Fallow Agroecosystem Dynamics and Socioeconomic Development in China : Two Case Studies in Xishuangbanna Prefecture, Yunnan Province

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Two Case Studies in Xishuangbanna Prefecture, Yunnan Province

Using twenty years of statistical data and household survey data from 1998 to 2001, this paper examines the link between socioeconomic factors and conservation of agrobiodiversity in fallow agroecosystems in two small rural villages, Daka and Baka, in Xishuangbanna, southwest China. These communities have long practiced traditional fallow field, or swidden agriculture, which has maintained a high degree of agrobiodiversity. However, we found that the area of fallow fields is dropping annually by 0.008 ha per capita in Daka and 0.001 ha in Baka. This loss seems to be driven by population increase and the loss of fallow lands to rubber plantation, paddy field, and other high-yield, income-generating crops that are strongly affected by market trends and government policy. In addition, many farmers are reducing the duration of fallow and increasing the amount of time that land is under cultivation. The loss of fallow agriculture means a loss in agrobiodiversity, as the traditional variety of crops and plants is replaced by exotic varieties with great ecological tolerance. In Baka in 1999 there were 20 upland rice varieties; by 2001 this number had dropped to 14 varieties. There is an urgent need to maintain the diversity and knowledge tied to fallow agroecosystems. Practical innovations by the expert farmers that conserve agrobiodiversity are particularly valuable and need to be encouraged.

Keywords: *Fallow agroecosystems; socioeconomic development; agrobiodiversity; on-farm conservation; expert farmer; China.*

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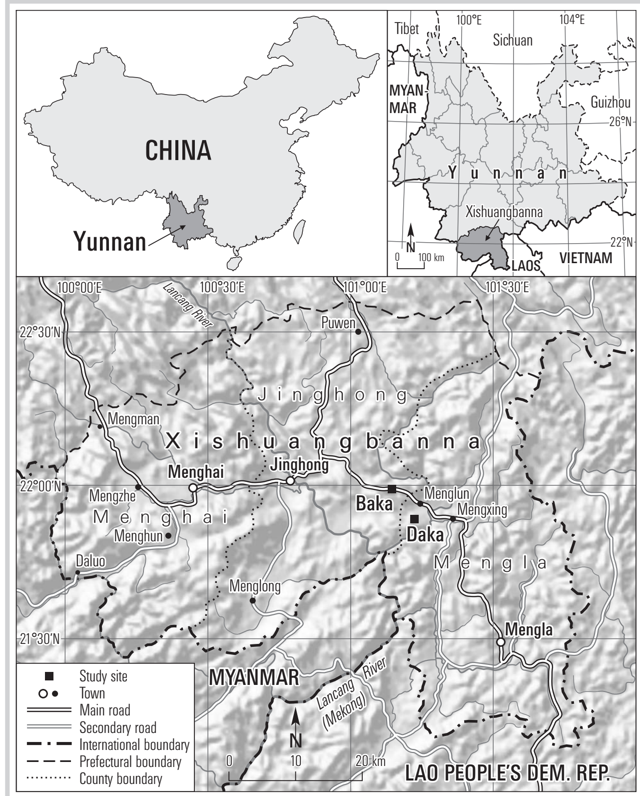


FIGURE 1 Location of Daka and Baka in southernmost Yunnan Province, China. (Map by Andreas Brodbeck)

Introduction

The smallholder farmers of Southeast Asia have historically been divided into 2 groups: shifting cultivators, or swiddeners, in the hills, and paddy farmers on the valley floors. The hill farmers with their hundreds of rice varieties, their many intercropped vegetables and fruits, and their cyclical farming methods are disappearing throughout the region (Roder 1997; Guo et al 2002). However, fallow agroecosystems remain especially important in Xishuangbanna, where this type of farming accounts for 63% of the total farmland area. Over 300,000 people depend on fallow agriculture.

Fallow agriculture, or swiddening, maintains a higher diversity of crops and secondary vegetation than sedentary farming techniques. Swidden farming enhances biodiversity and forest regeneration by means of protection of useful species in swidden-fallow fields, combining local annual crops and perennial tree crops, and domesticating native plants (Brookfield and Padoch 1994). The need to understand the potential importance of the link between this conservation of agrobiodiversity and a variety of socioeconomic factors in developing countries has been noted by several writers (Apia 2000; Rerkasem et al 2002; Upreti and Upreti 2002). Clarification is required on whether agrobiodiversity in fallow agroecosystems is enhanced or adversely affected by a raft of factors such as indigenous cultures, local needs, traditional and modern technological innovations, and various local, national, and international development policies. In terms of on-farm management, how can indigenous innovators be identified and supported in their traditional experimentation process to enhance sustainability and agrobiodiversity? The present article reports on 7 years of work studying rapid socioeconomic change and its influence on the management of fallow agroecosystems by indigenous farmers in Daka and Baka in Xishuangbanna in southern Yunnan Province.

Materials and methods

Study area

Daka is a Hani/Ahka village located in Menglun town, Mengla county, in Xishuangbanna Dai Autonomous Prefecture (Figure 1). The village, located at 21°41′ N, 101°25′ E, is about 10 km from the Menglun State Nature Reserve. The climate is seasonally tropical with an average annual temperature of 21.5°C and average annual rainfall of 1563 mm. Daka covers an area of 727 ha. The original vegetation was tropical seasonal rainforest, but land now consists of community forest, rubber plantation, and fallow agriculture. This small village is a rural subsistence community; the most recent census recorded 332 people (164 males and 168 females) in 65 families. Within this community, 17 people have graduated from middle school and in 2000 the average annual personal income was USD 171.6.

Baka, a village of Jinuo township, Jinhong City, Xishuangbanna Prefecture, lies at an elevation of 720 m (Figure 1). Located at 21°59′ N, 101°9′ E, it is close to the Menglun State Nature Reserve and shares a similar seasonal tropical climate to that described above for Daka. Baka covers an area of 173 ha, comprising fallow agriculture and cash crop plantation. The most recent census recorded 269 people (144 males and 125 females) in 68 families; 18 persons have graduated from middle school. Average annual personal income in Baka was USD 153.4 in 2000.

Field methods and data analysis

We carried out a socioeconomic investigation involving 60% of the village households (30 sample households in Daka and 36 in Baka) using an annual questionnaire from 1998 to 2001. This survey aimed to monitor land use and the level of agrobiodiversity within households. We also did complete inventories of crop diversity and variety in the fallow agroecosystems of Daka and Baka. In addition, we collected statistical yearbook data for the study area to examine socioeconomic development during the past two decades, using Participatory Rural Appraisal (PRA) (Chambers 1994).

Correlations between the major types of land use, crop varieties, and socioeconomic factors such as cash income and population were tested with Simple Linear Correlation (Pearson r) analysis and *t*-statistic testing (*t*-test) for significance of Pearson r through Microsoft Excel.

TABLE 1 Changes in amount (ha) of land under tenure at Baka, 1978–2000.

Land tenure type (ha)	1978	1982/1983	2000
State forest	0	0	6.7
Collective forest	40	40	20
Mountain land allocated to families	0	3.7	3.7
Fallow forestland	418.7	218.7	136.7
Paddy fields	1	8	5.3
Total (ha)	**459.7**	**270.3**	**172.3**

Results and discussion

Socioeconomic development and impact on fallow agroecosystems

Land tenure change and impact on fallow fields

Prior to 1978, all land belonged to collectives of Daka and Baka under the commune system, but since the early 1980s several new policies have had a large effect on land use in these villages. These changes started when the *Household Responsibility System* was implemented in 1978, the purpose of which was to transfer communal land to households. Reform in the forestry sector began in 1981, when the State issued its *Linyesanding* (a regulation consisting of 3 articles governing forest tenure and production, such as stabilizing tenure of hill areas and forests, as well as delimiting the areas of individually held hills and forests, and setting out responsibility for forest production), immediately followed by the more detailed policy of *Liangshangyidi* (freehold and contracted forestlands and swidden fields) in 1982. Under these reforms, both freehold plots and collectively held forests were leased or contracted to individual households exclusively with fixed identifiable boundaries (Guo and Padoch 1995).

Changes in land tenure have significantly reduced the area of fallow fields in Daka and Baka. For example, with the introduction of the *Household Responsibility System* in 1978, 66.7 ha of fallow fields were transferred from Daka to another village. Similarly, in Baka, land use and land tenure have varied frequently in recent times (Table 1). Some examples include the transference of 33.3 ha of state forest from Mangkong village to Baka for use as fallow fields, of which 6.7 ha were not suitable for cultivation and thus kept as state forest since 1990. However, generally fallow fields have been lost. Relatively large areas (200 ha and 66.7 ha) of fallow fields were transferred from Baka to nature reserves in 1978 and 1982, respectively. In addition, 40 ha of fallow fields were given over to rubber plantation by the Menglun government to establish a state farm in 1982. In terms of individual allocations, each household in Baka was given 0.07 ha of mountain land at Ziliushan and each person was allocated 0.53 ha of fallow fields in 1983. In the other Jinuo villages, people were allotted an average of 1.53 ha of fallow fields. The net result of these changes has been a reduction in fallow fields and,

TABLE 2 Demographic change and changes in cultivation (ha) in Daka and Baka, 1985–2000.

Year	Daka					Baka				
	Population	Paddy fields (ha)	Fallow fields (ha)	Fallow fields (ha per capita)	Rubber plantations (ha)	Population	Paddy fields (ha)	Fallow fields (ha)	Fallow fields (ha per capita)	Rubber plantations (ha)
1985	277	18.3	61.3	0.22	0.7					
1987	283	18.3	50	0.18	19.9	255	8.3	48.4	0.19	23.3
1990	284	19.3	50.9	0.18	43.1	256	7.1	72.9	0.29	28.7
1995	304	19.7	56.9	0.19	94.5	259	6.8	47	0.18	28.2
2000	332	19.7	29.3	0.09	134	269	5.3	46.7	0.17	42.2
Change in total area (ha)	55	1.4	–32	–0.13	133.3	14	–3	–1.7	–0.02	18.9
Change per year (ha)	3	0.09	–2	–0.008	8.33	1	–0.21	–0.12	–0.001	1.35

consequently, indigenous households have had to shorten fallow periods and increase the duration of cultivation.

Paddy field development and impact on fallow fields

Paddy fields are increasing while fallow fields are decreasing in both Daka and Baka (Table 2). Government policies encourage local people to develop paddy fields as a replacement for swidden agriculture. Local living patterns changed from high-altitude sites to low-altitude sites, from mountain to valley, and the neighborhood of the highway after people began to plant paddy rice. As of 1968, when villagers started moving from their traditional high-altitude swidden sites to their present lower-altitude locations, they began to cultivate paddy fields. With the implementation of the *Household Responsibility System* in 1983, each person was allocated 0.026 ha of paddy field from communal land, the ownership of which remained collective. In addition, this system means households can build and own new paddy fields and, in fact, indigenous households are encouraged to cultivate new paddy fields even far away from the village. For example, by 1998 there was a 13.5% increase in paddy field area constructed by sample households of Daka. This increase in rice production was in response to the local environment, which, being lower and warmer, was more conducive to rice growing: data from the households in Daka showed that the yield of lowland paddy fields was 3.81 t/ha, while that of upland rice was only 2.01 t/ha in 1998. Similarly, in Baka, the shift in location from traditional high-altitude sites to present sites at lower altitudes also allowed an increase in rice yield: data for 2000 show that the yield of upland rice was 1.8 t/ha while lowland paddy rice was 5.25 t/ha. Households that own more paddy fields have in turn planted cash crops such as rubber and Chinese litchi in the old fallow fields. Despite these high rice yields, however, the lack of an irrigation system affects the stability of paddy fields in Daka and Baka. An irrigation system built in Daka in 1983 failed after 4 years, and at the same time an 1800-m irrigation channel in Baka only worked for 4 years before being abandoned.

The dominance of rubber and its impact on fallow fields

Rubber plantations have developed rapidly in both villages, especially in Daka, where rubber plantations increased from 0.7 ha in 1985 to 134 ha in 2000 (Table 2). Rubber plantations have replaced not only fallow fields but also collective forests. As the villagers experimented, there were three development stages of cash crop plantation in fallow fields. First, upland rice was intercropped with rubber; following this, upland rice was intercropped with rubber and with passion fruit (87% of 30 sample households in Daka planned to cultivate passion fruit in 1998). Presently, local people have started to plant Chinese litchi and common teak instead of passion fruit, as the price of the latter dropped greatly in 1999.

Deforestation and impact on fallow field

Deforestation has been widespread in both Baka and Daka. Trees were removed as timber for both local needs and for sale, and more recently forests have been replaced by cash crop plantation before the logging ban. This deforestation has at times verged on the irresponsible: for example, part of a collective forest maintained to conserve the catchment for drinking and irri-

TABLE 3 Simple Linear Correlation (Pearson r) coefficient and significance test (*t*) of fallow field and socioeconomic factors for Daka and Baka.

	Paddy field		Rubber plantation		Population		Fallow field	
	r	*t*	r	*t*	r	*t*	r	*t*
Paddy field	1							
Rubber plantation	0.52	3.77	1					
Population	0.84	15.10	0.83	14.12	1			
Fallow field	–0.23	–1.29	–0.34	–2.03	–0.42	–2.70	1	
$t_{0.05,df=28}$								2.05
$t_{0.01,df=28}$								2.76

gation water in Daka was cleared for rubber plantation in 1988. In Daka, the secondary forest available for fallow agriculture declined from 520 ha to 107.7 ha from 1968 to 1996. This represents a per capita decrease from 3.1 ha to 0.3 ha. Similarly in Baka, the forest for fallow declined from 418.7 ha to 136.7 ha from 1978 to 2000.

As secondary forest for fallow was lost to rubber plantations, indigenous households had fewer fallow fields available for shifting cultivation. Hence they had to shorten fallow duration and enlarge swidden duration to satisfy livelihood needs. For example, fallow duration in Daka has shortened from 7–10 years to 5 years since the 1980s. At the same time, fallow duration in Baka has been reduced from the traditional 13 years to 5–6 years.

Population development and impact on fallow fields

The Hani and Jinuo nationalities have traditionally believed that more children mean more happiness because of the great need for labor during periods when living conditions are harsh. Recently, however, the population growth rates of both villages have been reduced by the national family planning policy. For example, Daka's average annual population growth rate dropped from 33.58% between 1968 and 1985, to 10.23% between 1986 and 1996.

Although population growth is slowing, the farmland allotted to each person has declined in both Daka and Baka. In Daka over the last 2 decades, fallow fields have declined by 0.008 ha per capita annually, while population has increased by 3 people annually (Table 2). Meanwhile, Baka shows a similar, though less dramatic pattern, with an annual decline in the per capita area of fallow fields of 0.001 ha and an annual population increase of 1 person.

Diversity of land use change in Daka and Baka

Overall, population has a significant negative simple linear correlation with the availability of fallow fields. This is to be expected, as the fallow field resource is limited and those born since the land reform cannot be allocated new fallow fields. Rubber plantation and paddy fields also showed a negative correlation with fallow field availability (Table 3). Again, this supports the observation that development of these activities has occurred largely at the expense of fallow fields. Contrary to this, there was an extremely significant positive correlation between population and paddy fields and rubber plantation. Population increase greatly stimulates the need for food consumption and cash income.

TABLE 4 Number of cultivated crops in fallow fields in Daka and Baka for 60% of sampled households in 2000.

Crop category (use)	Daka	Baka
Fruit	8	11
Vegetable	3	5
Beverage	2	3
Starch	3	3
Staple food	1	3
Wood	1	3
Flavoring	1	2
Medicinal	1	1
Cereal	2	1
Sugar	1	0
Fuelwood	1	1
Fiber	1	0
Seed	0	1
Gum	1	1

FIGURE 2 Expert farmers' strategies for alternatives to fallow agriculture in Daka and Baka: a multi-species orchard in a fallow field in Baka. (Photo by Yong-Neng Fu)

Fallow agroecosystem changes during the past 20 years

Change in fallow crops

A feature of fallow agroecosystems is the high diversity of cultivated species and varieties: there are 26 and 35 species planted in the fallow fields in Daka and Baka, respectively (Table 4). According to our sample of households in Baka in 2000, the highest cultivation frequency crops were rubber, upland rice, maize, and passion fruit. Recently fruit has been increasingly planted in fallow fields to earn cash income (Figure 2). In addition, some traditional crops, such as cotton, are still being cultivated. Fallow crops are dominated by the staple upland rice and maize in both Daka and Baka, while cash crops, encouraged by the government, have tended to be more vulnerable to fluctuating market prices. For example, passion fruit had a high yield and produced a rapid cash income for local households as of 1997, when the price was USD 145/t; however, most of the passion fruit has been abandoned or even removed from fallow fields since 2000, when the price dropped to only USD 24/t.

Change in upland rice variety

A diversity of upland rice is produced to suit different natural and social conditions among local minorities: 20 indigenous upland rice varieties are planted in Baka and 7 in Daka. Some traditional varieties, such as *mowanggu* and *honggu* (local names), are still cultivated; however, with less area under fallow cultivation, they are gradually being replaced by exotics, such as hybridized varieties. Nevertheless, local varieties such as *xihong* and *hejieba* have been cultivated by most households, as they grow on less fertile soils (Figure 3).

There was an extremely significant positive correlation between upland rice fields and crops in fallow fields, and cultivated upland rice varieties in Baka (Table 5). Cash income, however, showed a significant negative correlation with cultivated upland rice varieties. In essence this means that although fallow agriculture supports a diversity of upland rice varieties, households with more cash income do not have to worry about food demand (as they can buy from the market), so they cultivate fewer upland rice varieties and concentrate instead on select varieties with good quality in spite of low yield (Fu and Chen 2002).

Traditional indigenous varieties are closely linked with the livelihood customs and farming practices of indigenous minorities. Indigenous varieties are threatened not only by the introduction of exotic varieties such as hybridized strains (the latter with high yield and great ecological tolerance) but also by the loss of fallow fields, meaning many traditional varieties are no longer in cultivation. There were 20 traditional upland rice varieties in Baka in 1999 (Fu and Chen 2002), while in 2001 there were only 14, and these were dominated by varieties characterized by drought resistance and tolerance to poor soil fertilizer, as well as with high yield (Gong et al 2004). The disappearance of local varieties, especially those with excellent characteristics and breeding potential, is a grave loss in terms of agrobiodiversity.

Change in cultivation technology

Loss in species and varieties is mirrored in the loss of traditional cultivation techniques. Traditional knowledge of land classification, in terms of categories for different cultivation technologies and different fallow crops and varieties best adapted to local conditions, forms the basis of fallow agriculture. These skills are being lost as hybridized varieties that can adapt to different environments are planted widely both in Daka and Baka. Consequently, intercropping technology and long-term continuous cultivation technology with differ-

FIGURE 3 Occurrence of upland rice varieties cultivated in Baka in 2000.

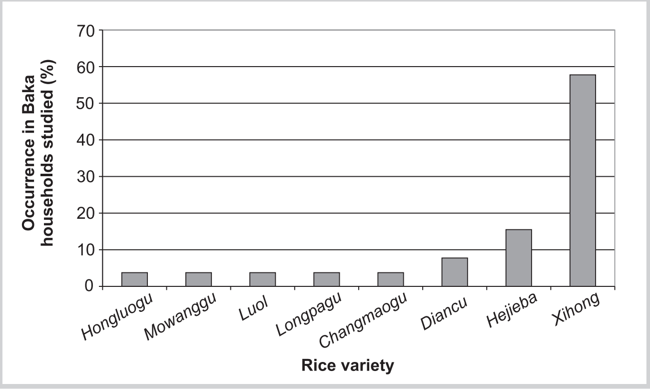


TABLE 5 Simple Linear Correlation (Pearson r) coefficient and significance test (*t*) of cultivated crops and upland rice varieties with fallow fields in Baka in 2000.

	Population		Paddy field		Fallow field		Upland rice field		Cash crop	
	r	*t*	r	*t*	r	*t*	r	*t*	r	*t*
Crops in fallow field	0.22	1.13	0.1	0.49	0.3	1.62	0.55	3.86	0.02	0.10
Cultivated upland rice varieties	0.04	0.20	–0.05	–0.05	–0.25	1.31	0.48	3.06	–0.37	–2.10
$t_{0.05,df=24}$										2.06
$t_{0.01,df=24}$										2.8

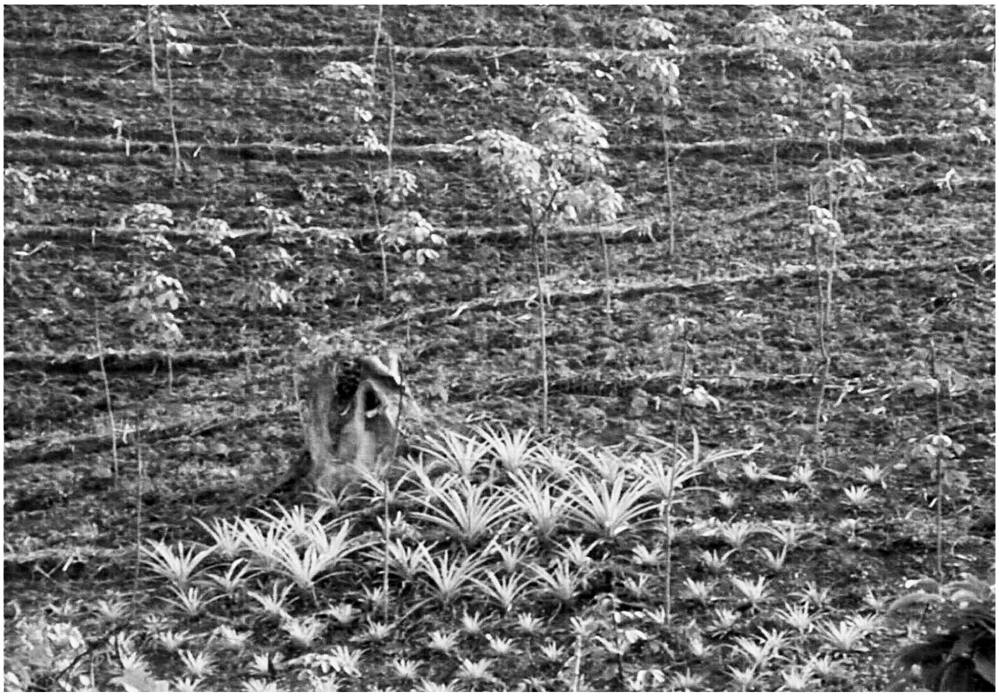


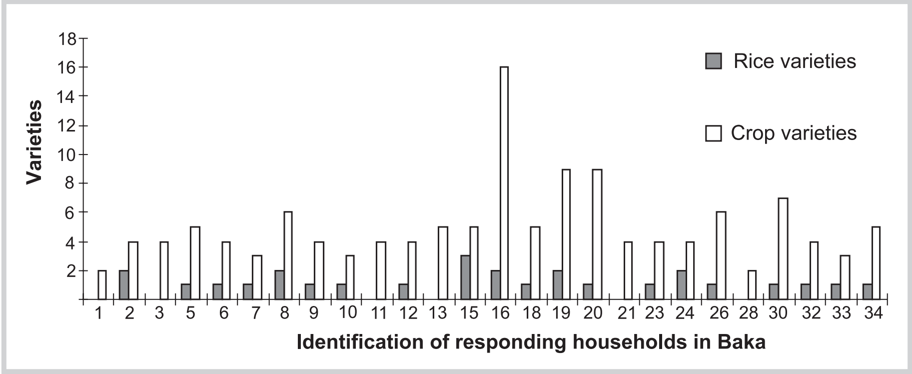
FIGURE 4 Mulched rubber and pineapple in fallow field in Baka. (Photo by Yong-Neng Fu)

ent crops has been ignored, resulting in a reduction of fallow crop diversity. In addition, the shortage of secondary forest for fallow has led to a decline in fallow duration from 13 years to 5 years in Baka and from 8 years to 5 years in Daka. At the same time, short-term continuous cultivation has replaced long-term continuous cultivation, causing a rapid decline in soil fertility and an increase in soil erosion. These changes have been hastened by the introduction of new technology: cultivation tools have advanced while pesticides and herbicides have been introduced to upland rice fields and maize fields, especially in Baka.

Expert farmers and their role in agrobiodiversity conservation
Rapid changes in farming practices in these rural areas of China are now subject to individual farming households' decisions under the *Household Responsibility System* and the expanding influence of the market. Many farmers successfully take these opportunities and innovate or adapt their farming systems and techniques to the new social landscapes. Expert farmers are often those who have some practical technique for natural resource management, together with extensive knowledge of wild plants and their uses. These local experts may possess special skills in propagation, eg germination of rare species and grafting improved varieties of tree crops onto local wild types.

For example, one household in Daka began to plant common teak in fallow fields for commercial purposes, as well as for personal use to remedy future lack of construction wood from collective forests. Moreover, some households cover the soil around young rubber trees with maize stems to reduce soil erosion and maintain moisture (Figure 4). Some households keep tree roots for better natural regeneration of vegetation and enhanced soil fertility for shifting cultivation. The number of crops and upland rice varieties grown varied greatly between households (Figure 5). Households that

FIGURE 5 Number of crops cultivated in fallow fields and number of upland rice varieties for households that responded to the questionnaire in Baka, in 2000.



cultivate more upland rice varieties do not intend to cultivate more crops in fallow fields. Some households cultivated rare upland rice varieties to meet special tastes. Others cultivated several varieties to reduce natural risk. At the same time, some households cultivated numerous crops in fallow fields to meet family consumption needs and earn cash income, while avoiding market risks, as is the case with farmers in other regions who diversify agricultural production to hedge against the risk of food shortages (Frei and Becker 2004). All these practices are the result of a long association with the environment and the specific needs of the community.

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