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Original Article

Determinants of Land Use Change in Phonthong County, Phonxay District, Luang Prabang Province, Lao PDR

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ABSTRACT

Land use change is a key global issue with significant impacts on human livelihoods and the environment. This study aims to identify the factors influencing land use change practices among local communities in Phonxay District, Luang Prabang Province, in the Northern Uplands of Lao P.D.R. A binomial logistic regression analysis was conducted to examine the determinants of land use change, based on data collected through structured interviews with 252 households in two villages. The questionnaire focused on demographic and economic characteristics, land tenure, physical conditions, and institutional factors. The results indicate that significant factors influencing land use change in Phonthong County include landholding size, product prices, access to quality extension services, distance, and household income. These variables were found to strongly influence local land use decisions. The findings suggest that demographic-economic characteristics, land tenure systems, physical factors, and institutional support all play a crucial role in shaping land use practices. To promote more sustainable land management in the Northern Uplands, policy measures should be tailored to the local context, encouraging communities to adopt responsible and sustainable land-use practices. This includes empowering local people to manage their village resources effectively and implementing context-specific policies that enhance sustainable land resource management.

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INTRODUCTION

Land use change is a critical global issue that significantly affects human livelihoods and the environment. Forest reduction, in particular, results from both internal and external factors. Internal factors often stem from subsistence farming, while external factors are driven by market demand. Other drivers include population growth and poverty (Lao, 2005). (Bhattarai et al., 2009) identified multiple factors contributing to deforestation in development centres, such as the conversion of forest land to farmland. These include gender, age, farming population, distance, road access, elevation, migration, river erosion, and more. According to (Newby et al., 2014) Forest change is mainly driven by three issues: forest policy, land use intensification, and economic development. In response, the Lao government has made efforts to reduce deforestation in the highlands caused by shifting cultivation. These efforts include introducing sustainable land use systems at the village and household levels (Douangsavanh et al., 2006). While natural resource use remains vital for rural livelihoods, it is also a major driver of land use change through illegal logging, agricultural expansion, and population growth (Kamwi et al., 2015). Development policies have influenced land use patterns at the local level, but land use decision-making remains complex, influenced by more than just forest fires.

Other factors include accessibility, landscape features, soil depth, and the value of timber and non-timber forest products (Monzón-Alvarado et al., 2012). (Evans et al., 2006) noted that land use decisions, even in seemingly simple contexts, are diverse and often driven by early economic returns. As such, researchers and policymakers have increasingly focused on the linkages between land use and land cover change (LUCC) and the dynamics of human-environment systems at broader scales. LUCC is influenced by decisions at both household and individual levels, shaped by socio-economic, biophysical, and environmental factors (Bilsborrow, 1987; Brown et al., 2013; Giri et al., 2003; Lambin et al., 2003; Mitsuda & Ito, 2011). Globally, land use change significantly impacts livelihoods and ecological balance, contributing to climate change through interactions between spatial, biological, and temporal processes (Agarwal, 2002). As (Anaafo, 2015) argues that land use change is a key marker of global environmental transformation driven by human activity. The intensification of land use through deforestation, land development, and forest degradation alters soil structure, biodiversity, and ecosystem services, threatening ecological security at regional and global scales (Kong et al., 2006); (Valbuena et al., 2010)). Empirical causes of LUCC include resource scarcity, population growth, decreased land availability, market-driven land use shifts, external policy interventions, and diminished adaptive capacity among local populations (Lambin et al., 2003). For example, in Guilan, changes in agricultural land use were most affected by socio-economic conditions and policy-related management (Allahyari *et al*., 2013).

Despite efforts by the Lao government since the 1990s, including the land use planning and land allocation program aimed at protecting forests and supporting socio-economic development, these initiatives are widely viewed as unsuccessful. Studies show that they negatively impacted subsistence livelihoods (Lestrelin et al., 2011), created social tensions (Fujita & Phanvilay, 2008) and even led to further forest encroachment (Hansen, 1997). Socio-economic and environmental factors continue to influence ecological land change (Xie et al., 2017), while farmer decisions are shaped by factors such as farm size and labour availability (Wannasai & Shrestha, 2008). Although the Lao government imposed a ban on illegal logging in the 1990s, forest degradation has continued, largely due to policies allowing degraded forests to be used for agriculture and because of internal migration (Thapa, 1998).

In response to these complex challenges, this study focuses on one main objective: to identify the factors influencing land use change practices among local people. This includes examining demographic-economic characteristics, land

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tenure, physical conditions, and institutional contexts. The study seeks to answer key questions: What are the main determinants influencing land use change decisions?

LITERATURE REVIEW

Ethnicity is represented as a dummy variable, measuring whether the individual belongs to the Khumu ethnic group (coded as 1) or a minority ethnic group (Laosoung or Laoloum, coded as 0). Studies have shown that different ethnic groups in Laos, such as the Lao, Khmu, and Hmong, have distinct practices regarding shifting cultivation and their production systems. These groups aim to both provide for subsistence and generate income (Sodarak, 1999). Land-use issues often arise from the relocation of villages in the highlands, leading to isolation. Factors that positively influence the decision to grow fruits and vegetables include membership in the Hmong community (Fox et al., 1994).

Age measures the age of the household head compared to other individuals in the household. Several studies have shown that the age of the household head influences land-use conversion (Nualnoom et al., 2016). Additionally, household head age is negatively related to forest-related income at the 0.05 significance level (Hogarth et al., 2013).

Educ is a dummy variable that measures the educational attainment level of the household head. It is coded as 1 for an educated household head and 0 otherwise. The coefficient for the education variable shows a positive relationship with land-use decisions (Johnson et al., 1997). The level of education among farmers influences land-use practices, with education from primary to secondary school levels being associated with a reduction in deforestation rates (Pan & Bilsborrow, 2005). Educational attainment of the household head is statistically positively correlated with income from non-timber forest products (NTFPs) at the 0.05 significance level (Liu & Moe, 2016). However, the variable of educational attainment is negatively significant concerning land-use change (Boundeth et al., 2012).

Household size refers to the total number of individuals within a family. The number of family members available for farm labour can influence land-use conversion decisions (Nualnoom et al., 2016). A decline in labour availability, combined with capital intensification, has been shown to significantly affect land-use decisions (Hao et al., 2015). Additionally, larger households are less likely to participate in non-farm work and tend to be more engaged in agricultural activities compared to smaller households (Ghimire et al., 2014).

D-forest measures the distance from the village to the forest area. Households located closer to forest areas are more likely to engage in land-use change practices compared to those farther away. Forest dependency is negatively associated with distance from the forest; villagers living closer to forests tend to rely more on them (Gunatilake, 1994). Additionally, distance from the forest is also a key factor that strongly influences forest loss (Mon et al., 2012).

D-road measures the distance from the farming area to the main road. Households located closer to main roads are more likely to engage in land-use change practices compared to those farther away. The distance to main roads is negatively correlated with forest cover, with areas closer to roads experiencing more disturbance and forest loss, significant at the 0.05 level (Boundeth et al., 2012). Furthermore, farmland located within 500 meters of a main road has a higher probability of undergoing land-use change due to easier access and proximity to infrastructure (Boundeth et al., 2012).

The price of products refers to the value at which goods are sold by households. Households that receive higher prices for their products are more likely to engage in land-use change practices compared to those receiving lower prices. Price fluctuations have been found to influence land-use decisions more significantly than agricultural land expansion. Additionally, the output of all land uses is negatively and statistically significant at the 0.01 level (Marcos-Martinez et al., 2017). On the other hand, an increase in price fluctuations

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and associated risks also impacts land-use change, with all land-use shares showing a positive and statistically significant relationship (Boere et al., 2015).

Slope measures the degree of land inclination, which affects accessibility for land-use activities. Households located on steeper slopes are generally less likely to engage in land-use change practices compared to those situated on flatter terrain. The altitudinal slope limits accessibility and influences the extent of land that can be used for agricultural production (Bader & Ruijten, 2008). Moreover, slope has been found to have a negative and statistically significant correlation with forest area loss over time, indicating that areas with higher slopes experience less deforestation (Htun et al., 2013; Muller & Zeller, 2002).

Elevation measures the altitude of an area, which influences land-use decisions. Households located at higher elevations are generally less likely to engage in land-use change practices compared to those at lower elevations. Some evidence suggests that elevation is positively correlated with a decrease in forest cover, with higher elevations showing more forest loss at the 0.01 significance level (Phompila et al., 2017). However, other studies have found that elevation is negatively and significantly correlated with long-term forest area loss, indicating that areas at higher altitudes may be less affected by land-use change (Htun et al., 2013; Vance & Geoghegan, 2002).

Access to credit is a dummy variable that measures whether households have access to credit services for farming development activities. It takes the value of 1 if the household has access to credit, and 0 otherwise. Access to credit has been shown to positively influence land allocation decisions for crop cultivation (Kokoye et al., 2013). Furthermore, the availability of credit from both formal and informal sources has a statistically significant positive effect on smallholder farmers' decisions regarding land allocation (Rashid et al., 2002).

Extension access (Extension acc) is a dummy variable that measures whether a household has access to agricultural extension services for farming development activities. It takes the value of 1 if the household has access to extension services, and 0 otherwise. Numerous studies have found that access to extension services has a significant positive impact on sustainable agricultural practices. For example, (Jabbar et al., 2020) found that access to extension services positively influences the adoption of agricultural intensification practices aimed at sustainability. Furthermore, (Oyetunde-Usman et al., 2021) highlighted that access to extension services is an important endogenous factor influencing the adoption of agricultural technologies.

Tinc measures total household income, including earnings from forest products, agriculture, livestock, and wages from both farming and non-farming activities. Households with higher income levels are generally more likely to engage in land-use change practices than those with lower incomes. However, income sources and their impacts on land use vary.

Several studies highlight the complex relationship between income types and land use. (Fu et al., 2009) found that gross income from non-timber forest products (NTFPs) in Baka and Daka villages is negatively correlated with household income at significance levels of 0.09 and 0.08, respectively, indicating that poorer households depend more on NTFPs. (Suleiman et al., 2017) note that NTFPs contribute 20–60% of total household income in many cases, and their use is significantly influenced by factors such as gender, age, occupation, household size, and distance to forests and markets. (Mcelwee, 2008) found that over half of rural households receive a significant portion of their cash income from forest environments. Agricultural income also plays a critical role. (Kamanga et al., 2009) Argue that while households with lower agricultural income are less involved in forest-based income generation, higher agricultural income doesn't necessarily reduce forest dependency, many households rely on both (Mujuru & Obi, 2020) found that total farm income is significantly and

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positively associated with food security at the 1% level. Regarding income from livestock, Mcelwee (2008), observed a negative correlation with forest income, while livestock itself was found to positively influence land cover change and natural forest impact (Nzunda et al., 2013). (Nkamleu, 2007) noted that livestock grazing negatively affects soil nutrient retention.

Land title is a dummy variable that measures whether a household possesses legal land ownership, classified under either permanent or temporary rights. It takes the value of 1 if the household has land property rights, and 0 otherwise. Land titles are closely associated with land-use decisions, such as the use of land for forestry, pasture, or perennial crops. Ownership tends to encourage long-term investments and the adoption of sustainable land-use practices. Additionally, secure land tenure can help reduce encroachment and deforestation (Pan & Bilsborrow, 2005). (Liu & Moe, 2016) found that ownership of agricultural land is negatively correlated with dependency on non-timber forest products (NTFPs), suggesting that landowners are less reliant on forest resources. Conversely, land tenure insecurity has been shown to significantly and positively influence land cover change, indicating that insecure land rights may lead to more rapid and potentially unsustainable alterations in land use (Nzunda et al., 2013).

Land size (Permanent/Temporary) measures the total area of land under either permanent or temporary ownership that is potentially subject to land-use change. Households with larger land areas are generally less likely to adopt new land-use practices compared to those with smaller landholdings. Several studies support this relationship. For instance, (Nguyen et al., 2017) found that farmland size negatively affects the use of land for annual crops, suggesting that households with larger land areas are less likely to shift to intensive cropping systems. (Nzunda et al., 2013) Revealed that the expansion of farm size significantly and positively influences land-use and land-cover changes (LUCC), indicating that larger farms may contribute more to changes in land patterns over time.

MATERIALS AND METHODS

Study Area

Phonthong is a county within Phonxay District, covering a total area of 43,362 hectares. It comprises seven villages with a combined population of 5,359 (Luangprabang, 2018). For this study, two villages Boukham and Viengchaleun were selected, with a total population of 1,547. Both are located near the Nam Et-Phou Louey National Park.

Boukham Village is situated approximately 56 kilometres from the Phonxay district centre. The majority of its population belongs to the Kumu ethnic group, and the village consists of 125 households. Viengchaleun Village lies around 60 kilometres from the district centre and also has a predominantly Kumu population, with a total of 127 households. These two villages were chosen as the focus areas for this research.

The geographic coordinates for Boukham are approximately latitude: 19°59'5.85"N and longitude: 102°55'37.62"E, while Viengchaleun is located at latitude: 19°59'20.24"N and longitude: 103°4'12.33"E. The location of the study sites is illustrated in Figure 1

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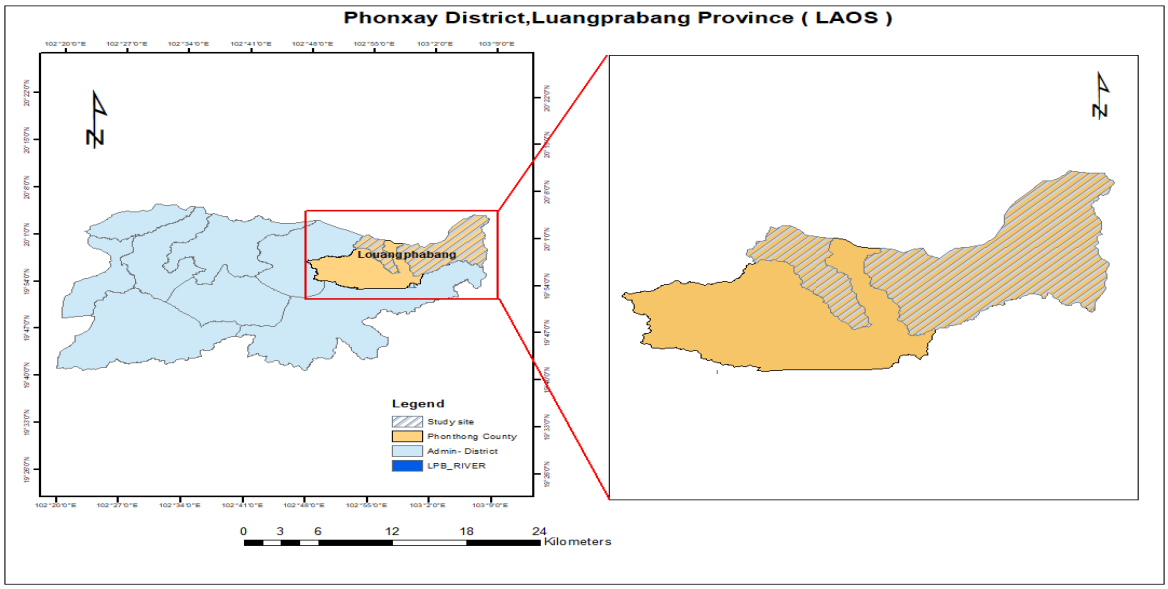
Figure 1: Study Site



To obtain primary data on the current context of land use change practices in Phonthong County, two villages were randomly selected from a total of seven. The goal was to identify the determinants influencing land use change in terms of socio-economic, land tenure, institutional, and physical factors.

A structured household questionnaire was used to collect data on demographic characteristics, socio-economic conditions, land tenure status, and institutional and physical factors. Interviews were conducted with either the household head or an available household representative.

The data collection process involved three main stages. The first stage was the selection of a representative district within Luangprabang Province, based on land use activity. The second stage was the selection of representative villages within the selected district. The third stage involved determining the sample size and conducting a full household survey in the two selected villages in Phonxay District.

In total, 252 households were surveyed in 2021 using cross-sectional data. These villages were chosen due to their noticeable intensification of land use change compared to other villages, particularly due to encroachment on land within the Nam Et-Phou Louey National Park, as they share its borders. These are considered poor villages, with underdeveloped infrastructure, poor road access, and limited electricity.

Most residents depend heavily on natural resources, practising subsistence farming and livestock husbandry. Economic development in the area is slow due to its mountainous terrain, which limits the availability of land for permanent agricultural production, especially rice paddies and other crop farming. Many residents lack sufficient land to produce adequate food, leading to illegal encroachment into forest areas for rice cultivation, livestock rearing, and the collection of non-timber forest products (District, 2019). To represent the population, a complete list of households was obtained from village headmen and elder committees, identifying 252 households across the two villages. One representative from each household preferably the head was selected to participate in the survey based on their ability to provide relevant information.

The data collection was conducted between December 5, 2020, and February 5, 2021. This study aims to explore land use change and its associated factors, which are central to understanding current and future land management strategies in the region.

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Empirical Model of Binomial Logit

This study employed a regression model using STATA 14 to identify the determinants influencing land use change practices. Cross-sectional data collected in 2021 were analyzed using a binomial logistic regression model. The purpose of this model was to examine the likelihood of households adopting different land use practices, particularly upland crop cultivation and other agricultural land uses. The dependent variable was binary, representing the choice of a specific land use type coded as lying between zero and one.

Following previous studies such as (Handavu et al., 2019; Verburg et al., 2002) Binary logistic regression was applied to analyze land use and land cover change (LUCC) and its determining factors. Similarly, employed this method to assess environmental and socio-economic determinants influencing land use change at the local level. Additionally, (Goswami et al., 2012) used logistic regression to examine factors affecting farmers' decisions regarding land clearing for agricultural purposes. These studies provided a foundational basis for the methodological approach used in this research.

Let Y_i The dependent variable in the natural binary takes the value 1 in case a household practices land use change, and 0, a household does not. P_i, the probability that a household practices land use change, and 1-P_iThe probability that a household does not. According to (Gujarati, 2004; Hosmer Jr et al., 2013) The general logistic regression equation used to estimate the probability of land use change practices by local people is expressed as follows:

$$P_i = \frac{e^{\beta_i \chi_i}}{1 + e^{\beta_i \chi_i}} \quad (1)$$

Where, β_i is the coefficient, and X_i It is an explanatory variable. Therefore, the equation is rewritten by the models below:

$$\left(\frac{P_i}{1 - P_i}\right) = \beta_i X_i \quad (2)$$

The replacement by odds ratio for land use change practice, where the logit equation is the natural logarithm of odds. Therefore, the model was defined by the following;

$$L_i = In\left(\frac{P_i}{1 - P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots\cdots + \beta_k X_k \quad (3)$$

The model proposed the analyzing factors that influence land use change practice is specified below, and describes the statistical factors that are presented in Table 1

$$Y_i = f\,(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, \varepsilon_i) \quad (4)$$

Where,

Y_{UC1} = 1, if local people are practicing land use change (Rice), and 0, if local people do not

Y_{UC2} = 1, if local people are practicing land use change (Crash crop), and 0, if local people do not

Y_{OA3} = 1, if local people are practicing land use change (Feeding), and 0, if local people do not

Y_{OA4} = 1, if local people are practicing land use change (Grass grain fields), and 0, if local people do not

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X_1 = Ethnicity within the village, X_2 = age of the household's head, X_3 = educational attainment of the household, X_4 =Number of members of a household, X_5 = Distance from the village to the forest area, X_6 = Distance from a farming area to the main road, X_7 = Price of products is sold by people, X_8 = Contrasts accessibility for activities, X_9 = Point of elevation that being land use, X_{10} = Access to credit by household head, X_{11} = Access to extension service, X_{12} = Total income from many sources, X_{13} = The land has the property rights, X_{14} = Land size of temporary rights, X_{15} = Land size of permanent rights, ε_i = random disturbance term

RESULTS

Factors Influencing Land Use Change Practice

The results obtained from the binomial logistic regression analysis revealed that land use change (LULC) practices were influenced by various independent variables, including demographic and socio-economic factors, land tenure, physical characteristics, and institutional aspects, as presented in Table 1.

According to Table 1, 88.10% of the respondents belonged to the Khumu ethnic group, while 12.08% were from the Laosoung and Laoloum ethnic groups. The age of respondents ranged from 41 to 60 years, with an average age of 43.6 years. About 76% of the respondents had attained primary school education. The average household size was approximately 5.93 persons, with a minimum of 1 and a maximum of 13 members. The average distance from the village to the forest area was 4.15 kilometres, and from the farm area to the main road was 2.86 kilometres. The average slope of the land was 10.92 degrees, while the average elevation was 678.14 meters above sea level. Regarding institutional access, 17% of respondents had access to credit services, while 82.54% had access to extension services. The respondents' total monthly income from all sources exceeded 1,600,000 Kip, with an average income of 806,225.7 Kip. The breakdown of monthly income sources is as follows: Non-Timber Forest Products (NTFPs): less than 100,000 Kip, average 99,678.02 Kip; Agricultural income: ranged from 100,000 to 250,000 Kip, average 189,745.4 Kip; Livestock income: ranged from 100,000 to 250,000 Kip, average 241,828.7 Kip; Wage income: ranged from 100,000 to 250,000 Kip, average 424,179.9 Kip.

Additionally, 100% of respondents possessed land titles, which included both permanent and temporary rights. The average temporary land size was 4.294 hectares, while the average permanent land size was 0.043 hectares.

According to Table 1, land use was converted to other types of land use over time. This included practices where households changed upland crop areas into rice fields or cash crop plantations, and repurposed agricultural land for livestock grazing and grass cultivation, aiming to improve economic returns and provide feed for their animals.

The estimated results from the binomial logit model are presented in Table 1. Among the predictor variables, 10 determinants were found to be statistically significant at the 1%, 5%, and 10% significance levels. The model achieved a prediction accuracy ranging from 73.56% to 88.94%, based on pseudo-R^2 statistics, indicating that the binomial logit model was an appropriate and well-fitting regression. The independent variables significantly explained the variation in the dependent variable, with the overall model statistically significant at the 1% level, as confirmed by the Chi-Square test.

Table 1 further showed that the variables eth1 (ethnicity), age, education (educ), distance to the forest (d-forest), price of products, and total

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income (tinc) were statistically significant at the 5% level. Meanwhile, household size, distance to road (d-road), extension service access (extension acc), elevation, land title, and temporary land size were statistically significant at the 10% level. Notably, only tinc and temporary land size were statistically significant at the 1% level, indicating a strong influence on households' decisions regarding land use changes, particularly for upland crops and other agricultural practices.

The results indicated that certain explanatory variables related to socio-economic status, land tenure, physical, and institutional characteristics significantly influenced land use change practices. The model was estimated using a binomial logistic regression, as presented in Table 1. The study provided key statistical evidence showing the association between several factors and land use change behaviour.

One notable finding was related to the ethnicity variable, which had a negative coefficient and was statistically significant in influencing land use change practices. Specifically, the results suggested that individuals from the majority ethnic group (Khamu) were less likely to engage in land use changes for activities such as rice cultivation (b = -1.188, p = 0.044), cash crop production (b = -1.355, p = 0.017), and livestock feeding (b = -1.370, p = 0.042) when compared to individuals from minority ethnic groups (Laosung).

A positive coefficient for age indicated that younger household heads were more likely to engage in land use changes for grass grain fields (b = 0.044, p = 0.010) compared to older household heads. Similarly, the positive coefficient for educational attainment suggested that households with no formal education were more likely to practice land use changes for grass grain fields (b = 1.247, p = 0.009) than those with some level of education.

In contrast, the negative coefficient for household size implied that smaller households were slightly less likely to convert land for rice cultivation (b = 0.267, p = 0.062) when compared to larger households.

A negative coefficient for the distance from the village to the forest area indicated that households located closer to the forest were slightly less likely to engage in land use changes for grass grain fields (b = 0.269, p = 0.028) compared to those located farther away. Similarly, the negative coefficient for the distance from the farm to the main road suggested that households located farther from the main road were slightly less likely to convert land for cash crops (b = 0.194, p = 0.054) compared to households with farms closer to the main road.

A negative coefficient for the price of products indicated that households receiving lower product prices were slightly less likely to engage in land use change for cash crops (b = 2.821, p = 0.043), compared to those receiving higher prices. Conversely, a positive price coefficient showed that households with higher product prices were more likely to practice land use change for grass grain fields (b = 2.892, p = 0.006), relative to households receiving lower product prices.

A negative coefficient for extension service accessibility indicated that households without access to extension services were slightly less likely to engage in land use change for cash crops (b = 1.306, p = 0.069), compared to households with access to extension services.

A negative elevation coefficient indicated that households located at elevations above 50 meters were slightly less likely to practice land use change for livestock feeding (b = 0.002, p = 0.061), compared to households situated at elevations below 50 meters.

A negative total income coefficient indicated that households with higher income were more likely to practice land use change for rice growing and livestock feeding (b = 1.29e-06, p = 0.000; b = 8.99e-07, p = 0.008, respectively), compared to households with lower income. In contrast, the same negative coefficient also suggested that households with higher income were slightly less likely to engage in land use change for crash crops

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(b = 6.50e-07, p = 0.012), relative to lower-income households.

A positive land title coefficient indicated that households with land titles were more likely to engage in land use change for livestock feeding (b = 1.382, p = 0.097), compared to households without land titles. Additionally, positive coefficients for temporary land size suggested that households with larger temporary landholdings were more likely to practice land use change for crash crops (b = 0.318, p = 0.001), livestock feeding (b = 0.244, p = 0.060), and grass grain fields (b = 0.187, p = 0.059), compared to households with smaller land sizes.

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Table 1. Results of Factors Influencing Households' Decisions on Land Use Change Practices in Phonthong County, Phonxay District, Luang Prabang Province

Factors	Upland crop (Uc)						Other agriculture (OA)					
	Rice			Cash crop			Feeding			Grass grain fields		
	B	Exp(B)	P-value	B	Exp(B)	P-value	B	Exp(B)	P-value	B	Exp(B)	P-value
Eth1	-1.188	0.304	0.044**	-1.355	0.257	0.017**	-1.370	0.253	0.042**	-0.242	0.784	0.643
Age	-0.003	0.996	0.864	-0.025	0.974	0.129	0.022	1.022	0.368	0.044	1.045	0.010**
Educ	-0.408	0.664	0.483	-0.181	0.834	0.661	0.594	1.812	0.438	1.247	3.481	0.009**
Household size	-0.267	0.765	0.062*	0.008	1.008	0.934	0.143	1.154	0.277	0.040	1.041	0.699
D-forest	0.089	1.093	0.538	0.057	1.058	0.613	-0.148	0.861	0.316	-0.269	0.763	0.028**
D-road	-0.079	0.923	0.532	-0.194	0.823	0.054*	0.045	1.046	0.748	0.173	1.189	0.125
Price of products	-1.114	0.327	0.274	-2.821	0.059	0.043**	-1.954	0.141	0.069*	2.892	18.029	0.006**
Access credit	-1.491	0.225	0.118	-0.908	0.402	0.137	0.635	1.887	0.369	0.042	1.043	0.943
Extension acc	1.014	2.757	0.331	-1.306	0.270	0.069*	1.746	5.733	0.117	0.561	1.753	0.453
Slope	-0.002	0.997	0.943	-0.012	0.987	0.645	0.044	1.045	0.307	-0.020	0.979	0.514
Elevation	0.001	1.001	0.380	0.0009	1.000	0.391	-0.002	0.997	0.061*	0.0005	1.000	0.647
Tinc	1.29e-06	1.000	0.000***	-6.50e-07	0.999	0.012**	8.99e-07	1.000	0.008**	3.43e-07	1	0.154
Land title	-0.953	0.385	0.139	-0.248	0.779	0.597	1.382	3.983	0.097*	0.308	1.361	0.532
Temporary	0.205	1.228	0.089	0.318	1.375	0.001***	0.244	1.276	0.060*	0.187	1.205	0.059*
Permanent	8.196	3627.41	0.133	5.295	199.506	0.472	-42.273	4.37e-19	0.141	-8.739	0.0001	0.320
Constants	-1.490	0.225	0.405	5.790	327.334	0.002	-3.362	0.034	0.074	-7.320	0.0006	0.000
Number of obs = 208				208			208			208		
LR chi2(15) = 35.28				62.23			64.39			57.57		
Prob > chi2 = 0.0022				0.0000			0.0000			0.0000		
Pseudo R2 = 0.2147				0.2245			0.3605			0.2215		
Goodness of fit test by Hosmer-Lemeshow chi2(8) = 8.15				9.08			1.72			10.99		
Prob > chi2 = 0.4188				0.3353			0.9884			0.2022		
Correctly classified = 88.94%				73.56%			88.46 %			75.96%		

*Mark * statistical significantly at level of p-value (***: p<0.01, **: p<0.05, *: p<0.1)*

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DISCUSSION

Based on the results presented in Table 1, the study identified several determinants that influence households' decisions regarding land use change practices. These factors include ethnicity, age, education, household size, distance from the village to the forest area, price of products, distance from the farming area to the main road, total household monthly income, extension service accessibility, and total temporary land ownership size. In Phonthong County, Phonxay District, land use for upland crops was significantly influenced by factors such as ethnicity (eth1), age, education (educ), distance from the forest (d-forest), and price of products ($p < 0.05$). Meanwhile, household size, distance from the road (d-road), and extension service accessibility (extension acc) were significant at the 10% level ($p < 0.1$), while income from non-timber forest products (tinc) and temporary land rights were significant at the 1% level ($p < 0.01$). Table 1 shows that a decrease in the distance from the forest (d-forest) reduced the likelihood of households using grass grain fields by approximately 26%, while an increase in temporary land ownership raised the likelihood of households engaging in cash crop production by about 31%.

The positive and statistically significant coefficient for ethnicity1 supports the hypothesis and shows that minority ethnic groups (Laosung and Laoloum) were slightly less likely to engage in land use change practices such as growing rice, cultivating cash crops, and feeding livestock compared to the majority ethnic group (Khamu). Specifically, the probability of the majority ethnic group being more likely to adopt land use change practices such as growing rice, cultivating cash crops, and feeding livestock was higher. These results are consistent with findings from previous studies. For example, (Tran Duc Luan, 2009) notes that the land use systems of the Laosoung people have changed over time, shifting from swidden agriculture to sedentary agriculture, with ethnicity being a key driver of land use and land cover change (LULCC) (Overmars & Verburg, 2005). Additionally, factors such as ethnicity play a significant role in forest clearing, with ethnic groups clearing nearly 3 hectares more forest than others (Carr, 2005).

The positive and statistically significant coefficient for the age variable presents results opposite to the hypothesis, implying that younger households were more likely to engage in land use change practices, specifically with grass grain fields, compared to older households. According to the study, for every additional year of age, the probability of selecting land for grass grain fields increased. This aligns with findings from (Damene et al., 2020), which reveal that the age of the household head strongly influences decisions regarding land allocation, with a statistically significant positive effect on the amount of land allocated to growing plants (grass pea). As the age of the household head increases by one year, the amount of land allocated to plant cultivation increases by approximately 0.002 hectares. Age is an important factor in land use dynamics, as older individuals tend to have a better understanding of land use and land cover changes (Tran et al., 2018). Additionally, age significantly affects a farmer's decision to continue farming (Alassaf et al., 2011), and farmers' age is a positive determinant of land use decisions (Islam et al., 2020).

Similarly, a positive and statistically significant coefficient for the education variable supports the hypothesis, indicating that household heads with higher education levels were more likely to engage in land use change, specifically in grass and grain fields, as a livelihood strategy, compared to those who were uneducated.

The results align with findings from several studies. For instance, (Marenya & Barrett, 2007) revealed that the educational attainment of respondents has a positive and significant effect on the adoption of practices that improve natural resource management. Additionally, (Oyetunde-Usman et al., 2021) point out that education plays a crucial

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role in the adoption of sustainable agricultural practices and land-use intensification.

A positive and statistically significant sign on the household size variable indicated that the results were opposite to the hypothesis. It suggested that smaller households were slightly less likely to practice land use change for growing rice compared to larger households. This finding contradicts previous research, such as the study by (Gessesse et al., 2015) which found that household size has a positive effect on reforestation, afforestation, and agroforestry systems. Larger families, in particular, tend to use a larger portion of their landholdings. Increasing household size is generally expected to correlate with a higher likelihood of land use change decisions. This effect on household size and land use change practice becomes clearer when considering that the average household size in this study was 5.9 persons. Furthermore, the decision to engage in rice-growing decreased, possibly due to households seeking better outcomes from rice cultivation. Another study (Newell et al., 1997) notes that family size positively influences the demand for farm labour, with larger families being able to produce slightly more per hectare with less labour per hectare.

The negative and statistically significant sign on the d-forest variable supported the hypothesis and indicated that households located farther from the forest were less likely to practice land use change for grass grain fields compared to those closer to the forest. Specifically, as the distance from the village to the forest increased by 0.5 km, the probability of selecting grass grain fields for land use change decreased. However, the probability of selecting rice-growing and cash crop land use practices increased. These results are consistent with studies by, and, which show that distances of 0.3-3 km from the forest significantly influence deforestation. The forest land in the village regions is increasingly converted into agricultural land for various uses (Entwisle et al., 2008). Additionally, deforestation in developing regions is influenced by factors such as distance and roads, with most of the forestland being converted to farmland (Bhattarai et al., 2009).

The negative and statistically significant sign on the price of products variable supported the hypothesis and indicated that households with lower product prices were slightly less likely to practice land use change for cash crops compared to households with higher product prices. A positive coefficient for the price of products indicated that households with higher product prices were more likely to engage in land use change for grass grain fields compared to households with lower product prices. These results align with several previous studies, which identify that higher commodity prices significantly influence changes in crop acreage and agricultural land use patterns in upland areas (Santiphop et al., 2012). Similarly, (Djaenudin et al., 2016), found that land use characteristics in Indonesia are significantly influenced by product prices. Furthermore, the factor of product prices was statistically significantly positive in influencing landowners' decisions regarding land use, especially for satisfying plant-related needs (Karelakis & Tsantopoulos, 2017).

The positive and statistically significant sign on the tinc variable supported the hypothesis, indicating that for each 10,000-kip increase in household income, the probability of selecting cash crops in land use change practice decreased, while the probability of selecting feeding and rice growing for land use change practice increased. These results are consistent with several studies, such as (Alassaf et al., 2011), who found that farm income influences farmers' decisions to continue farming. Additionally, the majority of households' median net income (80.2%) is derived from agriculture and livestock production (Soriano et al., 2017), and over 50% of household income comes from activities related to the forest and farming (Luna et al., 2020). Moreover, annual income is a significant determinant of land use change decisions (Islam et al., 2020) Income sources are key factors in altering land use patterns (Silva et al., 2017).

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The negative and statistically significant sign on the d-road variable supported the hypothesis, implying that households farther from the farm to the main road were less likely to practice land use change for cash crops compared to households with shorter distances. As the distance from the farm to the main road increased by 0.5 km, the probability of selecting cash cropland for land use change practice decreased by approximately 19%. However, the probability of selecting land for feeding and grass grain fields for land use change practice increased by about 4% and 17%, respectively. These results align with several studies, including those by (Carr, 2005; Kucsicsa & Dumitrică, 2019), which found that the distance from farms to roads negatively impacts deforestation at the farm level. Distance from the forest road is a critical factor in converting forest land into farmland (Bhattarai et al., 2009). Additionally, the distance from villages to roads strongly influences farmland use (Zhang & Li, 2015).

The negative and statistically significant sign on the extension accessibility (extension acc) variable was opposite to the hypothesis, indicating that households with access to extension services were slightly less likely to engage in land use change for cash crop cultivation compared to those without access to such services. This suggests that the use of land for cash crops decreased among households with extension service access. In contrast, households without access to extension services were more likely to practice land use change for feeding and grass grain fields.

The results were in contrast with many previous studies. For example, the study by (Cherotich et al., 2021), found that access to extension services has a positive relationship with loan uptake and supports the adoption of sustainable agricultural practices. Similarly, (Oyetunde-Usman et al., 2021) emphasized that extension service accessibility promotes land-use intensification and diverse adoption of sustainable farming techniques. Furthermore, (Handavu et al., 2019) highlighted that agricultural expansion, often facilitated by institutional support like extension services, is a key determinant of forest cover change. These findings suggest that contrary to this study's results, extension access is generally expected to encourage more active land use changes, particularly in agriculture.

The positive and statistically significant sign on the temporary land rights variable was contrary to the initial hypothesis. The findings implied that households with smaller temporary land rights were more likely to engage in land use change toward cash crops, feeding, and grass grain fields when compared to those with larger land rights. Specifically, an increase of 0.5 hectares in temporary land rights size was associated with an increase in the probability of selecting crash crops by 31%, feeding by 24%, and grass grain fields by 18%. These results contrast with several previous studies. For instance, Van Song et al. (2020), found that larger farm size positively influences the adoption of sustainable land management (SLM) practices. Their study reported that for every 1,000 m² increase in the area for growing annual plants, the probability of adopting SLM practices rose by approximately 2.9%, and for forests and perennial plants, by 3.2%. Similarly, (Damene et al., 2020). showed that landholding size significantly affects the allocation of land for planting grass peas, with every additional hectare of land resulting in about 0.03 hectares more allocated for crop planting. Furthermore, Jera & Ajayi (2008) also concluded that farm size is positively associated with farmers' decisions to adopt new technologies.

CONCLUSION

The determinants influencing land use change encompass a range of factors, including demographic-economic, land tenure, physical, and institutional elements. Almost all households within the village exhibited land use change practices over time. One key influencing factor was the price of agricultural products, which played a significant role despite the availability of extension service

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access. This suggests that landholding management had a strong influence on local communities' decisions regarding land use change. Furthermore, distance-related variables (e.g., proximity to forest or road) and household income also demonstrated a considerable degree of impact on land use change practices.

The findings of this study suggest that various demographic-economic, land tenure, physical, and institutional characteristics significantly influence land use change practices. These factors should be considered when designing interventions aimed at enhancing the effectiveness of land management strategies in local communities, particularly in areas experiencing higher rates of land cover change. The study recommends implementing measures that encourage local people in the northern uplands to adopt sustainable land use practices and take an active role in the responsible management of natural resources within their villages. Furthermore, it is essential to adapt policies to the specific local contexts to ensure the successful promotion of sustainable land use management.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript.

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