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An analysis of factors affecting agricultural land use patterns and livelihood strategies of farm households in Kanchanaburi Province, Thailand

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An analysis of factors affecting agricultural land use patterns and livelihood strategies of farm households in Kanchanaburi Province, Thailand

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Development of specific agricultural land use patterns and livelihood strategies is affected by farm households' characteristics as well as exogenous factors. This study, based on a survey of 210 households in Kanchanaburi Province of Thailand, applied a stepwise multiple regression technique to analyze the factors influencing agricultural land use patterns and livelihoods. The result of the analysis revealed a number of influencing factors of economic, demographic, and physical characteristics. Multiple regression analysis showed that there were three and six significant factors explaining the crop acreage change in upland and lowland households, respectively, explaining 59–71% and 81–94% of variability of agricultural land use pattern. This indicates the adoption of different and changing agricultural land use strategies as influenced by exogenous factors.

Keywords: agriculture; land use patterns; livelihood strategies; socioeconomic factors; farm households; Thailand

1. Introduction

Development of certain rural land use, including agricultural land use, by the people is influenced by social, economic, and political factors (Lambin, Turner, and Geist 2001). The dominant rural land use by human activities, population dynamics, and agricultural policy leads to an expansion in agricultural areas or change in crops (Geist and Lambin 2002). The changes are often intended to increase the commercial production of cash crops. Cash crops response to market demands is a result of government's policy shifts. Rural household livelihood is largely based on a subsistence agricultural production system of Thailand. The system of production assists in fulfilling the demand for home consumption and in selling some surplus products to purchase the necessities, which are not grown on the farm. Being an agricultural country, Thailand has approximately 56.7% of its population engaged in farming (NSO 2001). Its present major exports of agricultural commodities such as rice, maize, and cassava reflect the country's dependency on agriculture.

Farmers' livelihoods are constrained by the amount of land available for food production in Kanchanaburi Province of Thailand, where this study was conducted. Shrinking farmland due to increasing population leads to increase in cropping frequency. The use

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of high chemical fertilizers to increase production has negative impacts on soil quality in the long term because the acidity in the soil increases. It affects the soil quality and the land becomes infertile. Kanchanaburi has a large proportion of its area dedicated to intensive crop cultivation. Although land use should be determined preferably based on land capability, land use decision-making is largely need-based as farmers need to grow rice to feed their own families and other cash crops such as sugarcane, corn, cassava, fruits, and vegetables for additional income (IPSR 2001).

In the study area, the household income depends on agricultural products, which are declining over time. Declining agricultural productivity is likely to decrease household income and cause breakdown in communal land management controls. The study area has experienced rapid land use and rural livelihood changes over the past decade. Five districts of Kanchanaburi Province have large agricultural areas of upland sugarcane and lowland paddy rice and also have important industries of sugar and agricultural products in the area. The study aimed at identifying the factors influencing land use change and documenting the changes in land use pattern between 2000 and 2007 in the study area with respect to rural upland and lowland farming systems.

2. Conceptual framework

Population growth, agricultural change, and livelihood strategy are strongly interlinked. Population growth causes an increasing demand for agricultural products and increasing availability of the labor force for agriculture. Rural livelihood is so dependent on agriculture that decline in agricultural productivity is likely to decrease household incomes and cause breakdowns in communal land management controls (PRB 1998). The Boserup's theory revealed the relationship between population pressure and agricultural change pattern, that is, increasing population leads to intensive crop cultivation (Boserup 1981; Marquette 1997). Intensive crop cultivation means more hours of work such as additional hoeing, weeding, multiple uses of land, the use of fertilizers, pesticides and herbicides, high productivity seeds, and improved irrigation (Cruz 1996).

Bilsborrow and Ogendo (1992) revealed that farmers' livelihood strategies shift the traditional crops to cash crops on small plots and resort to local off-farm employment for additional household income. Households' livelihood strategies are composed of activities that generate the means of household survival. The strategies are defined as the range and combination of activities and choices of farmers. Farmers do activities in order to achieve their livelihood goals, including productive activities and cropping investment (Ellis 2000; Eneyew and Bekele 2008). Schreinemachers and Berger (2006) explained that the farmers' decision in land use spans three stages: annual investment cost; production of crops including expected yields; and consumption of product based on actual yield and price. Reenberg (2001) studied that farmers select crops that do not necessarily share the same production purpose. Farmers' decision to select any crops depends on their available information. Entwisle, Walsh, Rindfuss, and Vanwey (2005) and Braimoh (2009) grouped the relevant factors of crop selection such as increased demand for food, market price, intensified labor use, labor active force, government incentive, agricultural market, agricultural technology, and chemical fertilizer.

The use of technology is an important condition for crop growing. Availability of technology affects the number of laborers in the farm because it replaces manual labor. The use of technology in agriculture also affects market growth and encourages the cultivation of higher value crops which leads to increased output per land unit. Vegetables, such as cabbage, cucumbers, and legumes, are important crops because these crops can be sold readily

so farmers can generate income faster. In addition, vegetables can be grown in any season as the water requirement can be managed relatively easily compared with the rice crop. Corn is another major crop for farmers due to its higher productivity and market demand.

Household characteristics and external factors, such as market price, tremendously influence people's land use decision-making regarding the choice of crop particularly when there is a guaranteed market and commodity price as there had been in Thailand. This often leads to the majority of farmers growing those promoted crops, for example, cassava, sugarcane, due to a guaranteed market and price set primarily to have adequate production for export. It is also true that their motivation to grow particular crops depends on the land ownership type and land holding size. Land ownership allows farmers to be able to perform some agricultural activities in their land particularly change of crop (Nielsen and Zobisch 2001).

3. Study area

The study area is located in Kanchanaburi Province of Thailand, 129 km to the west of Bangkok between 13°45′ to 15°40′ north latitude and 98°15′ to 99°53′ east longitude covering 19,483 km^2 (NSO 2001) and sharing border with Myanmar in the west. The study area consists of 14 villages of five districts, namely, Muang Kanchanaburi, Sai Yok, Tha Muang, Phanom Ton, and Bophlo (Figure 1). The total population is 835,282 (DOPA 2009)

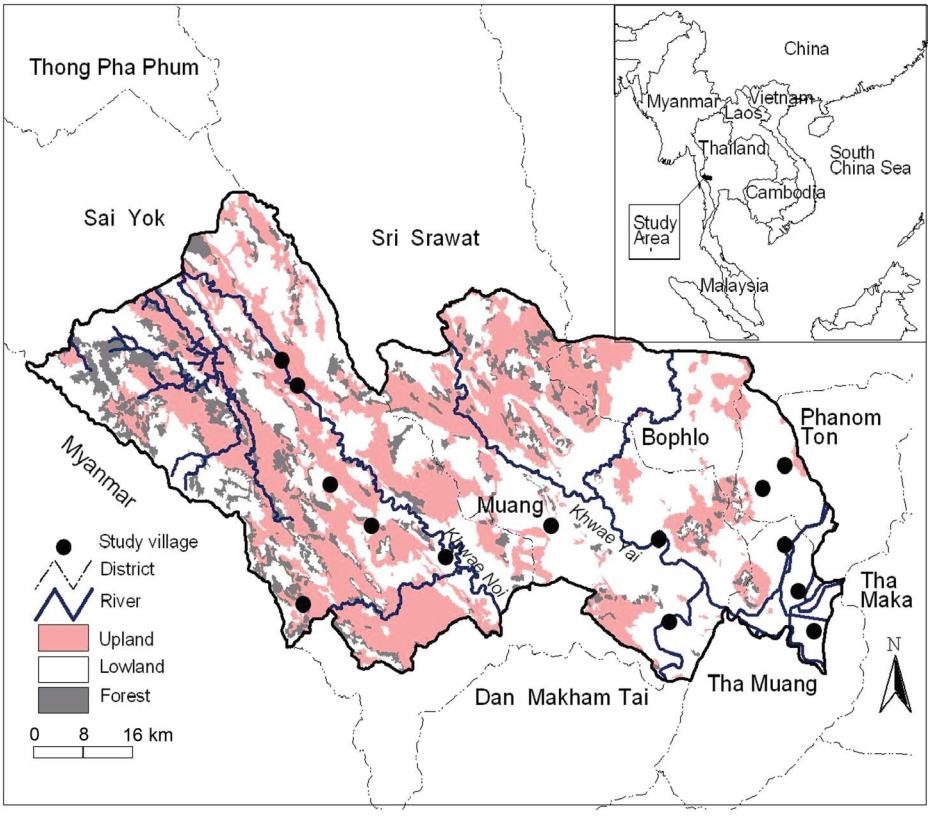

Figure 1. Location of study area in Kanchanaburi Province of Thailand.

with 1.02 male:female ratio. Apart from Thais, several ethnic groups, including Karen, Mon, Laotian, and Burmese, most of whom, except for the Karen group have settled in the plain rather than in the highland. The ecological units of study area were categorized into upland and lowland. Upland areas located in the northern part of the study area usually have crops other than rice. The upland is home to a variety of ethnic groups and has both documented and undocumented migrants. Land use has rapidly changed for intensive cropping and available crops are unique feature of the area. People practice mixed cropping and multi-cropping in some areas of upland. An inappropriate agricultural practice has resulted in land degradation such as soil erosion and fertility decline (Rindfuss *et al*. 2003).

Lowland area is usually under rice production with rice farming as the major occupation of lowland dwellers and other crops including cassava, sugarcane, and corn as the secondary occupation. The floodplain between Khwae Yai and Khwae Noi rivers is suitable for cropping, settlement, and industries due to fertile alluvial soils. However, the irrigation system is not sufficient for cropping in all areas. Farmers use rainwater, other natural sources such as canals, and constructed sources of water such as man-made ponds, small dams, and underground water (Sethaput 2005) for agriculture. The shortage of water can be a common problem, thus affecting the land use pattern in the area.

Kanchanaburi Province is well known due to its large cultivated area and big population, of which 54% of the labor force is involved in agricultural sector (Jampaklay 2005). The majority of the households in the province own land and agriculture is the mainstay (Boonchaiwatthana 2004). The farm systems are divided into upland farming, mostly sugarcane, and lowland farming, rice and cash crops. The improvement and development of a farm system was a serious issue as the farm development and management are limited by technology efficiency. So, the Royal Thai government promoted the suitable technology and innovation to grow cash crops for export by setting up a Mobile Clinic of Agriculture Program for Kanchanaburi in 2002 to provide extension support in solving all cultivation- and production-related problems (AEO 2002). Now, Kanchanaburi is one of those provinces of Thailand which has been transformed into an important source for intensive cash crops.

4. Methodology

4.1. Data collection

In this study, a field survey was conducted to collect socioeconomic data by administering structured interview questionnaires at the household level. The number of households for interview was determined based on the equation suggested by Yamane's (1967) given in Equation (1). A combination of stratified and random sampling was used to obtain the final sample households as follows:

$$n = \frac{N}{1+N(e)^2} \tag{1}$$

where n is the sample size; N is the population size; and e is the precision estimated at 7%. Of the total 1702 households in 166 villages, 14 villages were randomly selected from two strata, that is, upland and lowland areas. There were six villages (Kaeng Raboet, Wang Kra Chae, Yang Ton, Phu Noi, Nong Sampran, and Rang Kop) in the upland area and eight villages (Phu Pradu, Ko Samrong, Ta Chang, Nong Ta Puk, Nong Kae Ni, Phu Ruak, Lum Hin, and Makok Mu) in the lowland area. Finally, 210 households (120 from lowland area

Table 1. Sampled households by strata and study village.

Strata	Study village	Total households	Sampled households
Upland	Kaeng Raboet	136	16
	Wang Kra Chae	185	16
	Yang Ton	174	15
	Phu Noi	153	15
	Nong Sampran	121	16
	Rang Kop	60	12
Lowland	Phu Pradu	157	16
	Ko Samrong	120	16
	Ta Chang	137	16
	Nong Ta Puk	56	12
	Nong Kae Ni	110	16
	Phu Ruak	57	12
	Lum Hin	120	16
	Makok Mu	116	16
Total		1702	210

and 90 from upland area) were randomly selected from the group of villages in each stratum identified earlier for the questionnaire survey (Table 1). The collected information was related to household characteristics, land use type, and factors of land use decision-making.

4.2. Variable selection and data analysis

In identifying the factors of agricultural land use change, a set of factors representing cropping and socioeconomic factors was considered to run regression analysis (Lesslie, Barson, and Smith, 2006). The change of crop type and crop acreage by farm household is typical in the process of crop intensification. Hence, agricultural land use change can be considered as the acreage under new crops replacing the existing crops. Since many factors influence this process, the acreage of change of dedicated land area for intensive cultivation between years 2000 and 2007 was considered as the dependent variable in this study to find out the factors influencing crop intensification. A household's land use strategy depends on economic conditions because decision-making within a farm household regarding what crop to cultivate is highly influenced by external factors, such as market demand, commodity price, and additional income opportunities (Braimoh 2009). Typically, the income earning capacity of households in the study area depends on the size of land owned, the number of family members in the working age group, and the amount of non-land fixed assets used in production activities. The productivity of land would depend on the access to irrigation infrastructure, as it facilitates the adoption of high-yielding crop varieties and improved farming practices, labor productivity, and economic opportunities.

Independent variables were carefully selected as they influence the crop acreage change or decision to change land use often leading to intensification of land use practices (Schreinemachers and Berger 2006). These variables included the number of males and females in the household, household size, fertilizer expenditure, hired equipment expenditure, total household expenditure, household income, soil fertility, family active labor force (members 15–60 years of age), total land ownership, land area rented in and rented out, and crop yield index (Munroe and Muller 2006; Mwava and Witkowski 2008; Rowcroft 2008).

Initially, 27 independent variables representing internal and external factors that could possibly affect the crop acreage change were identified as shown in Table 2. A correlation analysis was carried out first to examine the correlation of independent variables. Table 2 shows the summary of those variables in terms of mean, SD, and their correlation with the dependent variable for both upland and lowland sample households. It is worth noting that all of them are not significantly related in all cases as presented at upland household group, lowland, and study area as a whole but at least in one context. The relationship, as expressed by the multiple correlation coefficients, between independent variables and the dependent variable (Elifson, Runyon, and Haber, 1998) was in general higher and significant in the case of lowland households compared with upland households. The large SD values for few variables also indicate the wide range among observed values particularly in the case of upland households.

4.3. Model specification

Land use is the change of the household activity, which is influenced by complex sets of socioeconomic factors. Given that the socioeconomic factors, as influenced by other underlying factors, are often dominant factors of change, this study used the socioeconomic factor to predict the extent of land use change for crop intensification.

Models of land use are capable of predicting the possible development of land use patterns in the future. They also tell us the relative influence of the variables affecting the land use pattern and such information can be useful for households and other stakeholders in determining the cropping strategy. With the purpose of identifying the most significant factors of land use change, explained as crop acreage intensification, we conducted a multiple regression analysis. At first, the principal component analysis extraction method, which uses quartimax with Kaiser normalization rotation technique, of factor analysis was used to identify the significant factors as principal components.

A multiple regression analysis, which can be represented as shown in Equation (2), was carried out to identify the most significant independent variables. Based on criteria such as factor loadings of individual variable and correlation of independent variable with dependent variable, 20 out of 27 initially identified independent variables were entered in multiple regression analysis to examine their relationship with crop acreage change as the dependent variable. The independent variables include both metric and non-metric data types. A stepwise method was used for specifying the regression model to be estimated. It is to be selected for inclusion in the model, which starts by selecting the best predictor of the dependent variable. Independent variables are added as long as their partial correlation coefficients are statistically significant. They are dropped if their predictive power drops to a non-significant level when another independent variable is added to the model as follows:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_nX_n \tag{2}$$

where Y is the dependent variable; $X_1, X_2, X_3 \ldots X_n$ represent independent variables; b_0 is the intercept; and $b_1, b_2, b_3, \ldots, b_n$ are the coefficient values of independent variables (Carlson and Thorne 1997). The models were constructed using the stepwise probability criteria of F-value of an ANOVA regression model to enter ≤ 0.05, and probability of F-value to remove ≥ 0.100 (Hair *et al*. 2006; Yila and Thapa 2008). The highest partial correlation values of independent variables are selected as predictor variables. Each time the variables included in the equation are examined for removal if partial correlation remains low (Maxmillan 1996).

Table 2. Description and multiple correlation coefficients of independent variables considered for regression analysis.

Variables code	Variables description	Upland ($n = 90$)			Lowland ($n = 120$)		
		Mean	SD	Correlation coefficient	Mean	SD	Correlation coefficient
Y	Crop acreage change per household (ha)	0.41	2.14		2.76	16.05	
X_1	Number of male members in household	2	1	0.11	2	1	0.23*
X_2	Number of female members in household	2	1	0.10	3	1	0.18*
X_3	Household size (number/household)	4	2	0.13	5	2	0.28**
X_4	Fertilizer expenditure (baht/year)	20,384	42,289	0.01	31,840	198,702	0.93**
X_5	Expenditure on equipment rental (baht/year)	12,267	13,533	0.55**	13,002	24,776	0.89**
X_6	Expenditure on hired labor (baht/year)	53,437	140,899	−0.03	48,313	238,718	0.96**
X_7	Total household expenditure (baht/year)	204,582	637,796	−0.03	153,017	493,762	0.87**
X_8	Total household income (baht/year)	289,632	675,336	−0.04	156,945	184,669	0.02
X_9	Adequate labor within household (dummy)	73.89	16.63	−0.12	61.62	27.74	0.07
X_{10}	Soil nutrient availability (dummy)	71.93	18.77	0.05	62.27	26.02	0.05
X_{11}	Family active labor force availability (%)	69.96	21.23	0.06	66.88	24.89	−0.10
X_{12}	Owned land for cropping (ha)	5.21	8.74	−0.10	4	4.01	0.32**
X_{13}	Rented land for cropping (ha)	1.52	6.34	0.24*	2.94	16.04	0.99**
X_{14}	Crop yield index (kg/ha)	77.04	98.77	−0.18	94.73	258.8	−0.04
X_{15}	Age of household head (years)	53.3	12.28	−0.07	56.14	12.92	0.05
X_{16}	Gender proportion of household head (male:female)	0.7	0.46	−0.06	0.71	0.46	0.11

(*Continued*)

Table 2. (*Continued*).

Variables code	Variables description	Upland ($n = 90$) Mean	Upland ($n = 90$) SD	Upland ($n = 90$) Correlation coefficient	Lowland ($n = 120$) Mean	Lowland ($n = 120$) SD	Lowland ($n = 120$) Correlation coefficient
X_{17}	Gender proportion 15–60 years of age (male:female)	0.46	0.25	0.01	0.44	0.23	0.04
X_{18}	Household has rice seed stock (%)	76.19	24.41	0.02	75	25.61	0.01
X_{19}	High expenditure (%)	90.04	12.42	0.03	81.43	27.83	0.05
X_{20}	Irrigation facility (%)	70	15.08	0.06	68.33	17.07	0.07
X_{21}	Proportion of investment (%)	60.89	20.75	0.07	60.89	20.72	0.05
X_{22}	Expenditures on crop seed (baht/year)	17,336.21	34,947.56	−0.07	23,634.08	115,019.59	0.13
X_{23}	High commodity price (baht/kg)	7.38	18.28	0.04	4.79	8.88	−0.07
X_{24}	Increase net income (baht/ha)	510,53.45	105,547.61	0.05	38,529.97	83,181.79	−0.03
X_{25}	Number of market centers	2.66	0.48	0.10	2.74	0.44	0.09
X_{26}	Distance to the market center (km)	38.19	47.26	−0.09	28.56	36.35	0.06
X_{27}	Total agricultural product per year (kg/ha)	175,994.4	20,261.45	−0.07	24,027.4	81,952.49	0.01

Notes: Correlation coefficient (Pearson correlation) is the relationship between crop change (Y) and the respective independent variable, except for variables X_9 and X_{10}, which are Spearman rank correlation and these variables were dummy.
Baht is Thai currency (1 US$ = approximately 34 baht).
Crop yield index (CYI) is computed as follows: CYI = ($S_{1...n}$–Min)/(Max–Mean) × 100, where $S_{1...n}$ is the value from 1 to 210.
*, ** Indicate correlations which are significant at 0.05 and 0.01 levels, respectively.

5. Results

5.1. Crop selection and change in land use

Sugarcane was the dominant crop[1] for most of the households in both upland and lowland areas as this crop is grown in the majority of areas under the possession of a farm household in both cases. However, the proportional area of sugarcane cultivation within a farm household was found to steadily decline from 6.1 ha in 2000 to 5.0 ha in 2007 in upland areas, from 10.2 ha to 9.4 ha for the same period in lowland areas, while cassava was on the increase from 1.9 ha in 2000 to 2.2 ha in 2007 (Table 3). Cassava is an important economic crop[2] both in upland and lowland areas. In lowland areas, corn was another dominant crop in the past but has been declining from nearly 2.9 ha in 2000 to 1.5 ha 2007, while cassava was on the increase from 0.6 ha in 2000 to 0.7 ha in 2007. This was due to the fact that the government promoted cassava cultivation nationwide as there was very high scope for international export.[3] The expansion of cassava is usually the commercial orientation of farming in Kanchanaburi because cassava is primarily sold to the European market as a calorie-rich livestock feed (Rindfuss *et al*. 2003). This is true in many other regions of Thailand where a sharp increase in cassava growing can be observed. Corn is a more staple food than sugarcane, which is an economic crop with lots of sugar industries around. Corn cultivation experienced a much larger decline than sugarcane.

Upland areas fruit cultivation per household (e.g., grapes, bananas, oranges, peanuts) increased over time from nearly 0.8 to 1 ha during the study period as the area is indeed suitable for fruit farming and also the crop requires relatively less care and is less risky. Paddy area is steadily decreased in upland areas because the farmers needed to grow the cash crop that is easy to sell. So it is in the case of vegetable farming. Since 2000, a sharp increase in vegetables was observed. Vegetables occupied nearly 1.4 ha of farm size in 2000 but 2.3 ha in 2007. This is largely due to the availability of markets for vegetable production and increasing awareness of vegetable consumption.

In lowland areas paddy has remained as one of the major crops due to its subsistence and economic value to the households. Paddy area has stable cultivation in lowland because farmers preferred to grow crops that have market demand. Also rain-fed rice can easily be grown on relatively flat landscapes with high organic matter (Walsh, Entwisle, Rindfuss, and Pages 2006). Corn is the third important crop in lowland areas and has variation in terms of temporal acreage distribution as hectare per household of farm size was observed. Traditional crops such as cotton and eucalyptus, however, decreased between 2000 and 2007 because of decreasing yield due to loss of soil fertility, but more importantly because of market failure and low price as a result of changing preference over other crops.

Table 3. Crop acreage per household in 2000 and 2007.

	Upland ($n = 90$)		Lowland ($n = 120$)	
Crops	2000 (ha)	2007 (ha)	2000 (ha)	2007 (ha)
Sugarcane	6.1	5.0	10.2	9.4
Paddy	0.5	0.4	1.7	1.7
Corn	2.9	1.5	3.1	2.2
Cassava	1.9	2.2	0.6	0.7
Vegetables	1.4	2.3	0.6	0.7
Eucalyptus	0.2	0.4	0.2	0.2
Cotton	0.3	0.2	0	0
Fruits	0.8	1.0	0.3	0.4

Crop changes in the upland areas dramatically increased between 2000 and 2007 because most of the cash crops have a high price and more market demand. On the contrary, changes in the lowland steadily decreased in 2007. This indicates that the landholders bring about the land use changes based on locally defined needs and goals (Verburg, Groot, and Veldkamp 2003) and most often framed by agricultural policy.

5.2. Reason for crop selection and change

An interesting trend was observed in terms of the proportion of households who performed land use change during the years 2000 and 2007 between upland and lowland households. Of upland households, 44.4% responded that they changed their agricultural land use during 2000 against 36.7% in the case of lowland households and with no change in land use, 55.6% against 63.3%. In 2007, a greater proportion of upland households (74.4%) performed change against only 25.8% from lowland households and with no change in land use, 25.6% against 74.2% (Table 4). Such a huge change in the case of upland areas can be attributed to the increased interest of farmers on cash crops with market demand, which gives relatively quick and better return. However, a much slower increase was observed in the case of lowland respondents due to relatively established farming systems compared with upland systems and also less flexibility for alternate land uses.

Some of the main reasons why the farmers changed their crops were the higher commodity price in general in the study area as a whole and particularly with upland respondents, where about 36.7% households changed the land use during 2007 (Table 4). As mentioned earlier, the government promoted cash crops such as cassava by assuring the commodity price, which motivated the farmers to grow cassava without risking the ordinary market system governed by demand–supply theory. There were a number of other reasons for changing the crop in the farmland, but being easier to sell, having low production cost and thus high benefit, and market demand were the major reasons in the case of upland households. The reasons were similar in the case of lowland households.

Table 4. Proportion of households who have changed their land use and reason for change.

	Upland ($n = 90$)		Lowland ($n = 120$)	
Status	2000 (% HH)	2007 (% HH)	2000 (% HH)	2007 (% HH)
No change in land use	*55.6*	*25.6*	*63.3*	*74.2*
Change in land use	*44.4*	*74.4*	*36.7*	*25.8*
Reason for change				
Higher commodity price	20.0	36.7	13.3	12.5
Low production cost	7.8	6.7	5	2.5
Easy to sell products	5.6	10	1.7	4.2
Flexible growing season	3.3	2.2	1.7	0
Higher production	3.3	1.1	0	0.8
Low water requirement	2.2	2.2	0	0.8
Higher demand for commodity	1.1	3.3	4.2	2.5
Neighbor's suggestion	1.1	2.2	1.7	1.7
Previous crop was not profitable	0	4.4	5	0
Government incentives available	0	3.3	0.8	0
Farmers' liking	0	1.1	0	0
Less labor requirement	0	1.1	3.3	0
Private company incentives available	0	0	0	0.8

Note: HH, households.
Italic values indicate percent of HH status of no change and change in land use.

5.3. *Factors influencing agricultural land use*

Representing various possible characteristics of the farming system, for example, input, labor, economic, and biophysical, was followed by factor analysis to extract the group of variables as various components (Table 5).

These 20 variables, identified to be used in multiple regression analysis, described as six factors or components having an eigenvalue >1.0 were extracted from the factor analysis, which included a total of 20 out of 27 independent variables in either of the component based on the higher data loadings, which indicates correlation between original variable and its factor interpreted as correlation coefficient. These variables with higher factor loadings are likely predictor variables of crop change as represented by intensified crop acreage change. The variances explained by the first to the sixth factors were 16.72, 11.16, 10.87, 9.72, 7.74, and 6.81%, respectively, with a cumulative variance of 63.02% in upland areas (Table 5) and 17.81, 15.17, 13.82, 9.63, 8.63, and 6.23%, respectively, with a cumulative variance of 71.30% in lowland areas (Table 6).

According to multiple regression analysis, it was found that only 7 out of 20 variables were significant in explaining the observed land use change in terms of crop acreage intensification in both cases. In case of upland households, stepwise regression yields three significant variables as shown through three different models in Table 7 and they were expenditures on equipment rental (X_5), soil nutrient availability (X_{10}), and owned land area for cropping (X_{12}).

In case of lowland households, six variables were found to have significant relationship with crop acreage change and thus six models containing combination of those six variables were generated by stepwise regression. Two variables, expenditures on equipment rental (X_5) and soil nutrient availability (X_{10}), were common to both upland and lowland. Additional significant variables included were fertilizer expenditure (X_4), household income (X_8), crop yield index (X_{14}), and gender proportion 15–60 years of age (X_{17}). All of the models were significant at 99% confidence limits. The models explained prediction of variability of intensified crop acreage as indicated by computed R^2 ranging from 0.59 to 0.71 in case of upland households and from 0.81 to 0.94 in case of lowland households. Thus, the agricultural land use change models for the lowland area explained the variability best among all strata, indicating high level of explanatory power as seen by a relatively high adjusted R^2 compared with the models for upland area.

6. Discussion

Agricultural intensification in the study area is a major form of land use change, in many instances, on the cost of multiple crops. This has been happening as the farmers need to increase income to support their livelihood through the increase in labor, fertilizer, technology, and irrigation for the improved production and economic sustainability (Mahdi, Shivakoti, and Schmidt-Vogt 2009). In addition, the Thai government has been promoting cash crop cultivation, for example, cassava, vegetables, and fruits. This has resulted in a decrease in traditionally grown crops such as sugarcane, corn, and cotton particularly in upland areas, indicating the more pressing livelihood needs in the uplands as opposed to lowlands. The increase in crop area does not only involve subsistence farming but also cultivation of commercial crops (Pare, Soderberg, Sandewall, and Ouadba 2008). As a result, traditionally grown sugarcane and corn crop decreased in all strata over the study period. Crop acreage change is larger in the upland areas than in lowland areas brought about by changing socioeconomic reasons. As Entwisle *et al*. (2005) put and Boserupian

Table 5. Factor analysis of variables affecting agricultural land use in upland.

Variables	Factors						Communality
	1	2	3	4	5	6	
Number of male members in household	0.14	**0.81**	0.24	−0.18	0.12	0.01	0.78
Number of female members in household	−0.38	**0.73**	−0.26	0.16	−0.01	−0.18	0.80
Household size (number/household)	−0.15	**0.93**	−0.02	−0.01	0.07	−0.11	0.91
Fertilizer expenditure (baht/year)	**0.71**	−0.16	−0.15	−0.05	0.06	0.20	0.60
Expenditure on equipment rental (baht/year)	−0.02	0.00	−0.14	0.12	0.17	0.38	0.20
Expenditure on hired labor (baht/year)	**0.93**	0.05	−0.09	−0.01	−0.07	−0.10	0.90
Total household expenditure (baht/year)	−0.06	0.03	−0.07	**0.90**	−0.08	0.12	0.84
Total household income (baht/year)	−0.06	0.04	−0.08	**0.90**	−0.08	0.12	0.84
Adequate labor within household (dummy)	0.22	0.12	0.47	−0.06	−0.12	−0.08	0.31
Soil nutrient availability (dummy)	−0.18	−0.04	0.28	0.40	0.01	0.56	0.59
Family active labor force availability (%)	0.25	−0.08	−0.38	−0.40	−0.50	0.18	0.66
Owned land for cropping (ha)	−0.11	−0.03	−0.28	−0.20	−0.21	**0.82**	0.85
Rented land for cropping (ha)	**0.92**	0.06	−0.10	0.02	−0.03	−0.13	0.88
Crop yield index (kg/ha)	−0.08	0.20	−0.09	−0.28	0.35	0.20	0.29
Age of household head (years)	0.16	−0.07	−0.54	0.27	0.04	0.01	0.40
Gender proportion of household head (male:female)	0.04	0.02	0.08	−0.60	−0.19	0.09	0.41
Gender proportion 15–60 years of age (male:female)	0.19	0.00	0.10	−0.01	0.03	0.57	0.37
Household has rice seed stock (%)	0.11	0.58	0.00	0.03	−0.06	0.11	0.37
High expenditure (%)	0.06	0.02	−0.04	**0.69**	0.10	0.09	0.50
Irrigation facility (%)	0.13	0.30	−0.10	0.07	0.45	−0.04	0.32
Proportion of investment (%)	0.10	0.27	−0.05	0.26	−0.54	0.24	0.50
Expenditures on crop seed (baht/year)	**0.91**	0.10	0.19	−0.05	−0.18	−0.03	0.91
High commodity price (baht/kg)	−0.08	−0.07	**0.85**	0.05	−0.03	−0.08	0.74
Increase in net income (baht/ha)	0.01	−0.09	**0.92**	0.02	0.09	0.07	0.86
Number of market centers	−0.13	0.02	−0.02	0.20	**0.83**	0.29	0.83
Distance to the market center (km)	**0.67**	−0.28	0.28	−0.17	0.35	0.17	0.79
Total agricultural product per year (kg/ha)	0.24	−0.40	−0.14	−0.06	0.46	−0.04	0.45
Eigenvalue	4.35	2.90	2.83	2.53	2.01	1.77	
Percentage of variance	16.72	11.16	10.87	9.72	7.74	6.81	
Cumulative percentage	16.72	27.87	38.75	48.47	56.21	63.02	

Note: The factors in bold are significant factors.

Table 6. Factor analysis of variables affecting agricultural land use in lowland.

Variables	Factors						Communality
	1	2	3	4	5	6	
Number of male members in household	0.58	−0.14	**0.67**	−0.15	0.01	0.00	0.83
Number of female members in household	**0.78**	0.06	−0.16	−0.16	0.02	−0.04	0.66
Household size (number/household)	**0.85**	−0.05	0.32	−0.19	0.02	−0.02	0.86
Fertilizer expenditure (baht/year)	0.06	0.52	0.09	−0.10	0.32	**0.66**	0.83
Expenditure on equipment rental (baht/year)	−0.21	0.33	0.33	0.03	**0.62**	0.45	0.85
Expenditure on hired labor (baht/year)	0.03	−0.04	−0.32	−0.59	0.49	−0.06	0.70
Total household expenditure (baht/year)	−0.41	0.04	−0.25	**0.68**	0.05	−0.22	0.75
Total household income (baht/year)	−0.25	−0.02	−0.52	**0.62**	−0.31	−0.07	0.83
Adequate labor within household (dummy)	0.49	−0.04	−0.15	−0.53	−0.17	−0.19	0.60
Soil nutrient availability (dummy)	0.12	**0.70**	−0.48	−0.23	0.09	0.04	0.80
Family active labor force availability (%)	–**0.80**	−0.17	−0.30	−0.22	0.06	0.09	0.82
Owned land for cropping (ha)	−0.10	−0.15	−0.14	0.01	**0.90**	−0.22	0.91
Rented land for cropping (ha)	−0.14	−0.08	0.32	−0.12	−0.10	**0.65**	0.58
Crop yield index (kg/ha)	−0.06	**0.97**	0.03	0.10	−0.10	−0.02	0.97
Age of household head (years)	**0.71**	−0.22	−0.20	0.01	−0.08	0.04	0.60
Gender proportion of household head (male:female)	−0.08	0.13	**0.78**	0.17	0.17	0.10	0.70
Gender proportion 15–60 years of age (male:female)	0.16	0.06	**0.72**	−0.01	−0.36	−0.08	0.69
Household has rice seed stock (%)	0.25	0.02	0.22	**0.71**	0.01	0.02	0.62
High expenditure (%)	−0.17	0.09	0.26	**0.74**	0.19	−0.07	0.69
Irrigation facility (%)	−0.05	−0.08	**0.62**	0.23	−0.04	0.14	0.47
Proportion of investment (%)	−0.20	−0.26	0.30	−0.33	0.07	−0.54	0.60
Expenditures on crop seed (baht/year)	0.41	−0.14	−0.12	0.34	0.55	0.15	0.64
High commodity price (baht/kg)	−0.08	−0.11	0.13	0.13	−0.02	−0.37	0.19
Increase net income (baht/ha)	−0.08	**0.97**	0.08	0.09	−0.07	0.05	0.96
Number of market centers	−0.52	0.13	0.51	0.04	−0.15	−0.04	0.57
Distance to the market center (km)	−0.21	−0.19	0.21	0.18	−0.08	**0.66**	0.60
Total agricultural product per year (kg/ha)	−0.10	0.97	0.09	0.09	−0.05	0.08	0.97
Eigenvalue	4.81	4.10	3.73	2.60	2.33	1.68	
Percentage of variance	17.81	15.17	13.82	9.63	8.63	6.23	
Cumulative percentage	17.81	32.98	46.81	56.43	65.06	71.30	

Note: The factors in bold are significant factors.

Table 7. Regression estimates of predictor variables of agricultural land use pattern.

	Upland			Lowland					
Predictor variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	−1.07	−0.53	−0.42	−2.01	−1.61	−2.23	−3.72	−4.30	−4.37
Expenditures on equipment rental (baht/year)	0.01	0.01	0.01						0.05
Owned land for cropping (ha)		−0.13	−0.12						
Soil nutrient availability (dummy)			1.09					2.16	2.23
Fertilizer expenditure (baht/year)				0.02	0.03	0.02	0.02	0.02	0.01
Crop yield index (kg/ha)					−0.04	−0.04	−0.03	−0.04	−0.04
Total household income (baht/year)						0.04	0.05	0.06	0.06
Gender proportion 15–60 years of age (male:female)							3.18	4.23	4.14
F-ratio	43.94	30.88	24.44	126.16	107.09	83.35	75.29	73.26	70.25
R	0.77	0.82	0.85	0.90	0.94	0.95	0.96	0.97	0.97
R^2	0.59	0.67	0.71	0.81	0.88	0.89	0.91	0.93	0.94
Adjusted R^2	0.57	0.65	0.69	0.80	0.87	0.89	0.91	0.92	0.93
SE	1.43	1.29	1.23	2.46	1.97	1.84	1.70	1.55	1.45
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

(1981) theory revealed, the technology use affecting agricultural change sets the stage for additional cash-cropping production in upland areas. The perceived reasons for land use change in the study area are availability of market, technology and fertilizer uses, rented land, accessibility, and economic growth. The changing of the cash-cropping areas is the result of farmers' decisions and reflects the priority of possible land uses (Mwava and Witkowski 2008). The traditional crops grown in Kanchanaburi are harvested more than once annually because the cultivated areas are supported by the rainfall and irrigation system. In addition, technological progress affects the frequency of crop growing per annum and the irrigation improvement associated with high agricultural production (Rowcroft 2008).

The use of correlation analysis exposed the pattern of land use and strategy showing that there is a simple correlation between crop change and a farmer's decision-making factors which lead to an intensified cropland by a household. Obviously, the variables as determining factors of intensification of certain crops vary in relation. For example, owned land for cropping and crop yield index are negatively correlated with intensified crops acreage, whereas several others are positively correlated. It was also observed that the same variable exhibits a different type of relation with intensified crop acreage. For example, in upland areas where the average size of owned land parcel was significantly larger than in the lowland context, this variable is negatively related to crop acreage intensification.

Multiple regression analysis of the specific land use models is based on socioeconomic factors for understanding the causes and consequences of changes because they are useful for disentangling the complex suite of factors that influence the estimating of land use change. The land use model of the study area indicates the efficiency of prediction under the viewpoint of individual landowners who make land use decisions to maximize expected returns or utility derived from their land. Most cash crops were grown in the upland area rather than in the lowland area because crops can be grown on higher areas where submerged conditions do not take place (Vityakon 2004). Lowland areas have fewer options since the cultivated areas of paddy could not be changed easily to other crops because of terrain and flood conditions. Moreover, the intensification of cropland parcels by renting from the landlords who live in the city would be an additional expenditure for farmers. The factors of land use change, that is, crop acreage change, clearly show an inherent link between factors and intensified crop acreage. It also demonstrates that the nature of the factors at different spatial levels is different. In the upland case, the intensification is characterized by the influence of input factors, whereas it is income-related factors which are dominant in the case of lowland areas.

7. Conclusion

The study discusses comparative estimates of change in land use types separately in upland and lowland contexts in Kanchanaburi, Thailand. There has been a significant change in land use as demonstrated by the change in crop acreage during the period 2000–2007. Changes in market price of agricultural products and the opportunity to obtain some money by selling products have played an important role in determining the kind of upland crops to grow at any particular time. The pattern and strategy of land use explained how a household decision on what to do affects its land use pattern (Axinn and Barber 2003). Cash cropping is rapidly increasing particularly in the upland areas for the reason that farmers are willing to bring change in the land use pattern, pressed by economic problems, government's encouragement and support for change, and in the presence of options for change

compared with the lowland areas. This is due to the impact of market growth, availability of resources such as owned land, inputs, and increasing commercialization of agriculture arising from sociopolitical and economic change in national and international levels as recognized by several researchers such as Rindfuss *et al*. (2003), Vityakon (2004), and Coxhead, Rola, and Kim (2005).

The included variables in the developed models suggest that the factors determining land use change as expressed by intensified crop acreage are context based. These can actually be different in upland and lowland farming contexts, which implies the need for different strategies if the issues of land use change, sustainability of farming system, and peoples' livelihood are to be dealt with.

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Notes

1. Dominant crop refers to the large cropped area of farm households.
2. Important economic crop refers to the high value of production per kilogram.
3. International export means selling goods and services produced in home country to other markets.

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