., 1976. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper No. 964. United States Government Printing Office, Washington, 28pp.

Arnold, J.E.M., 1983. Economic considerations in agroforestry project. Agroforestry Systems 1, 299–311.

Assunção, J.J., Ghatak, M., 2003. Can unobserved heterogeneity in farmer ability explain the inverse relationship between farm size and productivity. Economics Letters 80, 189–194.

Ayalew, D., Dercon, S., Gautam, M., 2005. Property rights in a very poor country: tenure insecurity and investment in Ethiopia. GPRG-WPS-021, Global Poverty Research Group, 32pp.

Baltenweck, I., van de Steeg, J., Staal, S.J., 2004. Farming systems characterisation in the Kenyan highlands: use of alternative methodologies. Working document. ILRI, Nairobi, Kenya.

Brasselle, A., Frédéric, G., Jean-Philippe, P., 2002. Land tenure security and investment incentives: puzzling evidence from Burkina Faso. Journal of Development Economics 67, 373–418.

Bruce, J.W., 1988. A perspective on indigenous land tenure systems and land concentration. In: Downs, R.E., Reyna, S.P. (Eds.), Land and Society in Contemporary Africa. University Press of New England, Hanover, pp. 23–52.

Bundprasirichot, C., 2000. The dynamics of community for resource management: Thailand situation. Thailand Research Fund (TRF), Bangkok, Thailand.

Chomitz, K., Gray, D., 1996. Roads, land use, and deforestation: a spatial model applied to Belize. World Bank Economic Reviews 10, 487–512.

Deininger, K., Feder, G., 1999. Land policy in developing countries. Rural Development Note No. 3. The World Bank, 4p.

Eswaran, M., Kotwal, A., 1986. Access to capital and agrarian production organization. Economic Journal 96, 482–498.

Feder, G., 1985. The relation between farm size and farm productivity: the role of family labor supervision and credit constraints. Journal of Development Economics 18, 297–313.

Feder, G., Nishio, A., 1999. The benefits of land registration and titling: economic and social perspectives. Land Use Policy 15, 25–43.

Feder, G., Onchan, T., Chalamwong, Y., Hongladarom, C., 1986. Land ownership security, farm productivity, and land policies in rural Thailand. The Collaborative Project of the World Bank. Kasetsart University and Thammasat University, 210pp.

Feder, G., Onchan, T., Chalamwong, Y., 1988. Land policies and farm performance in Thailand's forest reserve areas. Economic Development and Cultural Change 36, 483–501.

Fox, J., 2002. Understanding a dynamic landscape: land use, land cover, and resource tenure in northeastern Cambodia. In: Walsh, S.J., Crews-Meyer, K.A. (Eds.), Linking People, Place, and Policy: A GIScience Approach. Kluwer Academic Publishers, Boston, Dordrecht, London, pp. 113–130.

Fox, J., Kanter, R., Yarnasarn, S., Ekasingh, M., Jones, R., 1994. Farmer decision making and spatial variables in northern Thailand. Environmental Management 18, 391–399.

Futemma, C., Brondizio, E.S., 2003. Land reform and land use changes in the lower Amazon: implications for agricultural intensification. Human Ecology 31, 369–402.

Godoy, R., O'Neil, K., Groff, S., Kostishack, P., Dubas, A., Demmer, J., Mcsweeney, K., Overman, J., Wilkie, D., Brokaw, N., Martinez, M., 1997. Household determinants of deforestation by Amerindians in Honduras. World Development 25, 977–987.

Harwood, R.R., 1995. Broadened agricultural development: pathway towards the greening of revolution. In: Marshaling technology for development. Office of International Affairs, pp. 145–160.

Holden, S., Yohannes, H., 2002. Land redistribution, tenure insecurity, and intensity of production: a study of farm households in Southern Ethiopia. Land Economics 78, 573–590.

International Land Coalition (ILC), 2004. Towards a common platform on access to land. IFAD, Italy, 17pp.

Lesschen, J.P., Verburg, P.H., Staal, S.J., 2005. Statistical methods for analysing the spatial dimension of changes in land use and farming systems. LUCC Report Series No. 7. The International Livestock Research Institute, Nairobi, Kenya and Wageningen University, the Netherlands, pp. 45–46.

Lillesand, T.M., Kiefer, R.W., 2000. Remote sensing and image interpretation, fourth ed. Wiley, New York, Chichester, Brisbane, Toronto, Singapore, 724pp.

Long, C., Fox, J., Xing, L., Lihong, G., Kui, C., Wang, J., 1999. State policies, markets, land-use practices, and common property: fifty years of change in Yunnan, China. Mountain Research and Development 19, 133–139.

Long, S., 1997. Regression models for categorical and limited dependent variables. Advanced Quantitative Techniques in the Social Sciences, vol. 7. Sage Publications, London, 297pp.

Migot-Adholla, S., Hazell, P., Blarel, B., Place, F., 1991. Indigenous land rights systems in sub-Saharan Africa: a constraint on productivity? World Bank Economic Review 5, 155–175.

Ministry of Agriculture and Cooperatives (MOAC) and FINNIDA, 1993. Thai Forestry Sector Master Plan, vol. 2. Executive Summary and Proposed Forestry Sector Policy, Thailand, 24pp.

Molle, F., Srijantr, T., 1999. Agrarian change and the land system in the Chao Phraya delta. DORAS-Delta Research Report No. 6. Kasetsart University, Bangkok, Thailand, 191pp.

Müller, D., 2003. Land-use change in the central highlands of Vietnam: a spatial econometric model combining satellite imagery and village survey data. Doctor of Philosophy Dissertation. Georg–August University of Göttingen, Germany, 165pp.

Neef, A., 2001. Land tenure and soil conservation practices- evidence from West Africa and Southeast Asia. In: Stott, D.E., Mohtar, R.H., Steinhardt, G.C. (Eds.), Sustaining the global farm. Purdue University and the USDA-ARS National Soil Erosion Research Laboratory, pp. 125–130.

Neef, A., Sirisupluxana, P., Sangkapitux, C., Heidhues, F., 2004. Tenure security, long-term investment and nature conservation-getting causalities and institutions right. Paper Presented at the 85th Seminar of the European Association of Agricultural Economists Agricultural Development and Rural Poverty Under Globalization: Asymmetric Processes and Differentiated Outcomes, Florence, Italy, September 8–11, 2004.

Onchan, T., 1990. A land policy study. The Thailand Development Research Institute Research Monograph No. 3. Thailand Development Research Institute Foundation, 136pp.

Onchan, T., Feder, G., 1985. Land tenure security and farm investment in Thailand. Discussion Paper No. 7. Center for Applied Economics Research, Kasetsart University, 35pp.

Pichón, F.J., 1997. Settler households and land-use patterns in the Amazon frontier: farm-level evidence from Ecuador. World Development 25, 67–91.

Platteau, J.P., 1996. The evolutionally theory of land rights as applied to sub-Saharan Africa: a critical assessment. Development and Change 27, 29–86.

Poffenberger, M., 1999. Communities and forest management in South-east Asia. A Regional Profile of the Working Group on Community Involvement in Forest Management (WG-CIFM), Berkeley, Gland Asia Forest Network and the World Conservation Union (IUCN), 135pp.

Predo, C.D., 2003. What motivates farmers? Tree growing and land use decision in the grasslands of Claveria, Phillipines. Economy and Environment Program for Southeast Asia (EEPSEA), Singapore, 56pp.

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.

Rosset, P., 1999. The multiple functions and benefits of small farm agriculture in the context of global trade negotiations. Policy Brief No. 4: The Multiple Functions and Benefits of Small Farm Agriculture. The Institute for Food and Development Policy, 22pp.

Routray, J.K., Sahoo, M., 1995. Implication of land title and farm credit in Thailand. Land Use Policy 12, 86–95.

Saenjan, V., 1999. Land use/cover change in Thailand. In: Otsubo, K. (Ed.), Land Use for Global Environmental Conservation (LU/CEC)—Final Report of First Phase (1995–1997), pp. 50–53.

Serneels, S., Lambin, E.F., 2001. Proximate causes of land-use change in Narok district, Kenya: a spatial statistical model. Agriculture Ecosystems & Environment 85, 65–81.

Turner II, B.L., Moss, R.H., Skole, D.L., 1993. Relating land use and global land-cover change: a proposal for IGBP-HDP core project. IGBP Report 24, HDP Report 5. IGBP, Stockholm.

UNEP, 2000. GEO-2000. In: UNEP: Global Environmental Outlook Earthscan 2000, pp. 72–97.

Walker, R., Wood, C.H., Skole, D., Chomentowski, W., 2002. The impact of land titling on tropical forest resources. In: Walsh, S.J., Crews-Meyer, K.A. (Eds.), Linking People, Place, and Policy: A GIScience Approach. Kluwer Academic Publishers, Boston, Dordrecht, London, pp. 131–154.

Wanapinit, S., 1987. Effects of land use patterns after Sor Tor Kor No. 1 land distribution: a case study of Mae Wong–Mae Pern forests in Nakhonsawan province 1987. Master thesis, Kasetsart University, Bangkok, Thailand, 143pp. (in Thai, with English abstract).

World Bank, 1983. Land title security and farm productivity: a case study in Thailand. Research Proposal, Agriculture and Rural Department.