

## **Recent Land Use and Livelihood Transitions in Northern Laos**

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Sithong Thongmanivong and Yayoi Fujita

# Recent Land Use and Livelihood Transitions in Northern Laos

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*Landscapes in the mountainous north of Lao People's Democratic Republic (hereafter Lao PDR or Laos) are undergoing rapid transformation as road access is being improved and the area is integrated into the regional economies of Southeast Asia, particularly China. Rural livelihoods in the upland areas, long*

*based on subsistence agricultural production, are changing as more households engage in the market economy. This study assesses land use changes from 1993 to 2000, as well as agricultural production in 4 northern provinces of Laos: Luang Prabang, Oudomxay, Bokeo, and Luang Namtha. The spatial data available for this region are limited, but several trends are apparent from 1993: the area of traditional upland agriculture and swidden farming (ie shifting agriculture) has decreased, while permanent intensive agriculture has increased. There is some evidence that forest cover has increased since 1997, probably as a result of the succession of abandoned swidden areas to secondary forest, but the quality and extent of this forest cover remains unclear. Agricultural sector analysis in the 4 northern provinces supported the land use data, showing a rise in commercial agricultural production of cash crops (including sugar cane, paddy rice, and maize) at the expense of subsistence agricultural production. All these changes reflect the government's policy of reducing shifting cultivation practices in the upland areas and promoting cash crop production. The new exposure to external market forces has begun to bring about changes in Laotian rural communities, with the development of village collectives to manage resources and negotiate with outside traders. However, it is also envisaged that this commercialization will increase the demand for privatization of agricultural land; this will require a renegotiation of current government land allocation policies.*

**Keywords:** Land use change; agricultural production; market integration; resource management; Laos.

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## Introduction

Although economic development in Lao People's Democratic Republic (hereafter Lao PDR or Laos) faces many challenges, northern Laos is starting to undergo rapid socioeconomic and environmental transformation.

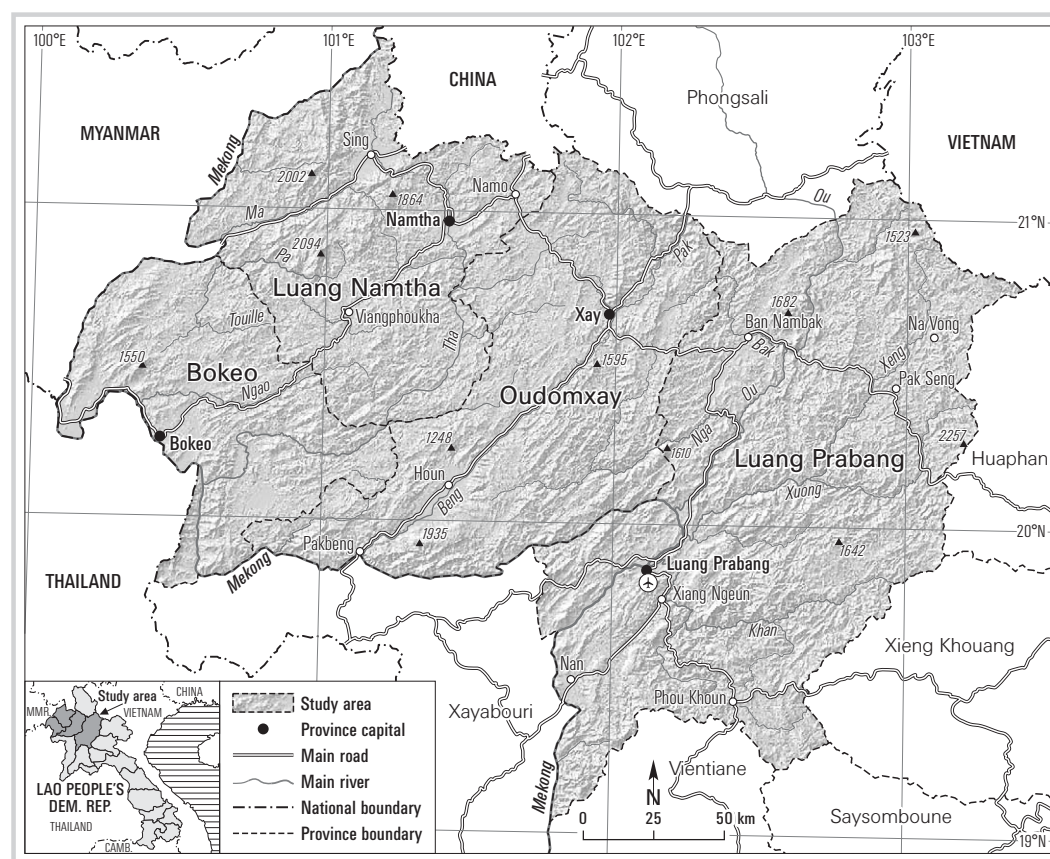
Change has been made possible with the restoration of political stability in the region, driven by the economic surge of Laos's neighbors, including China, Vietnam, and Thailand. Northern Laos, which includes 8 provinces (Figure 1), is considered to be an economically poor region of the country (Xu et al 2005). The National Poverty Eradication Program of Laos aims to develop the basic infrastructure of the northern provinces, linking them to growing regional economies. This program is supported by the influx of international and regional assistance directed to the Greater Mekong Subregion (GMS), promoting trade, tourism, and development. A significant part of this infrastructure is the construction of a road link from China and Vietnam to Thailand, via Laos. This road network will open a new trade pathway for Laos, a mountainous land-locked country with a relatively small population of 5.6 million people.

The present article provides an overview of recent changes of land and resource use and modifications of livelihoods in northern Laos. While commodity exchange has been prevalent for centuries in the region through land and waterways (Reid 1988; Osborne 2001; Donovan 2003), recent development plans aim to facilitate much greater trade, with the integration of regional economies through an improved transportation network. The greater influence of powerful regional economies such as China, Thailand, and Vietnam is already impacting not only on the mode of trade and movement of people in northern Laos, but also on local farming systems and livelihoods (Lyttleton et al 2004).

The scope of the current article is to trace land and forest cover changes in 4 northern provinces of Laos. Specifically, resource use in these provinces is likely to be affected by the improvement of Road Number 3 (R3), otherwise known as one of the economic corridors linking Laos with southwest China, Thailand and Vietnam (see also p 278 in this issue of *MRD*). In concert with these land use changes, this paper also provides an overview of current agricultural production in Luang Namtha and Oudomxay provinces to elucidate the growing importance of cash crop production in the northern provinces. It also examines the importance of diversified resource use practice for households, and formation of new institutions to manage resources in order to cope with changing socioeconomic conditions.

## Study area

The study area incorporates 4 provinces in northern Laos: Bokeo, Oudomxay, Luang Namtha, and Luang Prabang (see Figure 1). More than 80% of the land in northern Laos is mountainous, with the highest elevation (2257 m) in Luang Prabang. The 4 provinces fall under the subtropical zone, with annual rainfall averaging approximately 1240 mm. Annual average tempera-



**FIGURE 1** Map of study area, showing location of the 4 provinces within Laos. (Map by authors and Andreas Brodbeck)

tures range between 24°C during June and July, down to 14°C during December and January.

The total population in the 4 provinces is over 146,000 people, with the majority (45%) concentrated in Luang Prabang. Ethnic composition is highly diverse, with a high concentration of Khmu in Oudomxay and Luang Prabang. According to the National Poverty Eradication Program, the northern provinces have been identified as a region of high poverty incidence (51% of the population below the poverty line). While agriculture remains the predominant sector in all 4 provinces, the service sector is also becoming an important part of the economy.

### Case study villages

We examined the socioeconomic changes and resource management in 2 villages (Nampheng and Nahom) of Namo district in Oudomxay province. Nampheng village (20°58'48" N; 101°40'48" E) was established in the current location during the period of revolution in 1975, when families migrated south from Phongsali province in search of productive agricultural land. Initially, 17 families resettled in the area of Nampheng village. Today there are 81 families and the total population is 312. The village population is predominantly Khmu, categorized as Lao Theung (highland Lao group), a minority group among the Austroasiatic ethnolinguistic group (Chamberlain et al 1995).

The second village is Nahom (20°59'4" N; 101°40'12" E), established in 1991. The village is adjacent to Nampheng and is located on National Route Number 13 North. Nahom was founded by a group of

Khmu families who moved to escape population increase and shortage of residential areas in Nampheng. Most of the families who moved to Nahom already owned swidden plots in this area. After the establishment of Nahom, a group of Hmong families (Hmong-Mien ethnolinguistic group) also arrived, as the government encouraged the relocation of upland farmers. Currently, there are 56 Khmu families and 32 Hmong families living in Nahom village.

## Methods

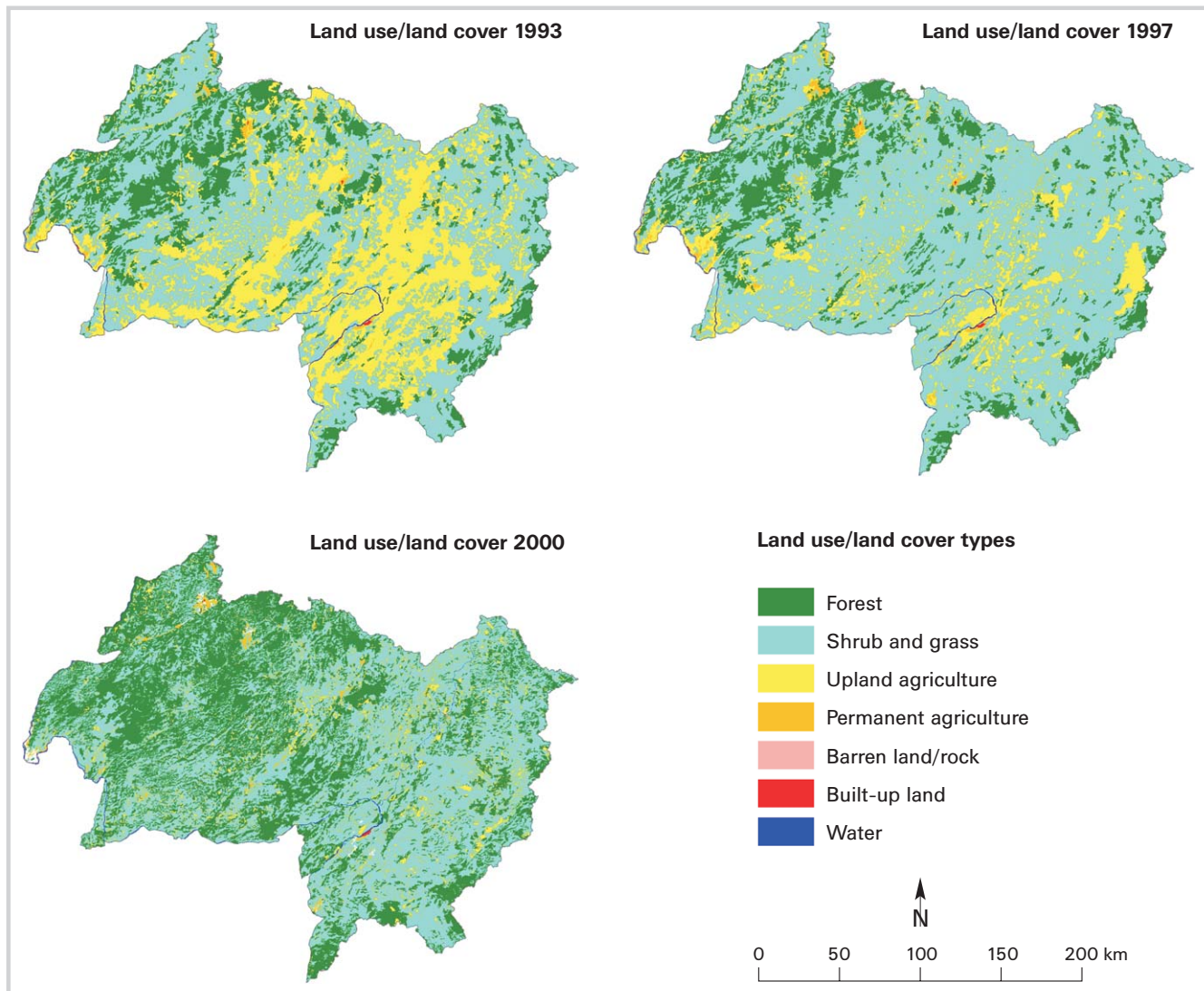
### Spatial analyses

Using existing sets of time series and land use and forest cover maps, we attempted to assess the changing patterns in Luang Prabang, Oudomxay, Bokeo, and Luang Namtha provinces. Land use and forest cover data sets for 1993 and 1997 were obtained from the National Agriculture and Forestry Research Institute (NAFRI), and the 2000 data set was acquired from the Forest Inventory and Planning Centre (FIPC). These land use data were compiled in digital format for geographic information system (GIS) analysis by the relevant agencies. These 3 sets of data were visually interpreted from Landsat satellite data, substituted by Spot satellite data where there were heavy cloud effects. For the current study, GIS (Arcview 3.2 with Spatial Analysis) was used to analyze the land use and forest cover changes.

Because the data supplied had pre-processed the vegetation classification types and metadata were unavailable, we developed a simple set of land use and



**FIGURE 2** Land use and land cover change in 4 northern provinces of Laos: status in 1993, 1997, and 2000. (Map by authors)



land cover classes to try and capture the major trends of land use changes for categories such as forest, shrub and grassland, and agricultural land. The 23 forest and land use classes from NAFRI and FIPC sources were reduced to 8 major classes as shown in Annex 1. Initially, we distinguished forest and non-forest land. Non-forest land was divided into 6 sub-classes based on vegetation and land use types; this includes shrub and grass, upland agricultural land, permanent agricultural land, barren land and rock, built-up land, and water.

Following the re-classification, we compared the changes in forest cover and land use between the 3 time periods. This was followed by patch analysis to assess the rate of forest fragmentation and changes of land type patch areas.

#### Analysis of agricultural and socioeconomic changes

We also conducted a time series analysis of agricultural production in 2 northern provinces, Oudomxay (1997 to 2004) and Luang Namtha (2000 to 2004), based on agricultural statistics provided by the Provincial Agriculture and Forestry Offices (PAFO). This analysis shows the trends in production of rice and major cash crops in the 2 provinces.

The detailed observations of changing resource use and socioeconomic environments for the case studies in Nahom and Nampheng villages were based on information collected by the Namo District Agriculture and Forestry Office (DAFO) in November and December 2004. Field interviews were conducted in the 2 villages to understand community land and resource use practices, as well as land use histories in each village. Focus group interviews were also conducted by district agricultural and forestry officers in the 2 villages.

## Results

#### Land use and forest cover changes

The results of the spatial analysis indicate considerable limitations in using the data from the 2 available sources (NAFRI, FIPC). Specifically, data problems were caused by differences in image classification techniques and varying times of data acquisition. For the satellite images acquired in the rainy season (June to November) it is difficult to distinguish shifting cultivation and shrubland or sometimes even secondary forest. Inter-cropped fields and shrubs during the wet season also

**TABLE 1** Land use and land cover changes (ha) in 4 northern provinces of Laos.

Classification	1993	1997	2000
Forest (including plantations)	862,712	816,680	1,883,082
Shrub and grass	2,353,429	3,283,856	2,508,578
Upland agriculture	1,546,592	652,429	343,243
Permanent agriculture	39,278	49,047	65,167
Barren land/rock	225	225	573
Built-up land	1251	1251	1356

have signature reflectance similar to that of the secondary forest. However, despite the difficulty of assessing the actual time series changes between 1997 and 2000, we observed a general trend of decreasing upland swidden and increasing areas of shrub and grassland (Figure 2). Table 1 also shows decreasing forest area between 1993 and 1997, in contrast to increasing shrub and grassland. Meanwhile, upland agricultural land (swidden) decreased significantly between 1993 and 1997, from more than 1.5 million ha to 652,429 ha.

While the absolute changes in land use between 1997 and 2000 are difficult to assess due to the use of 2 different data sets, we discerned a trend of decreasing upland agriculture during the study period (Table 2). Meanwhile, permanent agriculture showed a constant, though smaller, increase. In the meantime, forest area decreased between 1993 and 1997, but showed an increase between 1997 and 2000. According to Table 2, shrub and grass increased at a relative rate of change of 0.4 from 1993 to 1997, before decreasing by 0.2 between 1997 and 2000. While Table 2 also indicates a high rate of change for barren land from 1997 to 2000, this is a reflection of the small size of this category (148 ha), which accounts for less than 1% of the total study area.

The patch analysis shows the problematic nature of comparing the data sets with different minimum mapping units of 25 ha for 1997 and 1 ha for 2000. Results indicate a considerable gap between the 2 sets of data. In particular, we observed an enormous increase in patchiness between 1997 and 2000 (Table 3). It seems unlikely that

such drastic fragmentation occurred within 3 years, and this is likely to be a reflection of the more sensitive classification techniques and use of data sets with different minimum mapping units. Notwithstanding, the data do support several overall trends. There is a large increase in forest cover, and upland agriculture has clearly decreased. In terms of patch analysis, the 1993 to 1997 data seem more robust, and this suggests the same general land use trends: upland agriculture decreased in area and became more fragmented, while, conversely, shrub and grass increased in area and consolidated into fewer, larger patches.

#### Provincial agricultural sector analysis

For Oudomxay, changes in 3 types of rice production including rainfed, irrigated, and upland were assessed for the period 1997–2004. Rainfed and irrigated rice production are conducted in the lowland paddy fields, while slash-and-burn or swidden cultivation is applied to upland rice production. Three types of rice production were also assessed for Luang Namtha, but for a shorter period from 2001 to 2004 (Figure 3).

Production of rainfed paddy rice has increased in both provinces over the last 4 years. Meanwhile, production of irrigated rice increased by a factor of 7 in Luang Namtha, and doubled in Oudomxay between 2001 and 2004 (though these amounts are still dwarfed by the rainfed paddy). Recent high increases in both rainfed and irrigated rice production are attributed to the introduction of high-yielding varieties as well as the development of irrigation systems and new paddy fields.

In contrast, production of upland rice is decreasing in both provinces (Figure 3). The decrease is particularly significant in Luang Namtha, as official production fell by a third between 2000 and 2004. Upland rice production in Oudomxay remains more than 5 times as high as that in Luang Namtha. However, the total amount of upland rice production in Oudomxay has also been decreasing recently. Since 2000, upland rice production has been lower than rainfed rice production.

Besides rice production, other cash crops are also becoming increasingly important in both Luang Namtha and Oudomxay. Cash crops are produced for export to neighboring countries including China and Thailand. In Luang Namtha, one of the key cash crops is sugar cane, which accounts for more than 60% of the total cash crop production (Figure 4). Most of this is

**TABLE 2** Relative rates of land use changes in 4 northern provinces of Laos.

Classification	1993–1997	1997–2000
Forest (including plantations)	–0.1	1.3
Shrub and grass	0.4	–0.2
Upland agriculture	–0.6	–0.5
Permanent agriculture	0.2	0.3
Barren land/rock	0	1.6
Built-up land	0	0.1

exported to China. The volume of sugar cane production has doubled between 2000 and 2004. Meanwhile, maize and watermelon production have also increased in the last 2 years (Figure 4).

In Oudomxay, maize is the predominant cash crop (Figure 5) produced on sloping land. The proportion of maize production among cash crop production increased from 44% in 2001 to 64% in 2004. Meanwhile, sugar cane production decreased from 26% to 15% of total cash crop production between 2001 and 2004.

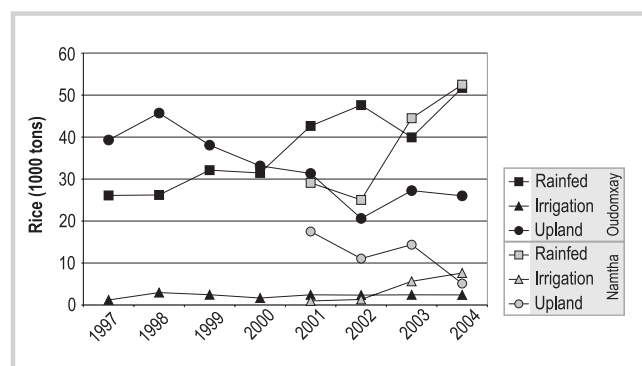
### Recent land use changes in Nampheng and Nahom villages

Until the 1990s, when village resource boundaries were delineated under the Land and Forest Allocation Policy (LFA), there was no restriction on areas of swidden cultivation in Nampheng and Nahom. Slash-and-burn or swidden cultivation was the predominant agricultural practice in both villages, allowing them to produce not only rice, but a wide range of other products for subsistence consumption. However, the implementation of LFA limited access to swidden to 3 plots per household. In the meantime, a large tract of former swidden and fallow was also incorporated into forestland, where conversion to non-forestland was prohibited (Table 4).

Limited access to swidden fields required transformation of agricultural production because areas of paddy fields were limited in the 2 villages. During the village interview, groups of farmers in both villages noted that lack of agricultural land (ie a shortage of rice) was the primary cause of household poverty. Other than land, households that had limited labor and capital were particularly disadvantaged in finding a secure livelihood basis for their family. Collection of non-timber forest products (NTFPs, ie bitter bamboo, cardamom, and rattan) from areas of former swidden fallows has also become commercialized in recent years, with sales to outside traders increasing the pressure on NTFPs. However, through introduction of sustainable harvesting of bitter bamboo and village-based marketing of NTFPs, the villages were able to increase household income and generate financial resources for the village, thereby relieving pressure on natural resources and improving households' economic well-being (Morris 2002). As northern Laos becomes increasingly integrated into regional economies such as China, agricultural production is also shifting from subsistence-based to market-based. More farmers are producing key cash crops such as watermelons, maize, and other vegetables, as well as rubber. Increased cash crop production for export markets, particularly to China, is also changing social relationships among local people in relation to land, as more farmers are signing contracts and agreeing to lease land to Chinese investors for this purpose.

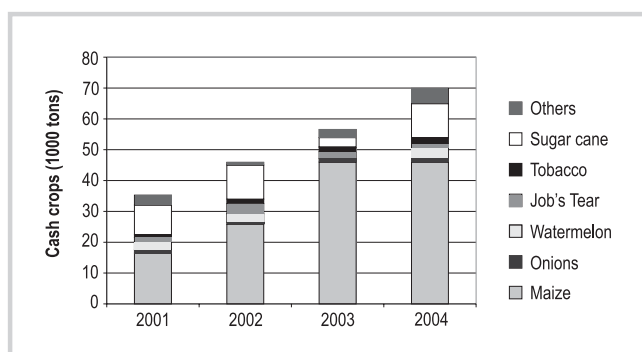
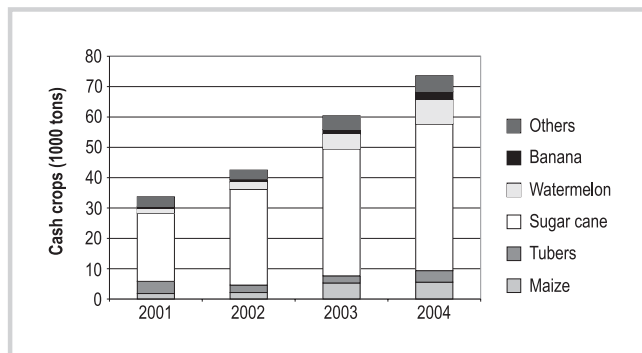
**TABLE 3** Patch analysis of forest cover in 4 northern provinces of Laos from 1997 to 2000.

	Classification	Number of patches	Mean plot size (ha)
1993	Forest	725	1190
	Plantation	4	334
	Shrub and grass	534	4407
	Upland agriculture	847	1826
	Permanent agriculture	110	357
	Barren land/rock	1	225
	Built-up land	4	313
1997	Forest	738	1107
	Plantation	4	334
	Shrub and grass	376	8734
	Upland agriculture	1646	396
	Permanent agriculture	132	372
	Barren land/rock	1	225
	Built-up land	4	313
2000	Forest	12,378	152
	Plantation	2	17
	Shrub and grass	17,344	145
	Upland agriculture	16,673	21
	Permanent agriculture	2456	27
	Barren land/rock	18	32
	Built-up land	47	29



**FIGURE 3** Rice production in Luang Namtha and Oudomxay from 1997 to 2004. (Based on 2004 agricultural production data of Provincial Agriculture and Forestry Offices)

**FIGURE 4** Cash crop production in Luang Namtha, in 1000 tons. (Based on 2004 agricultural production data of Provincial Agriculture and Forestry Offices)



**FIGURE 5** Cash crop production in Oudomxay, in 1000 tons. (Based on 2004 agricultural production data of Provincial Agriculture and Forestry Offices)

## Discussion

### Regional trends in northern Laos

There is a clear reduction in upland agriculture and a shift towards a more cash-crop oriented system in northern Laos. This change is in response to government policies aiming to discourage swidden systems (ie LFA) by limiting the number of household swidden plots. These same policies also aim to increase forest cover by preventing its clearance for swidden. Our initial results suggest that forest cover is increasing, but the exact nature of the forest (in terms of quality and patchiness) is difficult to gauge. The changes in shrub and grassland—an initial rise followed by a decrease—may indicate succession of abandoned swidden systems through an initial shrubby seral stage to secondary forest. This requires further research and analysis, based on better spatial data. At present there are problems in obtaining consistent time series data in Laos: survey timing depends on foreign-funded programs, and frequent organizational restructuring also impairs the continuity of data management and classification at the national offices. These problems limited our ability to analyze land use change, but the information was good enough to highlight the major trends.

The pattern of agriculture has changed rapidly in recent years in northern Laos, due to both increased market pressure and intensification of agricultural practices. Rice production has increased significantly in Luang Namtha and Oudomxay in the last 4 years for a number of reasons, including the development of

irrigation, expansion of paddy fields, and the use of high yielding varieties. Moreover, the shift away from traditional subsistence agriculture has seen a rise in cash crops. Some of the major cash crops, maize and sugar cane, are often produced on sloping lands that used to be part of the swidden-fallow system. This also means a shift from subsistence agriculture with a primary focus on rice production, towards market-based agriculture allowing farmers to purchase rice in times of need.

Much of the development of intensive agriculture has been driven by foreign investors, mainly from southwest China, who contract local farmers to produce maize and sugar cane. In the case of sugar cane, farmers purchase seedlings and fertilizers from China, and sell their products to Chinese investors. The sugar cane is then exported to China where it is processed in a sugar factory based in Mengla, Xishuangbanna, just across the Lao border (Manivong et al 2003). While most maize production is exported to China and Thailand, domestic demand for maize has recently increased owing to the development of an animal feed processing factory in Laos.

Watermelon, on the other hand, is produced in the lowland paddy fields during the dry season. While local farmers also grow watermelon, some Chinese farmers are renting dry season paddy fields from lowland villagers. In most instances fields are rented directly from local farmers and for a maximum period of 6 months. After the harvest, seasonal Chinese migrants return to southern China with their produce, while local farmers collect rent.

The influence of market forces is also evident in the changes in crop selection. In both Luang Namtha and Oudomxay, the choice of crops, apart from the dominant sugar cane and maize, tends to be highly variable. For instance, *mung* bean and peanut production were popular in 2000 in Luang Namtha, but production decreased in the following years, being replaced by other products such as tobacco, pineapple, eggplant, chilies, and onions. In Oudomxay, production of Job's Tear (*Coix lacryma-jobi*) oscillated. This crop was very popular between 1998 and 1999, declined in the following year, and then surged once again during 2000 and 2001. Sesame production also surged between 1998 and 1999, and again between 2002 and 2003. These changes in production reflect the fact that farmers in the 2 provinces are still experimenting with different varieties of cash crops, and that their choice of production is affected by fluctuating export prices.

### Village level changes

In Nampheng and Nahom, we observed that farmers were transforming their farming to a system based on upland rice cultivation, and also moving away from subsistence production towards commercial production. This transformation was driven by a number of concurrent factors,



**TABLE 4** Distribution of land use in Nampheng and Nahom villages. (Source: village survey 2004)

Forest and cropland types	Nampheng		Nahom	
	ha	%	ha	%
Utilization forest	123	4.7	126	4.1
Production forest	398	15.3	n.a.	—
Conservation forest	158	6.1	996	32.0
Protection forest	1579	60.8	1909	61.4
Regeneration forest	291	11.2	6	0.2
Cemetery forest	3	0.1	n.a.	—
Paddy rice field	7	0.3	15	0.5
Swidden field	26	1.0	46	1.5
Vegetable field	5	0.2	10	0.3
Other land	7	0.3	n.a.	—
<b>Total</b>	<b>2597</b>	<b>100</b>	<b>3108</b>	<b>100</b>

including government policy on land and forest management (ie LFA), together with growing regional market demand for agricultural and forestry products, and improvement of road access (ie improved market access).

However, increased commercialization of agricultural production is raising new problems. In particular, there are questions about whether the resource boundary and management agreed through LFA is viable or not, given that a shift from subsistence to commercial production demands privatization of land. Under current LFA-based land zoning, more than 95% of all land is incorporated into village forestland in both Nampheng and Nahom, while agricultural land accounts for only 1.5 and 2.3% of the total land in each village, respectively. This requires renegotiation of village land uses and development of resource management plans that meet the needs of local farmers.

There has also been a change in the status of NTFPs at village level. In Nampheng and Nahom, NTFPs, including wild vegetables and wild game, met an important part of households' daily needs for food and other material. Collection used to be essentially for self-use, but the importance of NTFP collection has increased in the last decade, with greater commercialization of the village economies. Bitter bamboo and rattan shoots, as well as cardamom, became particularly important sources of household cash income in Nahom and Nampheng, as traders began to purchase them from the villagers (Morris 2002). This occurred at the same time as the farmers were expanding their cash crop (eg maize and rubber) and livestock production (eg cattle, pigs). Integration in the market economy has also changed how farmers use NTFPs. In Nampheng and Nahom, we observed that farmers have begun to organize themselves into a collective with the support of international NGOs, to maximize economic benefits

for both households and the village. By organizing a collective, villagers in Nampheng and Nahom gained the ability both to negotiate with traders and manage resources collectively. They can also distribute profits to the community, as well as to individual households. Furthermore, increased demand for NTFPs has led villagers to consider domesticating some of the key NTFPs, with the technical support of government and international agencies (see also Ducourtieux et al 2006).

## Conclusions

Although spatial data are limited by variable quality and classification methods, these preliminary results, when used in concert with provincial surveys and village case studies, all show similar trends in land use change in northern Laos. We conclude that the agro-ecological landscape of the upland areas in these 4 northern provinces is undergoing rapid transformation from subsistence and swidden-based landscapes towards a more commercial and multifunctional use of the uplands. These changes reflect government efforts to control the expansion of swidden cultivation in the uplands in order to promote the development of cash crops. However, whether this same developmental policy has had an impact on forest protection remains questionable. Initial data suggest forest cover is increasing, but the quality and degree of fragmentation of this forest remains unclear and requires more analysis and better input data. Hopefully this sort of information will become available in the near future.

The government policy of restricting the expansion of shifting cultivation has induced farmers to seek alternatives. This has been further driven by integration into the market economy and the development of road networks. Now, rather than subsistence agriculture, more vil-



lage farmers are aiming their production at commercial markets. However, we also observed that farmers in both provinces are planting a mix of crops and have been experimenting with different crops over the last few years.

As the road links are improved and regional trade is institutionalized, we foresee increased commercialization of agricultural production and natural resource use in northern Laos. This will also mean an increased demand for agricultural land and privatization of such

land. For example, the interest mooted by Chinese investors to lease land for rubber plantations will require clear articulation of village land rights. For NTFPs, increased commercialization will also require a new approach to achieve sustainable use and equitable distribution of profits among the local people. It is deemed essential that the local land and resource management formulated through LFA must be renegotiated to meet the actual needs of the local communities.

## AUTHORS

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**ANNEX 1** Adaptation and simplification of National Agriculture and Forestry Research Institute (NAFRI) and Forest Inventory and Planning Centre (FIPC) land use and forest cover classifications.

Land use/forest cover classes for 1993 and 1997 (NAFRI)	New category for this article	Land use/forest cover classes for 2000 (FIPC)	New category for this article
Evergreen, high cover density	Forest	Upper dry evergreen	Forest
Evergreen, medium–low cover density	Forest	Lower dry evergreen	Forest
Evergreen mosaic	Forest	Upper mixed deciduous	Forest
Mixed (evergreen and deciduous), high cover density	Forest	Lower mixed deciduous	Forest
Mixed (evergreen and deciduous), medium–low cover density	Forest	Dry dipterocarp	Forest
Mixed mosaic	Forest	Gallery forest	Forest
Deciduous	Forest	Coniferous forest	Forest
Deciduous mosaic	Forest	Mixed broad-leaved and coniferous	Forest
Re-growth	Forest	Plantation	Forest
Plantation	Forest	Bamboo	Shrub and grass
Rice paddy	Permanent agriculture	Unstocked forest	Shrub and grass
Wood and shrub land, evergreen	Forest	Natural regeneration	Shrub and grass
Grassland	Shrub and grass	Ray	Upland agriculture
Bamboo	Shrub and grass	Savannah	Shrub and grass
Wood and shrub land, dry	Shrub and grass	Scrub	Shrub and grass
Cropping mosaic, cropping area <30%	Upland agriculture	Rice paddy	Permanent agriculture
Cropping mosaic, cropping area >30%	Upland agriculture	Agricultural plantation	Permanent agriculture
Agricultural land	Permanent agriculture	Other agricultural land	Permanent agriculture
Barren land	Barren land/rock	Barren land and rock	Barren land/rock
Rocks	Barren land/rock	Grassland	Shrub and grass
Urban or built over land	Built-up land	Swamp <sup>a)</sup>	—
Water	Water	Urban or built up area	Built-up land
Wetland <sup>a)</sup>	—	Water	Water

<sup>a)</sup> Wetland and swamp were omitted.