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SLASH-AND-BURN RICE SYSTEMS IN TRANSITION: CHALLENGES FOR AGRICULTURAL DEVELOPMENT IN THE HILLS OF NORTHERN LAOS[1]

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ABSTRACT Slash-and-burn rice production in the hilly areas of Laos have changed little over the past decades except for a reduction in the Callow period which has caused a tramendous increase in labor requirements for weed control. From 1950 to 1990, the population density increased from 7.6 to 17.6 persons/km^2, fallow periods den-eased from 38 to 5 years, and weeding requirements increased from 1.9 to 3.9 weedings/rice crop. because of high requirements for weeding, the return to labor is only 5 kg rice/labor day For slash-and-burn systems compared with 13 kg/day in lowland rice production. Soil organic C levels arc declining fast, with losses of S t/ha observed during a single rice crop Improvements of the living standard of the farm population, food security stabilization of upland agriculture, and increased rice production are the main objectives of development agencies working in hilly areas. However, the options available are limited by the market opportunities and there is little chance that any of the technologies offered will be adopted on a significant scale. Hill farmers have a comparative advantage for livestock and timber production but generally lack the necessary resources to make long-term investments in either operation. Market, credit opportunities, and land tenure are key factors affecting the direction of future bill agriculture in Laos.

RESUME *Systèmes de culture du riz sur brulis traition —Difficulties pour le developpement del' agriculture dans les collines du Laos du Nord.* Les systèmes de culture du riz sur brmllis dans les du collines du Laos ont peu change an cours des dernières dècennies, si ce n'est tine réduction de la période dejachère qui a cause une augmentation considérable de la main d'ceuvre néscesaire au désherbage. De 1950 à1990, la density de la population a augmentaté de 7, 6 à 17,6 habitants au km^2, les périodes dejachhé ont diminué de 38 à 5 ans et la nécessité du désherbage a augmenté de 1,9 à 3,9 désherbages par récolte de riz. A cause de la grande nécessité du désherbage, le rendement de production n'est que de 5 kg de riz par jour de travail pour les systèmes de culture sur brûlis, compare à 13 kg par jour de travail pour la production de riz aquatique. Les niveaux de C organique du sol tombent rapidement, avec des pertes de 5 t/ha enregistrées au cours d'une seule récolte de riz. L'amélioration du niveau de vie de la population vivant de l'agriculture, la sécurité alimentaire, la stabilisation de l'agriculture en altitude et l'augmentation de la production de riz constituent les objectifs principaux des agences de développement travaillant dans les zones de collines. les options disponibles sont cependant limitées par les débouchés et est peu probable que les technologies offertes soienc adoptées à une échelle significative. Les fermiers des collines jouissent d'un avantage relatif en termes de bétail et de production de bois d' ceuvre, mais ils ne disposent pas en générale des ressources nécessaires aux investissements à long terme pour ces deux activités. Le marché, les possibilités de crédit et le régime foncier Constituent les facteurs clés affectant l'evolution de l' agriculture dans les collines da Laos.

ZUSAMMENFASSUNG *Brandfeld-Reisanbau im Wechsel — Aufgaben bei der lantwirtschaftlichen Entwicklung im hügeligen Nordlaos.* Im hügeligen Teil von Laos hat sich der Reisanbau mittels Brandfeldtechnik ûber die vergangenen jahrzehnte kaum verändert; auâer daâ die Zeit, in der die Felder brach liegen, verkürzt wurde, was zur Folge hatte, daâ der Arbeitsaufwand zur Unkrautkontrolle enorn zunahm. Die Bevolkerungsdichte wuchs zwischen 1950 und 1990 von 7,6 auf 17,6 Personen /km^2, die Brachzeiten der Felder gingen von 38 bis auf 5 jahre zunrück, wobei die Unkrautbeseitigung von 1,9 bis auf 3,9 mal pro Reisernte anstieg. Wegen des groâen Arbeicsaufwandes bei der Unkrautbeseitigung ist der Ertrag beim Brandfeldbau nur 5 kg Reis/Arbeitstag, venglichen mit 13 kg Reis/Arbeitstag im Tiefland. Den organische Kohlenstoffgehalt des Bodens verbraucht sich schnell; bel einer einzigen Reisemte wurde ein Verlust von 5 t/ha festgestellt. Die Hauptziele der Entwicklungsorganisationen im hûgeligen Teil des Lanties sind: Verbesserung des Lebensstandards der Landbevõlkenung, gesicherte Lebensmittelversorgung, Stabilisierung der Landwirtschaft und Entragszunahmen beim Reisanbau. Da der Vcrinarktung Grenzen gesetzt sind, besteht kaum eine Chance, daâ irgend eine von den angebotenen Technolo. gien in groâem Rahmen zum Tragen kommt. Bergbauern haben zusàtzlich die Mõglicbkeit, Viehzucht und Holzproduktion zu betreiben, jedoch fehlen ihnen im allgemein die nõtigen Mittel für langfristige Investitionen. Die Richtung tier zukûnftigen Landwirtschaftsentwicklung im hûgeligen Laos wird entsacheidend von Fraktoren wie Marktlage, kredimõglichkeiten und Landbesitzverhàltnissen bestimmt.

INTRODUCTION

in the past, shifting cultivation or slash-and-burn agriculture was a major land-use system throughout the world (Spencer, 1966; Hillel, 1992). While it has largely disappeared in temperate regions, it remains important in subtropical and tropical environments, especially in mountainous regions, where it supports at least 300 mil-

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lion people (Warner, 1991). Slash-and-burn farmers often belong to minority groups. use fragile or poor soil resources, have disputed land tenure, and live in hilly, remore areas. Any of these factors will put them at a serious disadvantage when compared with other segments of the rural or urban populations. Poor communication, limited access to socioeconomic benefits and markers, poor repre-Sensation in government bodies, and lack of understanding by other groups contribute in maintaining or increasing the existing disparity. Thus, it is not surprising that slash-and-burn farmers are often blamed for forest destruction, land degradation. poor productivity poor response to new technologies offered, or simply for being backward (Singh and Singh, 1980; Dessaint, 1981; Mackie, 1985; Vienne, 1989). To redress these real or conjectured problems. many countries have mounted large campaigns to replace slash-and-burn agriculture with other land-use systems (Myers, 1992; Kleinman a at, 1995). Often these efforts have had little impact. Recent studies of slash-and-burn systems conclude that such systems are economically and ecologically sound in areas with low population densities (Fujisaka. 1991; Kleinman et at, 1995).

Slash-and-burn rice production is the major land-use practic'e in the hilly areas of Laos. Wherever possible, flood plains and valley bottoms where fields are bunded and level are used for lowland rice production (Roder et aL, 1996). but due to limited area of available lowland, farmers depend largely on upland fields that are not bunded and usually are not: level. Low population densities have made slash-and-burn agriculture the best land-use option for the rural population in the hilly regions of Laos and the adjacent hilly areas of Northern Thailand (Kunstadrer and Chapman, 1978), Burma, and Vietnam.

As in other parts of the world (Karlen at *al*, 1994; Kleinman et *al*, 1995), the dangers of resource degradation had been recognized in Laos decades ago. Many records gave evidence of such concerns and/or extension efforts aimed at improving productivity of slash-and-burn agriculture. Goubeaux (1930) listed 46 legume species tested for green manure. The presence of Mimosa invisa, a serious weed in some isolated upland areas, is an unpleasant testimony of those activities (Poilane, 1952). More than 50 years ago, Gourou (1942) made the following statement: "To avoid loss of soil fertility, upland farmers should change from slash-and-burn to permanent systems using perennials such as coffee, tea, rubber, fruit trees, lac, etc," However, Gouron (1942) realized that most of these options were not viable because of transportation problems. Similarly, 30 years later, Phommasthit (1975) wrote that 'the government has cautioned (the upland fanners) not to destroy the trees and dense forests for upland fields and has encouraged them to use the land for horticultural purpose or for reforestation.

The justification for change and the solutions offered today are no different from statements and recommendations made 50-70 years ago. Since then, however, the rural population has experienced significant changes, especially increased population density. wider access to education, increased economic expectations, better road facilities, and marginally better access to markets. The combined effect of these factors exerts substantial pressure on today's slash-and-burn farmers. Now they are eager to change to other land-use systems or live from other sources of income, provided that opportunities are available.

The present efforts of the government and numerous organizations committed to the betterment of the Lao upland ecosystem are laudable. To avoid unnecessary repetition, to achieve the best results possible for the hill populations, and to avoid disappointments, it is important not only to learn from past experiences but to analyze past and present development efforts honestly and realistically. In this paper, I will review and discuss, first, the trends in agricultural practices and their effect on the resource base, second, efforts of government and non-government agencies to change existing agricultural practices and their results and, third, recent findings from investigations that evaluated possible alternatives to slash-and-burn agriculture and technologies to improve upland rice yields.

MATERIALS AND METHODS

All available publications on agricultural research and development in Laos were reviewed and information pertaining to bill agriculture was used to discuss past and present research development efforts. Additional infomation was collected from development agencies working with slash-and-burn farmers in the uplands of Laos. Following a list compiled by the United Nations Country Program (UNDP, 1994), contact was made with all agen cies with active programs in 1994. Using a formal questionnaire, these agencies were asked to list the objectives of their project. major strategies used, and methods recommended to improve upland rice production. Responses were received from 12 out of 15 agencies addressed by the survey. The activities of the agencies interviewed were mainly located in the hilly regions of the north in the provinces of Luang Prabang. Bokeo, Viendane, and Xieng Khouang (Figure 1).

RESULTS AND DISCUSSION

GENERAL DESCRIPTION OF SLASH-AND-BURN AGRICULTURE

The population of Laos is made up of more than 60 ethnic groups (Stuart-Fox, 1986). The majority of the hill dwellers belong to Mon-Khmer (Lao Theung) and Tibeto-Burman (Lao Sung) groups. The northern part of the land-locked country consists of a continuous succession of rolling hills and rugged mountains with peaks

FIGURE 1. Location map of Laos.

FIGURE 2. Weeding upland rice in northern Laos.

rising up to 2,800 in. In the south, the Annmite Cordillera forms an almost unbroken range dividing Vietnam and Laos. The climate is tropical, with distinct dry and wet seasons. Precipitation occurs mostly from May to October and fluctuates widely, influenced by topography and the flow of monsoon winds.

Slash-and-burn agriculture is the prevalent land-use practice throughout the hilly regions, with most of the cultivation limited to the altitude range of 300-1,200 in. According to recent statistics (World Bank, 1995), 69% of the area used for upland agriculture had a slope gradient of 20 percent or more. Rice is the most important crop that accounts for more than 70% of the cultivated area (National Statistical Center, 1996). No tillage and inputs of fertilizers and chemicals are required. Land preparation consists of slashing secondary forest or shrub vegetation in January or February and burning the dry biomass in March or April. Rice, mostly glutinous, is planted with the onset of the monsoon rain in late May and June using a dibble stick (Roder et *al*, 1996). A single rice crop is usually followed by fallow periods of 2-8 years. Few farmers cultivate rice for two or more successive years. A vanety of other crops are planted in combination with rice. These include, in approximate order of declining importance, maize, cucumber, chili, eggplant, taro, sesame, gourd, pumpkin, cassava, loofah, sorghum, cowpea, peanut, sweet potato, job's tear, yambean, pigeon pea, sun hemp, tobacco, mungbean, phaseolus bean, watermelon, and spices.

Casual observers have related specific slash-and-burn practices to particular ethnic groups, following the exampies from Northern Thailand given by Kunstadter and Chapman (1978). Ethnically and culturally the population of Laos has many commonalties with the population oi Northern Thailand, but recent quantitative observations of land-use systems did not support the association of distinct practices with ethnic categories (Roder et at, 1995 d). Practices used today are largely a function of land capability, climate, population pressures, and past political events. Except for changes caused by shorter fallow periods and the introduction of new weed species, the production system has changed little. Only traditional rice varieties are used and tools such as knife, dibble stick, and weeding blade are the same as those used genera-(ions ago.

FALLOW LENGTH AND ITS EFFECTS ON WEEDS, WEEDING REQUIREMENTS, AND SOIL FERTILITY

The primary functions of fallow periods in slash-and-burn systems are to restore soil fertility and to reduce weed pressure (Nye and Greenland, 1960; Warner, 1991; Kleinman et at, 1995). To maintain long fallow periods, large land resources and consequently low population densities are required. The population of Laos has increased from less than I million in 1920 to more than 4 million in 1994 (National Statistical Center, 1995). With a present population growth rate of 2.4%, further substantial increase is expected. The province of Luang Prabang has the greatest area used for slash-and-burn agriculture representing about 25% of the national area. At the same time, this province has a population density of 21.7 persons/km^2 which is substantially higher than the national average. To protect the remaining forest and/or to allow the forest to regenerate, the government is regulating land use and farmers are not given land tenure. Traditional users' rights are overruled if the fallow vegetation

TABLE 1
Trends in fallow length, weeding requirement. labor input, population density, and wage equivalent in rice

	1950s	1970s	l990s
Fallow period (yr)[1]	38	20	5
Weeding requirement (no.)[1]	1.9	2.3	3.9
Total labor requirement for upland rice(d/ha)[2]	226	239	290
Population (million)[3]	1.8	3.0	41
Population density (Nationally person/km^2)	7.6	12.5	17.6
Rice equivalent or wage for construction (kg/d)[4]	8.4	n,a.	5
Rice equivalent of labor wage for farm work (kg/d)[4]	6 + meal	6 + meal	4 + meal

[1]Household survey 1992-93 (Roder a at, 1994).
[2] Calculated from household survey data assuming labor requirement for weeding is propor-. tional to the number of weeding requirements.
[3] Caculated or 1950 using 1970 data and an annual increase of 2A%; Whitaker et *al*, (1972) for 1970 data; National Statistical Center (1991) for 1990 data.
[4] Halpern (1961) for 1950 data; authors for 1970 and 1990 data.

has passed a certain number of years or if the fields are near a national highway. The combined effects of increased population density and government policies limiting farmers' access to land, have reduced fallow periods from about 40 years in 1950 to an average of only 5 years in 1992-1993 (Table 1). Over the same period, the requirement for weeding has. more than doubled.

Weed control in upland rice production (Figure 2) requires about 140-190 d/ha or 40-50 % of the total labor input (Roder et all, 1994). In the survey, upland fanners considered weeds the single most important constraint in rice production (Table 2). With stagnant or, as some authors suggest, declining yields (Fujisaka, 1991), upland farmers' returns to labor inputs have declined substantially. One labor day presently produces about 5 kg rice in upland production systems and 13 kg rice in lowland production systems (Roder a all, 1992). In another study carried out in Luang Prabang province. Leacock a at. (1993) reported labor inputs of 268, 205, and 194 d/ha or returns to labor of 4.3 kg grain/d for upland rice, 8.6 for lowland rice, and 13.3 for maize production.

Traditional slash-and-burn systems are believed to optimize return to labor while using large land resources (Ruthenberg. 1980). While this theory may have been pertinent earlier, it is far from the realities faced by today's farmers in the hills of Laos. Introduction of tillage with animal power is often a key factor in the change from slash-and-burn to more intensive land-use systems. Because of the steep slopes!, however, tillage would not be a sustainable solution for most upland farmers in Laos. Given the hilly topography. the absence of markets, the strong preference for rice, and the lack of other employment opportunities- farmers have no option but to grow rice in slash-and-burn systems. Lack of alternatives, rather than return to labor, is the main reason why they continue using slash-and-burn systems for rice production. It is also interesting that labor wages relative to rice prices have declined substantially over the last decade (Table 4 In part this may be a reflection of the decline in labor productivity in upland rice production systems. Nevertheless, it is also a strong indication of the limited alternative employment opportunities available to the hill population.

TABLE 2
Farmers' rating of major constraints to upland rice production based on household surveys [1]

	Respondents listing constraint (%)		
Constraint	Oudomxay (n=32) %	Luang Prabang (n=97) %	Bokeo (n=57) %
Weeds	81	86	93
Rodents	12	72	61
Insufficient rainfall	47	50	2
Insect pests	69	30	2
Land availability	47	31	-
Domestic animals	16	17	25
Soil fertility	31	22	2

[1] Oudomxay and Luang Prabang survey carried out in 1991-92, (Ruder a at, 1995b), Bokeo survey carried out in 1994 (LAO-IRRI, Annual Technical Report 1994, unpublished).

Changes in the crop-to-fallow ratio not only resulted in an overall higher weed pressure but also caused shifts in weed and pest populations. *Chromolaena odorata*, introduced to Laos in the 1930s, has become the most abundant weed and fallow species (Roder a at. 1995 a)- Elderly people interviewed could not recollect the dominant weed species prior to the introduction of C. *odorata*. It was suggested that C. *odorata* may have largely replaced tree species coppicing from old plants or growing from seeds. With increased cropping intensity a shift from C. *odorata* to Ageratum conyzoides was observed (LAO-IRRI, 1996). The same studies also revealed a strong association between the prevalence of N conyzoides and root knot nematode (*Mebidogine graminicola*). Present reduction in rice

TABLE 3
Relationship between soil fertility parameters, fallow period, weeds, nematodes, and ,ice yield

	Fallow period	Rice yield	Reference
Fallow period		No	1
Organic C	Some	Consistent but low	1
Soil pH	No	No	1
Available N	No	Some	1
Extractable P	No	No	1
Plant N at flowering	High	High	2
Chromolaena odorata	No	No	1,3
Ageratum conyzoids	Some	Some	1,3
Meloidogine graminicola	Some	Some	1

1) Roder et *al*, 1995b, 2) LAO-IRRI, Annual Technical Report 1995 (unpublished), 3) Roder et *al*, 1995a.

TABLE 4
Priorities of development agencies wetting in the hilly areas of Laos[1]

	Agencies listing objective (no.)	
Objective	Primary	Primary and secondary
Improvement of living standard	7	9
Food security	7	8
Stabilization of upland agriculture	6	8
Increase in rice production	6	7
Cash income for farming population	3	8
Increase in livestock production	3	5
Improved nutrition of farming population	2	6
Reduction of ecological damage	1	6

[1]Agencies (n=12) were asked to list their primary and secondary objectives

yield with repeated cultivation could be caused partly by a strong increase of root knot nematodes.

Based on household surveys carried out in three provinces, upland farmers considered rodents the second most important constraint to rice production after weeds (Table 2). Drought and insect pests were also considered important in some locations. Soil fertility, however, was not perceived as a major limitation. Similarly, extensive soil and rice yield measurements did not reveal strong associations between soil parameters and rice yield (Table 3; Roder, 1995 b). Yet, many recent documents discussing the potential of upland agriculture in Laos refer to sail fertility as a major constraint (SUAN, 1990; Fujisaka, 1991; Lovelace, 1991). The only soil parameters showing some association with rice yield were organic C and available N (Table 3). Substantial yield increases with the application of N fertilizer have been established (LAO-IRRI, Annual Technical Reports, 1994 and 1995, unpublished).

Considerable declines in soil organic matter and soil nitrogen have been observed during the cropping and fallow periods (Roder et *al*, 1995 b). In a study of five sites, losses of 5.6 ± 2.7 t/ha for organic C and 0.4 ± 0.13 t/ha for organic N were observed over the cropping perico of 200 days from the soil interval of 0-25 cm. Simdarlv. in another study covering four sites, losses over 3 years (1 rice crop, 2 yr fallow) were 9 ± 2.6 t/ha for organic C and 2 ± 1.1 t/ha for organic N. Through repeated cycles of short fallow periods, the organic matter levels in the Lao upland soils are expected to decline further until an equilibrium has been reached. Most of the organic C loss was attributed to mineralization; only about 10% was found in eroded soil (Roder et *al*, 1995 b). Measures reducing erosion, although important, will therefore reduce the total C losses by only a small percentage. The fallow length required to maintain soil fertiliq~ especially organic C, at an optimal level depends on soil and climatic conditions. For Laos, it was estimated to be 15-20 years (Gourou, 1942; Whitaker a at, 1972). More rime would be required to restore organic C to its original levels. Brown and Lugo (1990) suggested that the time for recovery of soil organic C during succession would be about 40-50 years for tropical forests.

Loss of potential rice yield and contribution to the CO_2 load in the atmosphere are the most obvious results of soil organic C decline. However, the most harmful effect for the farmer may be the loss of other land-use options which will become available with better access to markets. Such options could include fruits, condiments, vegetables, and other cash crops.

OBJECTIVES AND PRIORITIES FOR DEVELOPMENT ACTIVITIES

The forestry. livestock, and agriculture departments under the Ministry of Agriculture all work with upland farmers and advise them on technical issues. In addition to these government agencies. there are a number of projects whose main emphasis is on hill agriculture Current government policies award high importance to rice self-sufficiency and food security. Similarly, the most important objectives of the projects of the development agencies included in the survey were improvement of living standard, food security stabilization of' upland agriculture, and increase in rice production (Table 4). With a strong preference for rice, food security is generally considered equivalent to increased rice production. Rice deficits are frequently reported 'as a major problem for upland regions (VanGansberghe. 1994). Such shortages are certainly not new (Gouron, 1942; Wall, 1975) and it is important to realize that farmers had no use for surplus rice production. Since their storage losses due to rats and insects increase substantially with extended storage periods, the production shortages observed largely reflect the farmers' attempt to optimize storage losses and problems of overproduction. Over 50 years ago, Gourou (1942) observed that the rice and 'maize harvested by upland farmers was used for daily food consumption and for conversion to alcohol; it was rare for them to have sufficient rice reserves until the next harvest. As upland farmers in remote areas have no incentive to produce surplus rice, even small fluctuations in production will immediately result in shortages.

If the main reasons for today's apparent rice shortages at the national level are drought stress (Roder et at., 1996), pricing, and market policies (World Bank, 1995), then the emphasis on rice production will not help to solve the problem for the upland households. Emphasis on other crops such as maize and cassava is more likely to improve food security in remote areas. Maize and cassava are not only less susceptible to drought, they are also used as livestock feeds; thus, surplus production can be used for livestock.

While high levels of self-sufficiency with rice will remain an important goal, economic realities have to be considered- According to a recent review of agricultural profitability, the returns to labor were US $0.14, 0.74, 1.65, and 11 .9/d for upland rice production. upland maize production. buffalo raising, and pig fattening, respectively (World Bank, 1995). Upland rice production is, by far, the least profitable enterprise for the hill farmer. Considering the limited market opportunities for annual crops and horticultural products. the relatively low population densities, and the hilly topography, in general. upland farmers have a comparative advantage for livestock and timber production (Roder et al,, 1995 c). Livestock products are already the most important source of cash income, contributing 68% of the annual cash income [or the farmers surveyed in 1992 and 1993 (Table 5). With high value per weight and being partly mobile, they are less dependent on road facilities.

TABLE 5

Sources of cash income[1]

	Cash income (US $)	
	1992	1993
Rice	15	5
Livestock	76	59
Forest products	3	10
Other crops	3	5
Wages and off farm	15	8
Total	112	88

[1] Sample sizes were 64 in 1992 and 126 households in 1993 (Roder et *al*, 1996).

EXTENSION AND DEVELOPMENT EFFORTS AND TECHNOLOGIES PROMOTED/ADOPTED

The development agencies interviewed listed "advice on farming practices" as the most important strategy used to achieve the objectives of improved food security and higher rice production (Table 6). Meaningful advice to farmers can be provided only if the technologies at hand are superior to those presently used. Furthermore, slash-and burn, no tillage systems may be the only sustainable method for rice production in hilly environments. Therefore, the choice of realistic technologies available to change or improve the system is very limited, especially if rice production is to remain a major focus.

While there is some agreement that the land-use options of upland farmers are limited by die absence or inaccessibility of markets, none of the agencies interviewed had listed the provision of market support as a primary strategy. The marketing of upland products is left to private individuals or companies who seek high profit margins and who do not hesitate to exploit the unprotected farmers to the maximum limit possible.

Rotation systems with legumes, and hedge row/alley cropping systems

These systems (or combinations of them) are the most widely recommended technologies to improve upland rice fields (Table 7). Species recommended in these systems. in order of preference, by the agencies interviewed are: pigeon pea, leucaena, ruzzi grass (*Brachiaria ruziensis*), *Calliandra callothyrsus*, *Stylosanthes guianensis*. and vetiver grass. There is good potential for increased livestock production by replacing the fallow vegetation with fodder species. Improved fallow systems, which combine the effects of fodder plants and grazing animals. may not only increase fodder availability but also suppress weeds and accelerate nutrient cycling (Roder et *al*, 1995 c). Further research, with farmers' participation, will be necessary to identify appropriate species and to develop suitable rotation systems and technologies to manage the introduced species and their residue cover during the rice crop.

Hedgerow and alley cropping systems have been promoted in northern Thailand for many years with very little adoption by fanners. At the same time, the benefits

TABLE 6
Major strategies used by development agencies surveyed[1]

Strategy	Agencies listing strategy (no.)	
	Primary	Primary and secondary
Giving of advice on farming practices	7	10
Improvement of irrigation facilities	6	8
Vaccination of livestock	5	8
Setting up of revolving fund	4	8
Increase of area for lowland rice	4	7
Supply of seeds or fertlizers	3	8
Setting up of rice banks	3	4
Supply of fruit trees	1	7
Provision of marker support	-	2
Provision of market information	-	1

Agencies (n=12) were asked to list their primary and secondary strategies.

TABLE 7
Technologies recommended to improve upland via yields and extent of adoption

Technology	Number of agencies[1] (n=12)	Adoption [2] <10ha	Adoption [3] >l0ha
Rotation systems with legumes	9	4	1
Hedgerow system using trees	6	2	-
Improved varieties	5	3	-
Alley Cropping	5	4	-
Control of insect pests	3	-	-
Control of rodents	2	1	1
Fertilizer use	2	1	-
Terracing	1	-	-

[1]Agencies recommending technology as primary or secondary strategy (no.).
[2]Agencies reporting adoption at level c 10 ha (no.).
[3]Agencies reporting adoption at level> 10 ha (no-).

from alley cropping, especially in drier environments, have been seriously challenged (Coc, 1994; Ong, 1994). Although rotation benefits from pigeon pea have been demonstrated (LAG-IRRI, Annual Technical Report 1994, unpublished), its value is limited by the absence of a market for pigeon pea seed. While there may be some potential for modified hedgerow systems in parts of Laos, it is unlikely that any of the conventional systems with the Species presently recommended will ever be adopted by Lao upland farmers on a wider scale. Furthermore, there is presently no evidence that any of the species recoinmended for fallow improvement would be superior to C. odonna, the prevalent fallow species (Roder a at, 1995 a).

Alternative crops

Earlier efforts to introduce fruit production had enjoy limited success because of lack of market opportunities (Roder et al, 1995 d). All participating farmers from Oudomxay Luang Prabang, and Sayabouly provinces in a recent research program preferred teak over fruit trees (Table 8). While fruit plantations increased only moderately in the Luang Prabang province, the area under teak has increased exponentially over the past few years. The sudden rise in the interest for teak planting was associated with changes in laws governing the use of timber (allowing farmers to own timber Plantedt departure from collectivized agriculture, and increased confidence of the farmers in the political stability of the country. Yet, investigations have shown that most of the teak plantation owners are farmers who own lowland rice areas, indicating that teak, although planted under upland conditions, is not an alternative crop for the upland farmers (Roder et at, 1995 d). Resource-poor families, representing the bulk of the slash-and-burn farmers, generally cannot risk the long-term investments (land, labor, fencing, planting material) required. In fact, promotion of teak may result in further deterioration of the upland farmers' resource base as upland farmers may lease out their land-use rights to lowland farmers or other investors. Efforts should be made to support resource-poor upland farmers through credit and other means to make it possible for them to plant teak. Modified plantation systems combining food,

TABLE 8
Choice of perennials and conservation measures adopted in farmer's participatory research projects (1994)

	Rate	Extent of adoption [2]
Choice of perennials		Tree (no.)
Planting of teak	100	380
Planting of mango	23	13
Other fruit: trees [3]	23	20
Conservation measures adopted		Area (ha)
Planting of:teak along contours	31	0.5
Planting of grass strips (vetiver or *Brachiaria* sp.)	15	< 0.1

[1] Percent of fanners (n = 13) choosing species or adopting soil conservation measures.
[2] Number or area per farmer planting a particular species or adopting a conservation measure.
[3] lncluding pomelo, longan, jack fruit, and custard apple.

TABLE 9
Technologies evaluated to maintain or macale rice yield ornduce weed biomass

	Demonstrated effect			
Technology	Yield increase	Weed reduction	Limitations	Reference'
Increase rice yields	(%)	(%)		
Application of N fertilizer	0-150	0	Economic, input availability	a
Application of P fertilizer	0-15	0	Economic, input availability	a
Selection of improved varieties0	0			a
Crop rotation effects	0-50	(-)20-50	Additional labor, market	a
Planting density	(±)[2]0-40	(-)10-30	Yield reduction, grain qualities labor	a
Intercropping with legum	(±) 0-50	(-)10-40	Yield reduction, market, labor	a
Weed residue management				
Prepland glyphosate	0	30-50	Economic, input availability	b
Residue burning	0-70	0-30	Loss of organic C and N	a
Intercropping with maize	(-.)[3]10...70	0-20	Yield reduction rice, market maize	a

[1] a) LAO-IRRI Annual Technical Reports 1991-96 (unpublished), b) Roder et al, l995e.
[2] lncrease and decrease in yield in the range indicated have been observed.
[3]Yield decreast

livestock, and timber production could be possible alternatives.

The farmers' assessments of marker opportunities for horticultural products reflect past experience. Improved communication networks, local fruit processing industries, and growing local markets may provide opportunities for increased fruit production. Fast growing markets in urban centers offer a range of new opportunities for nearby upland farmers to produce high-value vegetables and fruits. When provided with the necessary information on market potential and appropriate seeds, innovative farmers are very quick at adopting new crops and technologies (P. Hoare, Australian Upland Project, 1995, pers. Comm.).

Soil conservation practices

The greatest effort toward changing agriculture practices in the recent years focused on soil' conservation through terracing, and contour tillage (Fujisaka, 1989). A large FAO-sponsored project used a "food for work" program as incentive for the farmers to adopt their recommended methods. Early project reports were very enthusiastic over the high adoption rate and the impact of these activities (SUAN, 1990). Slash-and-bum practices were said to have been completely abandoned in 27 villages and reduced by 50-80 percent in 163 other villages (SUAN. 1990). Only a few years later, no evidence of these changes was traceable and the same project was quoted as an example of an approach that failed because the technique was neither necessary nor economical (Fujisaka. 1989).

PERTINENT RESEARCH FINDINGS AIMED AT INCREASING RICE YIELD AND/OR REDUCING WEED BIOMASS

Variety improvement and agronomic practices

Traditional varieties and farmers' management practires were found to be well adapted to the given conditions- The limited number of introduced varieties tested and variations in planting date and planting densities did not consistently improve yields. There was, however,

increasing evidence that N availability limited Acids as implied by substantial response to N applications, especially applications after panicle initiation (Tables 3 and 9).

Cropping systems

Rice yield increase and/or reduction in weed biomass through crop rotation and intercropping systems has been demonstrated (Table 9). These systems always require additional labor investments, but without adequate markets for by-products such as cowpea, pigeon pea, and maize, the additional rice produced does not compensate for the extra labor investment. Improved fallow systems most likely to succeed are those that include grazing and that optimize nutrient and moisture management. Most promising species for such systems presently tested on station and in farmer's fields include *Stylosanthes guianensis*, Leucaena leucocephata, Olivicidia sepium, and £radijaria species. Caution is needed to avoid, introducing new weed species, such as Mimosa invisa which was proinoted as a green manure plant in the 1950s (Poilane, 1952) and has now become a serious weed problem in some upland fields.

Weed and residue management strategies

Various weed and residue management strategies including mulching, residue burning, live mulch cover, and herbicides have been investigated but the results offered little promise for practical application (Table 9; Roder a al., 1995 e). Residue burning, as practiced by the farmer, reduced weed biormass in all experiments carried out and increased rice yield in some years. Application of glyphosate before rice planting reduces soil erosion and labor requirements for weeding (Roder et at, 1995 e).

Traditional rice production practices in the hills of Laos have changed little except for the dramatic reduction in fallow length. Shorter fallow periods resulted in excessive labor requirements for weeding but have had few visible effects on soil fertility and crop yields. Weeding requirement$ and soil fertility problems are likely to become more acute with repeated cycles of short fallow periods. Because of the unsatisfactory returns to labor and increased expectations, the Lao hill farmers are under great pressure to change their land-use practices and may reach a critical point where it Will be profitable for them to shift to a more intensive agricultural system (Boserup, 1965) However, lack of markets, credit facilities, or alternative employment opportunities leave them little choice but to continue producing upland rice for their own consumption.

Efforts by government and non-government agencies and projects focus largely on increasing food security and producdon by providing advice to farmers on new technologies. The range of technologies available to increase rice production under the given conditions, however, is limited at best. Farmers wilt adopt new technologies only if they are necessary, appropriate, and economical (Fujisaka, 1989). The solutions recommended today are similar to those advocated decades ago with emphasis on improved Callow/alley cropping, rotation systems, soil conservation measures, and planting of perennials. Many of the technologies recommended may not fulfill the criteria suggested by Fujisaka (1989). It must be acknowledged that technologies which are adopted under coercion, or with subsidy incentives, are unlikely to provide long-term solutions. There is a strong tendency for development pojects to be over-confident in advising farmers of new technologies, and to be too optimistic when reporting the success of their efforts.

Available markets, credit opportunities, and land tenure are the key factors that will affect the direction of future upland agriculture. One should be realistic and take these factors into consideration when planning development and extension activities and should place more emphasis on the following:

- Providing better and more stable market opportunities;
- Developing competitive marker systems and protecting farmers from exploitation by traders and middlemen;
- Helping farmers to improve their land-use rights or land tenure and to prevent them from giving away or selling their rights to parties interested in timber plantation;
- Providing realistic, affordable, and available credit systems;
- Focusing on realistic food security systems which will not depend on increased rice production in the uplands:
- Providing better access to health and education facilities and paying attention to nutritional problems which may arise with the change from traditional systems to a market economy; and
- Creating alternative employment opportunities that are dependent on the growth of other sectors of the national economy.

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