

Can Shifting Cultivation on Acid Soils in the Southeast Asia Be Sustainable in the Future ? A Case Study in Northern Laos

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Sustainability of the local shifting cultivation practice in the mountainous region of Northern Laos was investigated. Due to low fertility of the soils derived from shale and its strongly weathered and acidic nature in the eastern side of the Nam Khan River watershed, shortening of the fallow period to produce enough amount of upland rice for the local population would not be sustainable any more. On the other hand, the eroded materials from limestone range were added to the soils in the western side of watershed which made the soil more fertile. Based on the calculated population capacity by Carneiro's equation, a system with 2- or 3-year fallow for 1-year cultivation can be the maximum to afford the current population. To make the shifting cultivation system more sustainable, introduction of fallow system with a tree species, paper mulberry (*Broussonetia papyrifera*) could be a good option to be proposed.

Key Words: northern Laos, population capacity, shifting cultivation, sustainability, upland rice.

Slash and burn farming with shifting fields (shifting cultivation) in the Southeast Asia has been practiced for many decades as one of the most important traditional farming systems. Although the emission of carbon dioxide during burning is often criticized in terms of global climate change, forest destruction itself is no more significant cause against the conservation of the local environment, i.e., there are no more good forests valuable for preservation. Commercial plantation is invading both natural and secondary forests aggressively recently. On the other hand, local farmers could not continue the traditional shifting cultivation due to deficiency of the farm lands for rotation and fallow management even in the mountainous region. In Laos, the combined effects of increased population density and government policies limiting access to land have reduced fallow periods from about 40 years in 1950 to only 5 years in 1992 (Roder et al. 1994). They, at present, are obliged to use their land continuously 2 to 4 years before abandoned to fallow.

According to the villager of Phon Xay (PX) village in Xiang Ngeun district, Luangphabang province, Northern

Laos, average area of upland rice or other upland crop cultivation per year per household is about 1 ha. Average number of people and labor in a household are 6 and 2 persons, respectively. The forest law of Laos established in 1996 states that an individual family is allocated an area of no more than 3 ha for each unit of labor in the family. In addition, the use of well-developed natural forest or fallow forest is also prohibited. Instead, farmer must do more intensive farming in the mountainous region. The implementation of land-forest allocation gave 1 to 4 plots, about 1 to 5 ha field area according to the number of labor in a household. To the household which possesses a wet land paddy field, only 1 plot of upland field was given. In the PX village, a common upland crop is rice. In 1999, Job's tears had been cultivated due to its high price in the market. However, a sharp decline of the market price in 2000, they could not get enough money to buy rice for their dairy consumption. The percentage of a household in a rice shortage reached to 70% in 2000 from 40% in 1999.

Watanabe et al. (2004) reported that soils collected in the three selected villages in Xiang Ngeun district, Luangphabang province, Northern Laos contained low activity clays abundantly, while exchangeable cations, available phosphorus, and total carbon and nitrogen contents were reasonably high. Total carbon and nitrogen

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contents correlated with fallow or cultivation length within 10 years, on the other hand, other soil chemical properties had a weak association with them. Restoration of soil nutrients during fallow may not be significant as compared with the input from ash through burning. Therefore, they considered that the significance of fallow period was to get a large amount of biomass to control the weed growth during the cropping period as well as to provide a source of nutrients. Based on these results, we further tried to analyze the current condition of shifting cultivation and future possibility of the shifting cultivation practice as a sustainable agricultural system at a selected village (Phon Xay village) among three villages in the former report (Watanabe et al. 2004).

MATERIALS AND METHODS

The study area (Phon Xay village, hereafter abbreviated as PX village) is situated in Nam Khan Watershed in Xiang Ngeun district, Luangphabang province (Fig. 1). It is located about 25 km southeast of Luangphabang city. Nam Khan River is running from southwest to northeast and geologically a lineament with 18 km length. The mean annual air temperature was 26.2°C, and the annual precipitation was 1,050 mm in 1998 and 1,226 mm in 1999. Precipitation occurs mostly from May to October. PX village established in 1972 was selected for the analysis of sustainability of shifting cultivation.

Carneiro's equation (Carneiro, 1956) was used to calculate the population capacity of the village. Population and the number of household in 2000 are 634 and 102, respectively. Total area of upland field is 223 ha, while that of wet land paddy is 17.7 ha in the rainy season and 12.8 ha in the dry season with a local irrigation.

The parent materials of the soils are mostly shale and sandstone, and only the top of the mountain of the western side of the Nam Khan River is capped with limestone. For the comparison of these two sides, soil samples from both surface and subsurface horizons were collected from 10 sites (5 sites from both the eastern and

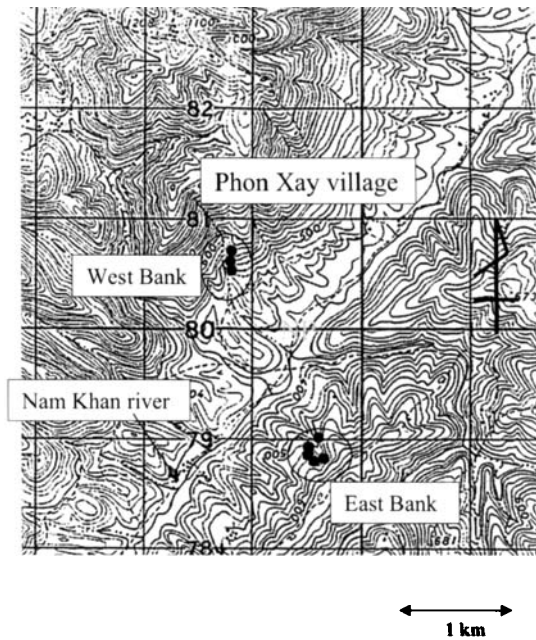


Fig. 1. Map of the study area in Xiang Ngeun district, Luangphabang province, Lao PDR. Phon Xay village and soil sampling sites are located approximately at 19°42'N and 102°07'E.

western sides of the river, which included natural forest and fallow field and crop field (Watanabe et al. 2004). In addition, the representative pedon of each side was described in detail and its data are shown in Table 1. Analytical methods for soil samples were described elsewhere (Watanabe et al. 2004).

RESULTS AND DISCUSSION

The soils in the PX village derived from shale are with high acidity. However, those in the western slope along the river were more affected by the eroded materials from the limestone range located in the higher part of the mountain. All the subsurface soils without significant influence of organic matter showed rather low CEC values (9 to 12 cmol_c kg⁻¹) irrespective of the high clay content; 26 to 38% in the western side, while 47 to 62%

Table 1. Selected characteristics of the soils in Phon Xay village.

Depth (cm)	pH in H ₂ O	EC (mS m ⁻¹)	Exchangeable cations				CEC	Av-P (mg kg ⁻¹)	T-C (g kg ⁻¹)	T-N	Clay content (%)
			Al	Ca	Mg	K					
Western side: Natural forest											
0–5	6.54	5.45	0.00	6.78	2.89	0.82	22.5	100.1	45.3	2.4	27.7
20–25	5.93	2.29	0.11	1.45	1.50	0.59	10.0	13.5	15.7	1.7	26.8
40–45	5.59	1.15	1.72	0.46	0.12	0.57	10.4	7.5	8.4	0.8	26.4
80–85	5.52	1.08	2.30	0.48	0.38	0.41	12.1	7.0	4.5	0.8	29.0
Eastern side: 1 y after cultivation											
0–5	5.54	5.28	2.52	2.09	2.79	0.32	13.6	10.2	30.5	2.6	47.2
20–25	5.12	3.99	1.43	0.31	0.65	0.13	9.7	5.3	13.1	1.8	55.0
40–45	5.05	3.95	1.04	0.11	0.30	0.09	8.9	2.8	9.4	1.7	57.7
80–85	5.13	3.98	0.83	0.25	0.15	0.10	9.2	2.6	6.9	1.5	62.4

in the eastern side (Table 1). Soils in the western side of the river were less acidic, probably due to the influence of lime materials from the top of the mountain. On the other hand, soils in the eastern side showed a moderate to strong acidity. In both soils, exchangeable aluminum increased and base saturation decreased with depth indicating the depletion of nutrient element and relative enrichment of aluminum upon weathering. Most of the soils in the eastern side could be considered as soils with low activity clays. According to Watanabe et al. (2004), there was a significant correlation between the length of fallow period and the amount of total carbon (T-C) at surface soils within the first 10 years ($r=0.525$, $p<0.05$), while the T-C content in the natural forest showed a wide variation. Longer fallow more than 10 years did not always contribute to the increase in T-C. Most of the nutrient showed higher content after burning and cropping (one crop of upland paddy) compared with that before burning. It is considered that the accumulation of nutrients from ash was higher than the loss of nutrients during cropping. In fact, recovery in soil nutrients during fallow period was not significant as compared with nutrients supplied by ash input when burned (Watanabe et al. 2004). Herbaceous vegetations are dominant in short fallow fields, while trees are dominant in long fallow fields. On the other hand, intensity of fire with herbaceous vegetation is smaller than those with trees when burned, resulting in a lot of weeds during cropping. Thus, they considered that the significance of fallow period was to get the large amount of biomass to control the weed by burning as well as a source of nutrients. When the people encounter the situation to utilize the land with a short fallow inevitably, introduction of fast growing tree species during fallow period was highly recommendable.

When considering the agricultural sustainability along with intensification, it is important to set up the target level of its sustainability. What kind of farming system could support the present population without expansion of the further upland field area? There are some methods to evaluate the intensification of shifting cultivation system, such as intensity of rotation (Ruthenberg 1976) or land use factor (Greenland 1974). These equations are based on the calculation of the ratio of fallow and cultivation length. That is, 5-year cultivation and 20-year fallow system and 1-year cultivation and 4-year fallow system become the same evaluation. Therefore, Carneiro's equation (Carneiro 1956) is preferably used to calculate the population capacity of one locale. The equation is popular in the field of anthropology and ethnology. Based on the research for the Indian of central Brazil, Carneiro presupposed that the relation between population capacity and 4 variables are shown by the following equation.

$$P = (T/(R+r) \times r)/A \quad (1)$$

where P : the population of community, T : the total area

of arable land, R : the number of years an abandoned plot must lie fallow before it can be recultivated, r : the number of years that a plot of land continues to produce before it has to be abandoned, and A : the area of cultivated land required to provide the average individual with the amount of food that he ordinarily derives from cultivated plants per year.

Assuming that one person needs 2,500 kcal per day and all the consumption calories are obtained from rice, the calculated consumption of rice gives a value of 0.325 t per person per year. The average lowland rice yield in the rainy season was $17.7 \text{ ha} \times 3.18 \text{ t ha}^{-1} = 56.3 \text{ t}$, and in the dry season was $12.8 \text{ ha} \times 4.33 \text{ t ha}^{-1} = 55.4 \text{ t}$ at the PX village (yield data was the average value in Xiang Nguen District in the cropping year of 1999). The number of population that lowland rice can support is $111.7 \text{ t}/0.325 \text{ t} = 343$ persons. The remaining 291 persons should be supported by the upland rice.

Based on these data, the number of population that can be supported by the total yield of upland rice can be calculated using Carneiro's equation. We assume that $T = 223 \text{ ha}$, $r = 1$ year and $A = 0.325 \text{ t}/1.67 \text{ t} = 0.2 \text{ ha}$ are constant. The only changing variable is capital R value. Until 7 years ago, the fallow period was about 6 years. The value of T can be calculated in case R and P is 6 and 291, respectively. Then, $T = 407.4 \text{ ha}$. It means that 407 ha of field are needed for establishing swidden field to support the population. However due to the limited land allocation to the people, only 223 ha is available. The P value, when the fallow period (R) is 2 or 3, can be calculated as follows;

$$R=2, P = (223/(2+1) \times 1)/0.2 = 371 > 291$$

$$R=3, P = (223/(3+1) \times 1)/0.2 = 278 < 291$$

Based on the above calculation, 1-year cultivation with 2- or 3-year fallow period system can support the current population. In this case, the population capacity calculated is corresponding to the current population. Even if this system is adopted, many villagers will be faced with rice shortage. According to the result of Carneiro (1956), there was 145 population of the Indian village in Brazil, and the calculated population which could be supported was 450, about 3 times as many persons as the actual population. Judging from this data, we can imagine that people in the PX village may feel a remarkable population pressure in fact. In addition, as for this calculation, it is a premise that the increase in population and the soil degradation do not take place at all. Considering both of the premises, it cannot help introducing a new system, namely, more intensive land use system with a 2- or 3-year fallow. At least, we should discuss whether this system would be sustainable or not.

Watanabe et al. (2004) concluded that soils in the PX village had high content of soil nutrients irrespective of the erosion-prone area on the slope land. Soil fertility status and the length of fallow within 10 years were

slightly correlated. However the amount of nutrients accumulated during fallow period were small compared with the nutrients supplied from the ash input when burned, because soil nutrients were found not to be exhausted within 1-year cultivation. One-year cultivation with 2- or 3-year fallow period is likely to be an adoptable system to support the current population when government can not permit farmers to expand the swidden field in order to protect forest area. However, it might not be sustainable for a century. Depletion of soil nutrients will proceed gradually and constantly, and eventually, the soil will become infertile and unsuitable for crop production.

As one of the practices of the local farmers, introduction of paper mulberry (*Broussonetia papyrifera*) in their field have been initiated recently. A manufacturer of local paper making in the Luangphabang city tried to buy the inner bark of this plant collected from natural stand in this area. At present some of the local farmers tried to make a plantation of this plant. Then, we came to think a new system to be sustainable, i.e., the system using paper mulberry during fallow period for 3 to 4 years after 1-year cultivation of upland rice.

According to the direct measurement in the study sites, herbaceous vegetation yielded 5 t biomass per ha per year, while paper mulberry could yield 10 t biomass per ha per year. Weeds in the paper mulberry field during fallow can be less than those in the fallow field without special weed controls. In addition, increasing fire intensity resulting from large amount of biomass in the paper mulberry field would decrease seed germination of weeds. Furthermore, we can expect that weed control is also possible because farmers cut the weeds 1 or 2 times per year before paper mulberry harvesting without the feeling of laborious. Since farmers can also obtain some income from selling inner bark of paper mulberry,

it is easy to recommend them to introduce this plant during fallow by the extension workers.

CONCLUSION

Without the addition of eroded materials from limestone range or without an appropriate management including fertilizer application, shortening of the fallow period to produce enough amount of upland rice for the local people would not be sustainable due to low fertility of the soils derived from shale. Therefore, this farming system with a fallow system with paper mulberry (*B. papyrifera*) deserves further investigation in the village studied here, to establish a sustainable farming system in the mountainous region of Northern Laos.

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