The Role of Livestock in Upland Farming Systems in Huaphan and Phongsali Provinces: Social Implications

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Abstract

The Lao Australia Health and Local Development Project is supported by the Australian Government and will be implemented gradually in Huaphan and Phongsali Provinces of Lao PDR during the next five years (1997–2001). Its purpose is to improve the quality of life of rural communities in targeted districts. Global objectives include improvement in the quality and delivery of primary health care services, with emphasis on Mother and Child Health (MCH), food security, and socioeconomic wellbeing. The project is being implemented through various agencies at provincial and district levels: health (involving MCH, and the Clean Water Institute), Lao Women's Union, agriculture (including irrigation, crops and livestock). While the project is just beginning, it will expand during the next five years to cover a total of about 150 villages in six districts of the two provinces.

HUAPHAN and Phongsali are two of the most remote provinces in the Lao PDR, and the most rugged and mountainous. In general, 90% of the land is classified as highland or mountainous, with only 10% classified as flat. This flat land is found in small pockets and valleys between sharp, rugged hills, mountains and ravines.

Due to the nature of the terrain, the flat and lower areas of these provinces are subject to severe flash flooding in the wet season. In general, there is an opportunity only for micro-scale irrigation, although there is potential for a few small-scale schemes.

The provinces have a high percentage of forest cover, probably due in large part to the remoteness and inaccessibility of the forest and its precious logs. The provinces are extremely fragile environmentally, with slopes so steep (between 45° and 65°) that naturally-occurring landslides are common.

Most farmers in these areas practise slash and burn (95% of this project's targeted communities). The provinces also have a high percentage of minority groups who traditionally grow hill rice, maize and opium, and raise cattle, goats, pigs and poultry on a small scale. People in the lower areas also raise buffalo.

Current government policy in both provinces involves voluntary, but heavily encouraged, relocation of highlanders to lower upland areas. In very few cases can communities be resettled in valley floor areas because land is simply not available, having been settled by others much earlier.

While the focus of these Proceedings is the role and potential of livestock in upland farming systems, some liberty has been taken here to focus on the people who practise the upland systems and who raise the livestock. It is important to add that these people are in transition, not only changing their physical location but also what they do and how they do it.

What is the role or potential for livestock? Certainly, the potential for markets appears favourable, given the province's proximity to China and Vietnam. Although road infrastructure is poor, these provinces are sufficiently close to borders to make cross-border trade feasible. Constraints relate to the environment itself and the current levels of technology and expertise among the people.

Farming is presently based on traditional methods and systems, with livestock only as a small-scale component, free-ranging according to local conditions. Further developments in the role of livestock must take these constraints into account.

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Livestock development will have to be intensive, due to the fragility of the environment and the lack of sufficient flat or rolling land to grow fodder or to graze animals. Intensive farming means intensive management, with detailed planning and education as a pre-requisite. This process would also have a social impact, with people in new situations having to use new technologies and practices, requiring massive behavioural and attitudinal changes.

Some communities are now taking on new ways of farming. Many will need draught animal power for ploughing, and there will be an increase in the number of buffalo being raised for this purpose as more people move away from the highlands, but it is not envisaged that this activity will develop beyond satisfying community needs for ploughing. Poultry and pig raising can be expanded easily as not so much land is needed as for grazing animals. However, it will still require adaptation by farmers to new conditions and new methods. Moving into lower, more populated areas will undoubtedly result in increased exposure to diseases.

Raising larger livestock such as cattle and goats presents a more difficult scenario. If it is to increase, it must be on an intensive basis, and this is where problems occur. At present, local farming communities are not familiar with intensive agriculture, or the intensive management that must accompany it to be successful. For government agencies, there is more to the challenge than simply introducing new technology to farmers. It extends to having to ensure that farmers are sufficiently trained and disciplined to undertake intensive agriculture.

Detailed planning is a pre-requisite to which communities have had little exposure. Communities are not sufficiently aware of the effect on the environment that particular farming practices can have. Cause and effect can be hidden by other systems of thought, such as animism. The people are not so sophisticated, scientific or diversified in their thinking as to understand, for example, how to embark on watershed management and protection or why.

State agencies must assist in the further education of these communities, in the development of land capability surveys and participatory land use plans. This type of planning will determine the areas physically suitable for raising particular types of livestock and to what scale, and any other agricultural activities that can be carried out on a sustainable basis. These plans must be able to demonstrate sustainability and set limits to the amount of livestock in a particular area.

The elements of intensive farming must be demonstrated to the communities and they must be trained to be responsible for all those elements. All concerned need to have a commitment to persevering with new management techniques, as the environment simply cannot handle an expanded role for large livestock without it. The communities must also accept that the traditional ways of allowing livestock to forage freely are no longer viable in a changing environment, and that their traditional slash and burn farming systems are obsolete.

It is this re-education process that requires attention. The links between research, extension and the farmers need examination and redefining to ensure that proven technology can be made available in order for farmers to conduct their own adaptive research. Extension agents must be thoroughly competent in their respective subject areas in order to provide a service of value to farmers. It is this 'end user' adaptive research that becomes important, with farmers seeing that they themselves, or others just like them, are capable of adopting new technology successfully.

The question is, how can this be done properly and effectively to ensure that farmers are adequately trained, monitored and supported, and as cost efficient as possible — a principal consideration when developing any delivery strategy, especially in developing countries. Perhaps one answer lies in the use of community development techniques to be applied to the research-extension-adoption process.

One such technique can be borrowed from the community organising strategy. Through the use of this strategy, communities are encouraged to form groups of their own choice comprised of farmers undertaking the same or very similar activities. These groups become the point of interface between research, extension and community. The grower group or the livestock group can then be trained to plan and to manage its own activities. The focus of the training becomes the group and its members must be encouraged to undertake trials and to set up demonstrations on their own land. The groups must eventually be seen to be stakeholders. Group strengthening strategies are needed to establish and to maintain group cohesion. There must be meaning to being a member of a group and there must be some tangible benefit. The benefit may be the opportunity to trial some new technology, or to receive instruction or advice. It may be that one must be a registered member of a group in order to undertake a particular activity.

Once a group is established strongly, it is able to maintain discipline among its members and, in the case of intensive farming, use its significant peer pressure to enforce compliance to rules or technical guidelines by its members. Agency staff should work through group structures, using them as conduits for the delivery of services, and in the process, strengthen the group by supporting its role and function.

It is basic that research to identify and to prove new technologies must be pursued. The point at issue is that farmers must be trained sufficiently so that they can successfully adopt any new technology, method or system. While research is able to develop many new technologies, and the training of technical staff to implement them is ongoing, it is the transfer of skills to farmers that lags behind. The linkage is weak. Extension agents often express frustration at the reluctance of farmers to adopt new technology or practices. Many agents seem not to understand the risk factors that are weighed by farmers contemplating experimentation.

Not much can be expected if results cannot be guaranteed. However, extension and training techniques can be modified. By the use of group strategy, farmers can be made to feel they are sharing the risks of new technologies. By encouraging farmers to test new technologies on their own land and under their own conditions, opportunities are provided to give farmers a much better understanding of the technology being tested and the methods and systems that need to be employed to be successful. By supporting and monitoring local adaptation and adoption, technologies and the extension process itself can be improved, with the aim of building up the confidence of farmers. The role of extension agents is to support farmers and to advise them on recommendations and guidelines. Actual testing is carried out by the farmers themselves, with the knowledge shared by all members of the group.

It is this philosophy that has and will shape the delivery strategies used in the Lao Australia Health and Social Development Project.

Livestock in Upland Rice Systems in Northern Laos

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Abstract

Upland rice is the predominant crop in northern Laos, grown on 60%–80% of the cultivated land area and accounting for the majority of grain production in several mountainous provinces. Most upland rice is grown in shifting cultivation systems. Government policy aims to end shifting cultivation and decrease areas cropped to upland rice by allocation of land to households and diversification of permanent production systems. Population growth and restrictions on land available for cultivation have led to shortened fallows, increasing weed problems, and declining soil fertility. Supplemental planting of fast-growing species can help increase biomass production for weed suppression and accelerated nutrient cycling and accumulation. Improved fallow plantings must be protected from free-ranging livestock for growth of sufficient biomass. Prior to cropping, farmers currently burn fallow vegetation to clear land and release nutrients as ash. Burning destroys most of the nitrogen and organic matter contained in fallow vegetation. Nutrients in ash are subject to leaching and runoff losses. Most species used for fallow improvement are legumes with high feed value and palatability to livestock. Controlled grazing of livestock on improved fallow vegetation can increase livestock production and cash income to households, while helping to conserve nutrients to maintain productivity of upland agroecosystems.

Upland Rice Production in Northern Laos: Changing Traditional Systems

The predominant crop in northern Laos is upland rice, which is nearly always grown in traditional rainfed, short-term bush fallow rotation systems, commonly referred to as shifting cultivation or 'slash-and-burn' systems. Forests, secondary fallow vegetation, and crop residues are burned to provide nutrients for annual cropping and for land preparation prior to dibbling seeds into untilled soil. Fertilisers and other modern agricultural inputs are generally not available to upland farmers and slope gradients are too steep for tillage. Fallowing and fire are the primary means of fertility regeneration and weed control; however, increasing population pressure and restrictions on cultivation of new lands have resulted in shorter fallow rotations with declining soil fertility and increasing weed problems (Roder et al. 1995a). In extreme cases, fallow periods have decreased to as little as three years, followed by two or more years of rice cropping. Productivity of the resource base is declining. The vast majority of rural households depends on the cultivation of a single upland rice crop each year to try to meet their basic food needs. Surplus production is rare and rice deficits are common.

Nationwide, upland rice is a major crop, planted on 28% of rice lands and accounting for 19% of grain production in 1996 (Table 1). In several mountainous northern provinces, upland rice is grown on 60%–80% of cropped land areas. In Luang Prabang, nearly two-thirds of the province's total annual rice harvest currently comes from upland fields.

Government policy aims to end shifting cultivation and decrease the area planted to upland rice (Table 1). Decreases in upland rice production will need to coincide with corresponding increases in lowland rice production in order to meet the policy goal for national self-sufficiency in rice production (Table 2). While land areas cropped to upland rice decrease, productivity on permanent upland fields

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Table 1. Targeted decrease in upland rice area and production.

	1995				2000			
	Area		Production		Area		Production	
Upland Rice	Ha	%	Tonnes	%	Ha	%	Tonnes	%
Lao PDR	178 500	28	266 000	19	52 500		81 000	4
Luang Prabang	35 900	77	59 500	65	18 900	59	34 020	41

Sources: Ministry of Agriculture and Forestry (1995). National Rice Research Program and Lao-IRRI Project (1997). Crops Section, Luang Prabang Agriculture and Forestry Service (1996).

Table 2. Policy targets for changes in land areas of rice environments in the Lao PDR and Luang Prabang Province.

		1994		2000		Change
Land areas of rice environments		Ha	%	Ha	%	%
	Rainfed upland	219 100	36	52 500		– 76
	Rainfed lowland	380 800	62	438 000	77	+ 115
	Irrigated lowland	11 000	2	75 000	13	+ 682
Lao PDR	Total rice land	610 910	100	565 500	100	– 7
	Rainfed upland	55 900	86	18 900	58	– 66
	Rainfed lowland	8 800	13	11 510	35	+ 131
	Irrigated lowland	400	0.6	2 150	7	+ 537
Luang Prabang	Total rice land	65 100	100	32 560	100	– 50

Sources: Ministry of Agriculture and Forestry (1995); MAF pers. comm. National Rice Research Program and Lao-IRRI Project (1995). Crops Section, Luang Prabang Agriculture and Forestry Service (1996).

must increase to feed the growing population. Increased productivity must be maintained to prevent abandonment of fields and shifting to new lands. National policy for improving productivity and stability of upland systems involves: land allocation to individual households, diversification of cropping systems, and increasing yields of upland rice by utilising higher yielding varieties, fertiliser inputs, and improved weed and pest management (Schiller et al. 1996).

Identifying superior varieties can help to increase yields of upland rice, but maintaining long-term productivity requires integrating and diversifying the upland 'rice-based' cropping system to include non-rice annual crops, soil improvement crops, fruit and timber trees, forages, and livestock. Key strategies for improving productivity of upland rice-based systems include: crop and fallow rotations with rice, fallow improvement, improved management of fallow vegetation, and soil conservation measures which encourage integrated landscape management. Livestock have an important 'value-added' role to play in providing incentives for implementation of these strategies, generating cash income to largely subsistence-based household economies, and raising productivity of the upland agroecosystem.

Current Situation: Under-utilised Fallows and Free-range Grazing

Natural fallow vegetation in most areas of northern Laos consists of annual weeds and aggressive shrubby perennials such as *Chromolaena odorata* in early years, followed by increasing predominance of bamboo and coppice regrowth of secondary forest trees in later years. Most fallow species are unpalatable to livestock or of poor nutritive quality.

Ruminant livestock[4] belonging to both lowland and upland farmers are commonly turned loose to

[4]This paper focusses on ruminant livestock in upland rice cropping systems. Small livestock (swine, poultry, fish) also depend on primary productivity from upland rice systems in the form of gleanings and grain milling by-products.

graze in fallows and forests during the upland rice cropping season. They are often a serious pest to the rice crop and necessitate construction and maintenance of sturdy fences. In surveys of upland farmers in Oudomxai and Luang Prabang provinces, 15% of (129) farmers interviewed indicated that damage from domestic livestock was a serious constraint to rice production (NRRP and LIP, 1992).

Fence construction requires up to 10 days of labour per hectare; but is generally less, averaging 2 days per hectare (Roder et al. 1997), because farmers group their fields together in blocks and share labour for fencing perimeters of the cropped area. Lowland farmers derive benefits from open grazing of livestock in the uplands, but they increase risks of livestock damage to upland rice fields without contributing labour or material resources for upland field protection. Among the upland farmers, it has generally been observed that Lao Soung (summit dwelling) ethnic groups are more advanced in livestock containment and grazing management practices than Lao Theung (midland dwelling) or Lao Loum (lowland dwelling) ethnic groups, but reasons for these differences (if they do, in fact, exist) are not clear.

Barbed wire, in quantities required for adequate protection of fields, is not affordable for most upland farmers. Most fences are constructed from bamboo and fence failures are common. *Jatropha curcas*, known locally as *houng kaew* is also commonly planted vegetatively as living fences, usually reinforced with bamboo or barbed wire. Participatory research on establishment and management of multipurpose tree species for use as living fences is needed.

As livestock populations increase in the uplands, communities will need to decide whether it is more efficient to continue fencing livestock *out* of fields or to begin fencing livestock *in* to pastures or stalls for controlled grazing and cut-and-carry systems. Fencing around upland fields is usually not maintained during fallow periods. Intensifying upland cropping systems (by fallow improvement and perennial plantings) and livestock systems (by planting forages) will depend on restricting free-range grazing practices.

Crop-Livestock Interactions: Prospects for Improvement

Though ruminant livestock are currently pests in upland rice fields in northern Laos, with proper management to control timing and intensity of grazing, livestock could utilise improved fallows and forage crop rotations to the mutual benefit of both livestock and crop components of integrated upland production systems.

Fallow improvement

Managing natural fallow regrowth is no longer an effective means of maintaining crop productivity. Supplementing natural fallows by cultivation of fast-growing species which produce large quantities of biomass can help to maintain or improve soil fertility and to control weeds. Accelerating biomass production increases cycling of nutrients by preventing losses from the system through leaching and erosion. Deep-rooting plants extract nutrients from a larger volume of soil and deposit them as leaf litter on the soil surface. Conserved and mobilised nutrients are thus available for crop production. Nitrogen-fixing species can add significantly to the pool of the nutrient which most often limits crop production.

Fast-growing tree species may be most promising for fallow improvement because they produce a canopy above most annual weeds and may help to suppress their growth by shading. Natural and improved fallows can be enriched by planting perennial crops with market value such as paper mulberry *(Broussonetia papyrifera)* (Fahrney et al. 1997). Paper mulberry bark is harvested and sold to provide cash income during the fallow phase of the rotation. Leaves are also a favoured fodder for ruminant livestock, pigs and fish.

Legumes are generally favoured for fallow improvement because of their rapid growth and potential nitrogen contributions to systems. Most legume species used in fallow improvement are attractive forages or fodders for ruminant livestock and have potential for increasing livestock production if sufficient biomass is allowed to grow (by protection from livestock) during the fallow regeneration phase of the rotation.

Improved management of fallow vegetation

Benefits to crop production of increased nutrient inputs and cycling from improved fallows may depend largely on how the biomass is managed in the conversion from the fallow to the cropping phase of the rotation cycle.

The amount of biomass produced by short-term improved fallows is similar to amounts produced by several years of natural fallowing. Fallow vegetation must be cleared prior to planting rice or other crops. Burning destroys most of the nitrogen and organic matter contained in fallow vegetation. Soluble nutrients contained in ashes may be lost by runoff or leaching.

Systems that involve burning may be necessary for clearing woody vegetation and for weed control, but 'biodigesters' — livestock — can help to clear leafy green vegetation from improved fallows or forage crop rotations, conserving, concentrating, and delivering nutrients in a relatively stable, but plant-available form, i.e., manure. More research is required to understand better the prospects for improving nutrient management in hybrid grazing/burning systems.

Livestock feed is usually in shortest supply at the end of the dry season. Utilising improved fallows as a forage or fodder resource should benefit livestock production. Cut-and-carry systems are a major departure from current livestock production practices and are likely to have less chance of adoption, at least in the near-term, compared to modifications to existing grazing practices. Controlled grazing practices (timing, numbers of livestock, etc.) which are optimal for both fallow management and livestock production have not yet been determined. On-farm studies are needed to develop grazing systems utilising improved fallows. Livestock and crop scientists will need to work together with farmers and village leaders to find systems that work.

Soil conservation and integrated landscape management

Soil conservation is essential for permanent cultivation systems, particularly on steep slopes that are cropped in northern Laos. Contour plantings of vegetative erosion barriers, forage strips, and fruit and timber trees can be the basis for transforming swidden rice fields into integrated and stable mixed farming systems.

Contour hedgerows (of vetiver grass, forage grasses, and *leucaena*, for example) are effective in reducing soil losses and increasing infiltration of water. Hedgerows break the slope into smaller lengths, reducing erosion, but they also break the field into management units which are useful for practicing rotations of rice with cash crops, forages, improved fallows, perennial plantings of fruit and timber trees, and livestock feeding pens. The dual-purpose nature of forages as hedgerows (feed resource, as well as erosion control) may serve as an enabling incentive for farmers to establish and maintain hedgerows.

Timber trees, such as teak (which after 4–6 years can serve as fence posts for barbed wire), or more closely spaced multi-purpose trees planted as living fences along contour hedgerows, can serve to contain livestock for cut-and-carry feeding of forages and improved fallow vegetation. Rotating locations of feeding pens can concentrate nutrients and organic matter in manure, rapidly building up soil fertility and water holding capacity, maintaining or improving productivity and increasing opportunities for crop diversification.

Rice-Based Cropping Systems Research Relating to Livestock Production

The uplands research component of the Lao National Rice Research Program and the Lao-IRRI Project conducts 'rice-based' cropping systems research at Houay Khot Station in Luang Prabang province and on farms at near-by villages in Xiengnguen District. In 1996, on-farm systems research extended into Luang Namtha, Oudomxai, and Xaignabouri provinces. Most cropping systems studies involve research on fallow improvement and rotations with legumes.

Establishment methods for potential improved fallow/forage species were evaluated on-station in 1992 and 1993 (Roder and Maniphone 1995b). Since 1993, an observation nursery of forage/fallow/cover crop species has been maintained and expanded on-station. Currently there are 48 species or varieties of mostly viney legumes, but also including some shrubby legumes and grasses. Table 3 shows suitability for various uses of some legumes considered to be promising for fallow improvement. Several of the legumes are 'three star' forages.

Two long-term on-station experiments, the Leucaena Rotation Study and the Continuous Rice Cropping Study (Maniphone and Fahrney 1996; NRRP and LIP, 1994–1997) aim to determine weed suppression and rice yield improvement potential of shrubby legumes (*Leucaena leucocephala*, *Gliricidia sepium*, and *Crotalaria anagyroides*, a non-forage legume) in various interplanting and rotational patterns as dry season or annual fallows. Similar studies could include grazing management treatments.

An observational nursery of different species and varieties of multipurpose nitrogen-fixing trees was established on-station in 1996, with seed material and technical support from the Forages for Smallholders Project (FSP), to test adaptability of various species to local micro-climates. The nursery will also serve as a seed source for further on-station and on-farm studies with promising varieties.

On-farm cropping systems experiments, established at four sites in three northern provinces in 1996, will test weed suppression and crop yield improvement potential of dry season fallows (*Stylosanthes guianensis, Crotalaria anagyroides,* and a mixture of the two species) oversown in rice fields after the third weeding of the current rice crop. Depending on quantities of biomass produced, researcher and farmer collaborators will decide on residue management prior to the 1997 rice crop. Treatments may include burning, mulching, grazing, or combinations. Another type of on-farm fallow improvement experiment, established at two sites in 1996, will determine weed suppression, cash income

Table 3. Multi-purpose uses for species showing promise for fallow improvement.

	Promising species for fallow improvement						
Species	Food	Fodder (quality)	Fuel	Cover	Weed suppression	Biomass	Seed
Arachis pintoi	◆	◆◆◆		◆◆	◆◆	◆	◆◆
Calopogonium caeruleum				◆◆◆	◆◆◆	◆◆	
Centrosema pubescens		◆◆◆		◆◆	◆	◆	◆
Crotalaria anagyroides					◆◆◆◆	◆◆◆◆	◆◆◆
Gliricidia sepium		◆	◆	◆	◆◆◆◆	◆◆◆◆	
Leucaena leucocephala		◆◆◆	◆◆	◆	◆◆	◆◆◆	◆◆◆
Stylosanthes guianensis		◆◆◆		◆◆◆	◆◆	◆◆	◆◆
Pueraria phaseoloides		◆◆		◆◆◆	◆◆	◆◆	◆
Mucuna cochinchinesis	◆◆	◆		◆◆◆	◆◆	◆◆◆	◆◆◆

Source: Modified from NRRP and LIP (1994).

benefits, and rice yield potential of interplantings of *Leucaena leucocephala* and *Broussonetia papyrifera* (paper mulberry) with rice, and subsequent fallows of varying durations. Both of these fallow species are high quality forages.

Livestock have been un-invited, but eager participants in many of the field experiments, particularly on-farm. Often, interactions with the livestock component have confounded interpretation of planned treatment effects. In the future, the authors look forward to working with livestock scientists to establish controlled studies (with livestock as treatments) which can demonstrate a synergistic relationship between cropping and livestock systems in the uplands.

Conclusions

Natural fallow rotations have shortened to the point of declining productivity of the natural resource base, with increasing weed problems and decreasing soil fertility. Fast-growing improved fallow species can supplement natural fallow vegetation, accelerating nutrient cycling and accumulation; but improved fallows must be adequately protected from free-ranging livestock to allow for production of sufficient biomass to effectively suppress weeds and restore fertility. Most species used for fallow improvement are legumes with high nutritive value and palatability to livestock. Controlled grazing of livestock on improved fallow vegetation can increase livestock production and cash income to households, while helping to conserve nutrients and maintain or increase productivity of the upland agroecosystem.

Sustainable upland production systems require adoption of effective soil conservation practices. Forages can be planted as contour hedgerows, encouraging rotations and perennial plantings in integrated landscape management systems.

Realising potential synergistic relationships between upland crop and livestock production systems will require a better understanding of nutrient dynamics within upland systems and the development of management practices that are acceptable within the social context of local communities. On-farm participatory research can aid in understanding of conditions that determine adoptability of improved crop/livestock systems.

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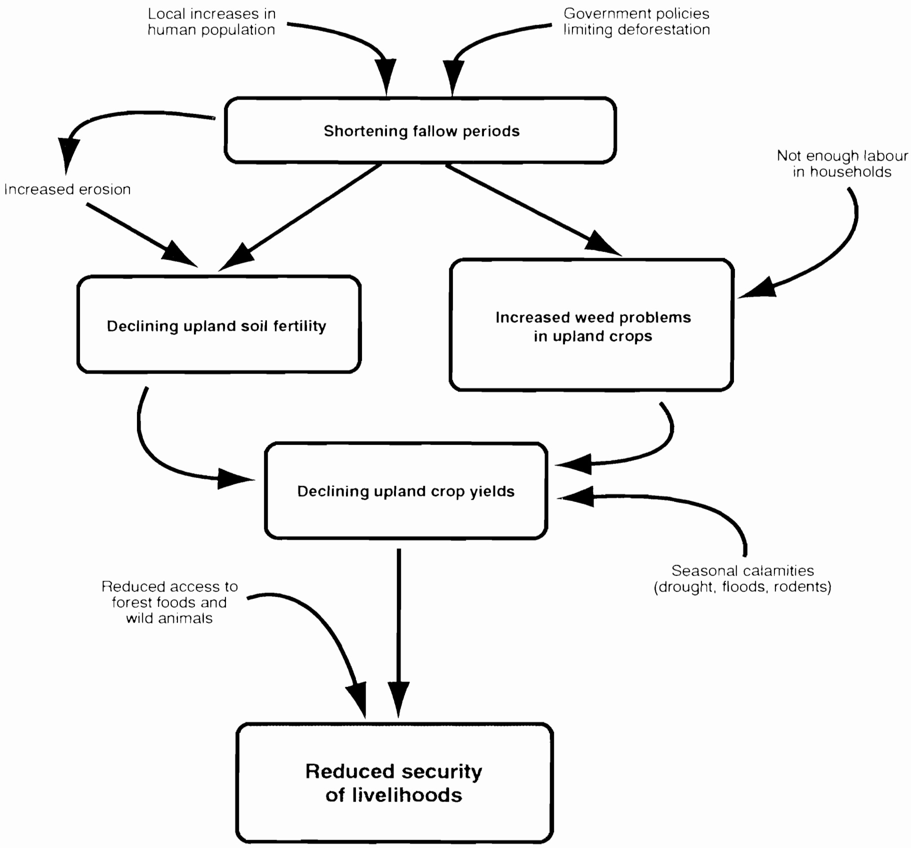

Figure 1. The changing dynamics of shifting cultivation in Lao PDR.

These shorter fallow periods have resulted in lower yields of crops in the *hai* mainly because of declining soil fertility and increasing weed problems.

Declining soil fertility

Although it has yet to be documented, fallow periods of 3–4 years probably return substantially less organic matter to the soil per year of fallow than longer fallow periods (8–10 years). Furthermore, with shorter fallow periods, the sloping *hai* are exposed more frequently to the heavy, erosive rains of the early wet season. The consequence of these two effects is rapid decline in soil fertility. In some areas of northern Laos, upland rice yields have fallen to 700–900 kg/ha after 4-year fallows compared with 1500 kg/ha after 9-year fallows in the same area (Figure 2).

Increasing weed problems in the *hai*

Shorter fallow periods result in shrubby fallow vegetation, predominantly *Chromolaena odorata* and *Ageratum conyzoides*, which seed prolifically and can become the main weeds in subsequent crops. Longer fallow periods (>7–8 years) result in arboreal fallow vegetation which has a lower weed potential. With the shrubby fallow vegetation of shorter fallows, at least two rounds of weeding are necessary to grow upland rice, which can take from 140–190 person-days/ha, amounting to 40%–50% of the total labour input in the *hai* (Roder et al. 1995). As a result, the area of *hai* that a family can cultivate is very often limited not by their consumption requirements, but by the availability of household labour simply to weed the *hai*.

These effects highlight the extent of the problem of declining productivity of the *hai*. However,

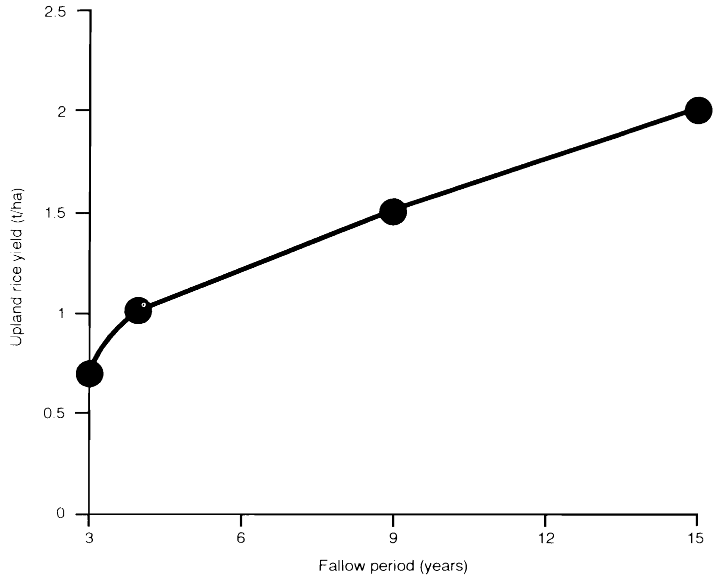

Figure 2. The relationship between shortening fallow periods and upland rice yields in northern Laos (after Chazee 1994).

shifting cultivation has always been a risky and time-consuming agricultural practice, which has resulted in farmers opting for diversifying rather than intensifying their livelihood systems to be able to deal with adversity. In the past, when crops in the *hai* failed because of natural calamities or when seasonal food shortages occurred, shifting cultivation communities were able to rely on traditional coping strategies to provide their food requirements until the next cropping season. The main strategies were:

(1) hunting wild animals and gathering forest foods for local consumption;
(2) gathering non-timber forest products for sale;
(3) selling labour;
(4) selling opium; and
(5) selling livestock (cattle, buffalo, pigs and chickens).

However, the first four of these strategies are becoming less reliable.

Primary forests in northern Laos have become both diminished in area and more heavily exploited for non-timber forest products. In the mountainous province of Luang Namtha, farmers report that wild animals that were common even 10 years ago are now rarely seen. Opportunities for selling labour are limited largely to communities near roads or towns. Opium production is being strongly discouraged by the Lao government. This has left farmers with an increasing reliance on livestock as a source of cash income and livelihood security.

The Role of Livestock in Securing Farm Livelihoods

As a resource for securing livelihoods in shifting cultivation areas, there are few better alternatives than livestock as an integral part of the cropping system. The benefits are numerous, with the most common ones mentioned by farmers being:

(1) Livestock can be sold at any time on a market which has a constant demand and relatively stable prices

By comparison, most fruit and vegetable crops must be picked when ripe and often sold on a market where prices are depressed by oversupply. A recent example is oranges, which are well suited to the northern regions, but which had a market value of only US$0.02 per fruit in provincial capitals at the height of the 1997 season.

(2) Larger livestock (cattle, buffalo and goats) can be walked long distances to market

In one recent example (cited by Horne 1997), Hmong farmers walked 20 bulls from Nong Het in Xieng Khouang province 350 km to market in the capital, Vientiane. The marketing flexibility this provides is especially important in a country where many communities are remote. SWECO (1990) found that only 57% of the district centres in Lao PDR (excluding provincial capitals) had year-round access by road and 17% had no access even in the dry season. For many farmers, the nearest road may be one day's walk or more from their village. This will limit their cash crop options, as most crop products are bulky and would have to be carried long distances to market for meagre returns per unit weight. In a study of shifting cultivation in four districts of three northern provinces, Pravongviengkham (these Proceedings) found that livestock (including both large and small livestock) had the highest share in household income generation across all districts.

(3) Livestock provide manure

In most areas of northern Lao PDR, farmers have either no cash to buy fertilisers or no access to fertiliser suppliers. Where soil fertility is poor (e.g., large parts of Xieng Khouang and Luang Prabang), farmers recognise manure as an essential input for maintaining the productivity of small areas of rice fields and home gardens. By grazing in surrounding forests and grasslands and returning to the villages each night, larger livestock effectively concentrate nutrients around the villages. Horne (1997) cites an example from Xieng Khouang where villagers are changing their livestock management practices specifically to bring cattle back to the village from the grazing land more often, so they can collect larger amounts of manure, thereby obtaining more sustained yields from their rice paddies and reducing reliance on the production from the *hai*. In some villages, livestock owners sell manure for significant cash or food returns.

(4) Livestock provide a relatively high profit for very low labour input

The two most common livestock rearing systems in northern Lao PDR are free-range systems: either (1) day grazing and penned at night; or (2) continuous grazing, returning to villages only occasionally. Both require little labour input compared to shifting cultivation.

(5) Larger livestock (cattle, buffalo and goats) use feed resources that cannot be utilised for any other purpose

These livestock are commonly grazed in forests, high grasslands or in fallow fields where they survive by foraging on grasses, shrubs, tree leaves and crop residues. The communally-owned feed resources provide farmers with substantial returns and livelihood security for little or no management input.

The importance of these numerous benefits to farmers is best demonstrated by the fact that, although large livestock frequently damage crops and are susceptible to disease epidemics, farmers continue to keep them as an asset to be sold in times of calamity.

Opportunities for Improvement—What Can Forage Technologies Do?

When asked what aspects of their farming systems they would like to strengthen, farmers in shifting cultivation areas of Lao PDR commonly give high priority to the following (see, for example, Connell and Ravong 1994):

- improved production from paddy fields and home-gardens (where they exist). The main issue is declining yields resulting from depletion of soil fertility.
- improved production from the *hai*. The main issues are declining soil fertility and severe competition from weeds.
- improved production from livestock. The main issues identified by farmers (commonly in this order) are animal disease, insufficient feed and crop damage caused by livestock. Introduction of 'improved' breeds (for example, cross-bred cattle) is sometimes requested by farmers but would be inappropriate until the existing management problems (disease, feeding and uncontrolled breeding) are resolved.

Forage plants have a potential role to play in all three objectives. By providing more feed of higher quality near villages, farmers may be able to better manage the manure resource which is so essential to fertility of rice paddies and home gardens. Forage legumes sown in fallow fields or oversown into the *hai*, can benefit both soil fertility (through cycling of nitrogen and organic matter and through erosion control) and weed control (*Stylosanthes guianensis*, for example, has potential to smother weeds in upland rice crops without adversely affecting the crop). Forage grasses and legumes can be planted in plots near barns to supplement grazing animals at night or at times of greatest need (such as at rice planting or harvesting, when animals are kept in the barn because there is not enough labour to look after them). Forage tree species can be used as both a source of high quality feed and fence lines to protect fields from wandering stock.

Although these potential uses of forage species have been well understood for a long time — for example, Shelton and Humphreys (1975a,b) demonstrated the effectiveness of *Stylosanthes guianensis* as a cover crop in upland rice in Lao PDR more than 20 years ago — very little adoption has occurred. One reason for this is that frequently the forage technologies offered to farmers were inappropriate for reasons unknown to the researchers. Another is that, until recently, traditional feed resources in shifting cultivation areas have been adequate. However, farmers now complain that these feed resources are becoming scarce or degraded because of:

- increased livestock numbers, resulting in over-utilisation of the feed resources;
- expansion of upland agriculture into traditional grazing lands;
- reforestation of grazing land;
- prohibition of cattle grazing on forested land;
- utilisation of paddy-fields for longer periods of cropping, excluding animals from grazing stubble.

In response to feed resource degradation, farmers have begun to develop their own strategies. Examples of farmers innovating in this way are:

- thousands of Hmong cattle farmers in Xieng Khouang and Luang Prabang provinces cultivating small plots of napier grass (*Pennisetum purpureum*) near their grazing lands to supplement their cattle in the dry season;
- Iko farmers in Luang Namtha province planting creeping legumes as cover crops in their upland fields to control weeds;
- lowland farmers in Champassak province managing and collecting green forage from islands in the Mekong river for feed during the rice-growing season (at other times the cattle graze on the paddies);
- farmers in one village of Xieng Khouang who collected *Brachiaria ruziziensis* seed from an old demonstration trial 40 km away and planted it near their barns so they could keep animals closer to the rice fields to provide manure.

In each case, the technologies were probably not the best (for example, *Brachiaria ruzizensis* is not well adapted to the long dry seasons and poor soils of Xieng Khouang), but the farmers demonstrated their capacity to try to solve their own problems by using and adapting whatever technologies were available.

These farmers are natural experimenters; frequently all they lack is promising species and information on how these species can be managed. However, species alone will not provide a solution to the three objectives described earlier. What is needed are 'forage technologies', which are the combination of adapted species with the way these species can be integrated within a farming system. Researchers can identify adapted, potentially promising species and suggest ways of using them, but only the farmers can develop these into working technologies. The AusAID-funded Forages for Smallholders Project (FSP) is working with innovative farmers (like those described above) in upland areas of Lao PDR to develop their own forage technologies that may contribute to solving the three common objectives described earlier. Promising forage technologies described in more detail by Horne and Stür (1997) are:

1. grass/legume mixtures for grazing;
2. legumes as cover crops and green manures in upland cropping systems;
3. grasses for hedgerows in upland cropping systems;
4. legumes and grasses for cut and carry feeding systems (in hedgerows or intensively-managed plots);
5. multipurpose tree and shrub legumes in fence lines, contour hedgerows and intensively-managed plots;
6. legumes for leaf meal production.

In the first two years (1995–1997) of the 5-year project, regional nurseries were planted at five sites throughout Lao PDR. The most promising, broadly adapted species that have emerged so far are *Brachiaria decumbens* cv Basilisk, *Brachiaria brizantha* (cv Marandu, CIAT16835, CIAT16827), *Brachiaria humidicola* CIAT6133, *Andropogon gayanus* cv Kent, *Panicum maximum* TD58 and *Stylosanthes guianensis* CIAT184. In the wet season of 1997, the work began with shifting cultivation farmers in Luang Prabang and Xieng Khouang provinces to develop these species into forage technologies. The approach being used, known as Farmer Participatory Research (FPR), has been described in detail by Okali et al. (1994), van Veldhuizen et al. (1997a, b) and Horne et al. (1997). In short, FPR methods are based on empowering farmers like these to develop their own solutions by providing the information and promising technologies they lack. The main difference from previous R&D approaches is that FPR is based on active involvement of farmers, who make decisions at all stages of forage technology development. In partnership with development workers, farmers identify and prioritise the problems they experience, decide which forage technologies to test, run their own experiments (often informal), evaluate the outcomes and modify the forage technologies to meet their specific needs.

What Forage Technologies Cannot Do

Forage technologies are new to farmers in Lao PDR. Farmers and researchers often have unrealistic expectations of these technologies. Common misconceptions are:

1. Communal grazing land can be improved with forages. Without control over wandering livestock or control of land by individual farmers, there is little that can be done to improve the feed resources of communal grazing land.

2. Forages can solve all feed resource problems. Forages will only ever be part of the solution, supplementing existing feed resources, such as native grasses, crop residues and tree leaves.
3. Forages require no management. Like crops, forages need careful management during establishment, especially to minimise the impact of weeds and wandering animals.
4. Forage grasses require no inputs. One forage technology that many farmers are testing is grasses planted in intensively-managed plots to provide cut feed to animals when they return from grazing or when the farmers are too busy to look after the animals (such as at rice harvest). If cut regularly, grasses can remove large quantities of nutrients from the soil. With napier grass yielding 18 tonnes dry matter/ha, for example, a nutrient off-take in a cut-and-carry system of 300 kg N/ha/year, 20 kg P/ha/year and 150 kg K/ha/year is possible. Unless nutrients are returned to the soil, yield decline of highly productive planted grasses (such as *Panicum maximum* and *Brachiaria decumbens*) is inevitable, to a point where they may be no better than naturally occurring grasses (as shown in Figure 3). Nutrients can be easily returned with manure, if the grasses are planted close to the barns.
5. Forage species exist that can give high yields during long dry seasons. There are no miracle species. During short, dry seasons, some species (e.g., *Brachiaria decumbens* cv Basilisk) can maintain reasonably high yields. However, if dry seasons are long (>5 months) and severe, yields of all forage species will fall substantially. Some species survive long, dry seasons better than others, but yields may be little better than the naturally-occurring grasses. Forage tree legumes can be useful in these situations as their deep rooting systems allow them to access soil moisture beyond the reach of grasses and legumes, maintaining production of green leaf long into the dry season.

Conclusions

Livestock are central to the livelihood security of resource-poor farmers in upland agricultural systems of Lao PDR. Traditional feed resources for these livestock are becoming scarce or degraded. Forage technologies exist that have the potential to overcome the livestock feeding problems as well as providing other benefits within shifting cultivation systems. However, the key is to provide farmers with access to these technologies, allowing them to evaluate and to develop them to suit their needs.

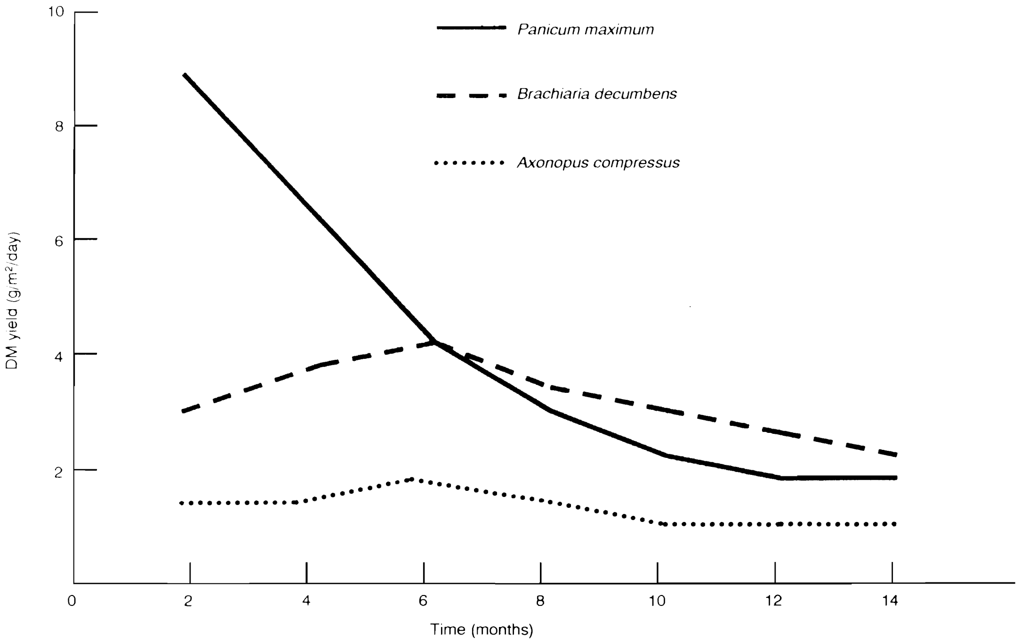

Figure 3. Yield of grass species cut every two months in an unfertilised cut-and-carry feeding system in Bali (I.K. Rika, unpublished data)

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Management of Trees for Animal and Wood Production in Upland Farming Systems

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Abstract

Existing information suggests that for considerable areas of the wet-dry tropics it would be possible to create an agroforestry system in which production of quality timber was combined with increased animal production. The essential feature of this system is the use of particular tree species at wide spacings in open grassland. These trees provide feed by (1) the dry-season fall of edible leaf, flower, or pod, and (2) by the tree canopy causing an increase in grass production and quality. Further animal production benefits would come from the moderation of seasonal extremes and the option of lopping part of the green canopy for drought feeding. Managing open-grown trees to obtain clear wood would require more management than for forage alone, but need not reduce forage production. Returns from wood production would depend on on-farm processing, the technology for which is increasingly available. Possible species for the Lao DPR include siris *(Albizia lebbeck)*, white siris *(Albizia procera)*, yemane *(Gmelina arborea)*, and raintree *(Samanea saman)*. A number of other species are also of interest and may well be found in the local flora.

THERE HAS been much consideration of the role of multi-purpose trees in the tropics. Usually this means trees for fodder with a number of other benefits such as fuel wood, fertiliser, or soil conservation. The practical application is best seen in the mixed garden system of West Java. However, there is a system that appears biologically feasible for *Imperata* dominated or degraded grasslands, yet is relatively untried. This involves tree species that have the potential to be grown at wide spacings for wood production while at the same time promoting animal production and restoring soil fertility.

Animal Production from Dual-Purpose Trees

This depends on considerably widening the concept of fodder trees, overcoming the assumption that trees can contribute feed only when animals browse green leaf, or it is cut and carried.

Deciduous leaf fall

The species of interest are obligately deciduous in the dry season, or else facultatively deciduous under prolonged dry conditions. In either case, the entire standing leaf crop becomes accessible to the grazing animal.

The suggestion that fallen tree leaf could make a useful contribution to grazing-animal nutrition is novel, as it has been assumed to have low feed value. However, in the tropics one must take account of the dry-season loss of feed quality in the grasses. When the rumen digestibility of fallen leaf from 27 native deciduous trees was compared with dry-season grasses in North Queensland (Lowry 1995) it was found in general to be more digestible than the grasses. However the fallen leaf has quite different nutritional characteristics (Kennedy and Lowry 1996). There is thus the contradiction of low digestibility and high intake, as was found for fallen leaf of *Albizia lebbeck* (Lowry 1989). Overall, it seems likely that utilisation of fallen leaf by grazing ruminants occurs to a considerable extent in tropical rangelands. The paucity of published accounts and research is simply because it is not a conspicuous behaviour and no one has paid much attention to it.

Flowers and fruit

Depending on the species, annual production of flower or fruit biomass may be negligible or up to

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20 kg/tree. It may have high feed value or none at all. It may be shed at a time of year for it to be of little use, or at a time when it has high strategic nutritional value.

Promotion of pasture in the wet-dry tropics by tree canopy

It is generally assumed that because trees compete for water with grasses, they will have an adverse effect on pasture. However, in northern Australia, it is very easy to observe that large isolated trees of *Albizia lebbeck* sometimes have a zone of enhanced pasture growth below the tree canopy. This is not an optical illusion. In North Queensland early wet season yields of grass dry matter were 82% higher under the canopy in grazed areas and 127% higher in an ungrazed area (Lowry et al. 1988). Apart from the question of relative overall dry-matter production, it was noted that grass below the canopy remained green and continued growing for up to two months after that in the open had died off, and that, at the end of the dry season, there was a more rapid response to rain from grass below the canopy. In addition, it has been found that grass associated with the canopy in North Queensland had digestibility 5–10 units higher than that in the open, and maintained quality for 6–8 weeks longer at the onset of the dry season (Liano 1990).

A fuller discussion of this aspect, and the mechanism by which it happens, can be found in the report by Lowry and Seebeck (1996). However, key references on the ecophysiology of grass enhancement by tree canopies in the African savanna are Belsky (1992 1994), and in Australia, on the effect of shade alone, showing that some grasses can be more productive under 50% shade, is Wilson (1996).

Overall, these results suggest that it is possible to devise agroforestry regimes for the seasonal tropics in which the trees will not only increase total pasture production but also prolong the period of higher pasture quality. It is also possible to indicate the conditions under which positive effects can be obtained: strongly seasonal climate, medium dense tree canopy (40%–60% transmission), medium to low fertility soils, and preferably but not necessarily a nitrogen-fixing tree species. Naturally, a major long-term effect will be improvement of soil condition in the sub-canopy area, so this system is also a strategy for rehabilitating degraded grasslands.

Wood Production from Dual-Purpose Trees

There are a number of tree species well recognised as fodder trees, that are, sometimes in a quite different context, also known as a source of quality timber. Normally, these uses would be somewhat exclusive. Fodder would be browsed or collected from wayside trees that would be of little use for timber. Quality timber would come from trees in forests or forest plantations that would provide little feed for livestock. It has been suggested that large isolated trees in grassland can promote animal production in the ways outlined above. The question is, can these trees be managed for quality timber? Trees growing in the open will tend to adopt a multi-branched spreading habit, and this is the aspect that requires active management. Pruning open-grown trees to obtain a good stem form is now a well-established practice in Australia and New Zealand, the number of species to which it has been applied is growing, and there seems no reason why any species of interest in the Lao DPR should not be managed similarly. The technology is simple, with labour costs less of a constraint. Developments in mobile milling technology mean that timber of precise dimensions can be cut from the log in situ (Lowry and Seebeck 1996). This avoids the use of heavy transport and allows the economic utilisation of small volumes of wood.

Notes on Particular Tree Species

The siris tree–*Albizia lebbeck*

Siris is a medium to large tree, found throughout much of Asia. It is of multi-stemmed widely spreading habit (to 30 m diameter, 20 m high) when grown in the open, but capable of good log form in plantation. The tree is fully deciduous in the dry season.

Large trees can boost animal production in all three ways noted here: as a feed, as a supplement, and by improving grass quality. Results of analyses and actual feeding experiments are reviewed in Lowry et al. (1994). The fallen leaf is of surprising value because of the high voluntary intakes shown by sheep. Fallen flower is an excellent feed. The value of siris as a supplement in extensive grazing systems would be that leaf, flower and pod drop sequentially during the dry season and can be utilised directly by grazing animals. In mature trees, leaf, flower and pod fall in comparable amounts (Lowry 1989) and can total 100 kg. The wood is of recognised value, and is exported to Europe as East Indian Walnut. A recent summary of timber properties is that of Keating and Bolza (1982).

White siris–*Albizia procera*

This species has a wide distribution through tropical Asia in savanna and deciduous forest habitats. It is regarded as a good fodder tree for all ruminants, the leaves being highly palatable and high in protein (Parrotta undated). However, there does not appear to be any published result from an actual feeding trial. Like siris, it is deciduous and the fallen leaf would be expected to have similar feed value. Leaf is the only feed supplied from the canopy. The biomass of the flowers is insignificant, while the pods are produced much more sparingly than siris. Isolated trees would be expected to have a promotional effect on pasture like that of siris and this appears to be happening with wayside trees but this has yet to be investigated. The wood has been described as follows: '*The timber is strong, elastic, tough and hard. Compared to teak it is 10% stronger in modulus of elasticity, 25% more resistant in compression parallel to the grain, and twice as hard . . . The heartwood is moderately durable . . . Moderately hard work and saw by hand, but the wood planes to a smooth surface more readily than* A. lebbeck *due to the less oblique grain angle . . . Uses: furniture, and table and counter tops*' (TRADA 1979).

Yemane–*Gmelina arborea*

This is a well-known timber tree of India and Burma. The suggestion that it could have a dual-purpose agroforestry role is novel and arises from observations of its leaf phenology in Townsville. The trees were completely deciduous in the late dry season, the large membranous leaves forming a considerable carpet on the ground. This fallen leaf turned out to have a 24-hour intraruminal digestibility of 80%. This was quite improbably high, but has since been confirmed. A single publication from India reports a feeding trial (Majgaonkar et al. 1987) in which the leaf had a dry matter digestibility of 57%, a crude content of 11.5%, and the protein was 55% digestible. Animals showed a very high dry-matter intake of 2.6% body weight, indicating it was palatable as well as digestible. All these parameters indicate the leaf is an excellent feed. These results suggest that if yemane was grown at wide spacings in pasture in the wet-dry tropics, there would be a substantial dry-season leaf fall with a digestibility so high that it could be regarded as an energy supplement. The plantation-grown timber is described as: '*. . . one of the best and most reliable timbers found in southern Asia. The sapwood is not distinct from the heartwood, yellowish brown, lustrous, with a smooth oily feel . . . works readily to a smooth finish and takes stain and polish well*' (TRADA 1979).

Rain tree, monkey pod *Samanea saman (Albizia saman)*

This is an excellent shade tree in much of the tropics. The timber is best known for wooden handicrafts but has a range of uses. The rain tree has been already documented as a fodder tree (NAS 1979). This is mainly in relation to a high production of nutritious pods. However, the species is also deciduous in August-September and has quite large leaflets. When the fallen leaf was fed to sheep it had a very low digestibility but this was offset by a surprisingly high intake (Lowry 1995). The material would probably be utilised if falling into mature pasture. The rain tree is also one of the species that can unequivocally promote grass growth (Jagoe 1949).

White cedar–*Melia azedarach*

Clear wood from white cedar is of very high value. The tree is found over a very wide range of habitats, including semi-arid areas. The leaf has an exceptionally high digestibility (Vercoe 1986) and is known as a fodder tree in India. In drier areas of Queensland, it has been said to be fed to dairy cows (Everist 1986). White cedar is conspicuously deciduous but the leaf drop occurs rather early in the dry season and this may detract from its feed value.

Leucaena–*Leucaena leucocephala*

Leucaena is usually hedged or otherwise managed for browse, and the question of sawn timber production does not arise. However, in the search for new lines, one of the most productive ('Tarang', K636) proves to be strongly arboreal (M. Shelton, pers. comm.). This opens the possibility of using it in a dual-purpose regime.

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Bioeconomic Modelling to Assess Possible Improvements in Upland Animal Production Systems

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Abstract

Shortening fallow lengths decreases farm profitability within shifting cultivation farming systems and makes such systems unsustainable, due to soil degradation. Although this is a widely accepted view, the lack of long-term data hinders empirical analysis of the issue. The need for a reasonable length of time-series data, quarantined from uncontrolled influences, virtually dictates the need for a modelling approach to the empirical analysis. Such an approach is followed here, making use of the SCUAF model. Economic and livestock dimensions are added to that model. A quantification of shifting cultivation systems for typical *Imperata*-dominated areas of Southeast Asia is undertaken. A particular example of an 'improved fallow', involving a *Gliricidia* plantation for soil quality enhancement and as a source of livestock feed, is then analysed. The potential of such a system to improve profitability and sustainability over the levels achievable with shifting cultivation is clearly revealed. With both the improved and unimproved fallow, animals can make a positive contribution to profitability, albeit with some additional soil degradation. However, the soil erosion consequences from animals were found to be far less severe than those from cropping. A modelling approach to address these issues has certain advantages, especially where existing models can be adapted at low cost. Data for modelling were obtained from farmer surveys, experiments, or researcher estimates. Modelling and field experimentation are complementary and can be interactive.

Bioeconomic Modelling and its Advantages

Bioeconomic modelling is a form of analysis that combines an appropriate mixture of biological and economic realism. It is usually computer-based for ease of calculation. Modelling can be undertaken either in an optimising framework, or in a simulation framework. A conventional economic budgeting exercise might be regarded as bioeconomic modelling, but most economic budgets do not include much biological detail.

Compared to field experimentation, bioeconomic modelling has two major advantages. It is relatively inexpensive, and can produce results in a short period. In Laos, bioeconomic-modelling expertise may be limited. However, standard computer spreadsheets can provide more than enough computing power as well as the flexibility to facilitate a good degree of realism. Alternatively, prototype models are often available for adaptation and use.

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In addition to providing analyses of specific issues, bioeconomic modelling provides a useful framework to enhance cooperation between economists and biologists.

A bioeconomic model

The core of the work described here is the model SCUAF (Soil Changes Under Agroforestry). Despite the name, SCUAF is quite a general model, and is not restricted to agroforestry applications (Young and Muraya 1990). SCUAF is a simple, deterministic model, designed to predict the effect of various tree or crop combinations on soils and commodity outputs, based on average-year climate and soil characteristics. It has the facility for long-run analysis, including details of soil parameters relevant to shifting cultivation in the uplands, including erosion.

Two previous applications of SCUAF give confidence in the simulation capacity of the model. Vermeulen et al. (1993) used SCUAF to simulate soil nutrient dynamics and plant productivity for the

Miombo woodlands and adjacent shifting cultivation systems with maize in Zimbabwe. SCUAF was judged to provide reasonable predictions for maize and tree growth, although it had no facility to attenuate growth as the woodland approached maturity. The attenuation of growth is not important in this analysis, due to regular harvesting and the short growth cycle. In the second case of hedgerow systems in the Philippines, Nelson et al. (1996a) compared the results from SCUAF with the results from a more complex dynamic process model, APSIM. They found SCUAF produced similar estimates of trends in medium term yield. However, SCUAF is an average year model, which abstracts from seasonal conditions. Short-term yield fluctuations cannot be predicted.

No economic or animal components were explicitly included in the original versions of SCUAF. Instead, the inputs and outputs of SCUAF were incorporated by the authors of this paper into a companion spreadsheet that contains information on those economic and animal components. These structures of the modelling framework and data sources are presented in Figure 1.

Bioeconomic Analysis of Shifting Rice Cultivation on a Typical *Imperata* Grassland Site Without Animals or Fertiliser (Indonesia)

The SCUAF model was used to trace changes in soil and other site characteristics, under a range of shifting cultivation regimes, for 'typical' Southeast Asian sloping upland site conditions (Menz and Grist 1996). This research focused on smallholder annual rice cropping/*Imperata* fallow systems in Indonesia, for a range of land availabilities.

Carbon and nitrogen in the soil profile are affected by erosion, uptake by plants and recycling of plant material. By simulating these parameters, SCUAF first predicts changes in soil fertility, and then changes in crop yield and *Imperata* biomass over time. The economic spreadsheet is then brought into operation to calculate the fallow length that gives the greatest economic return.

With reductions in land area availability, the economically preferred fallow lengths are reduced

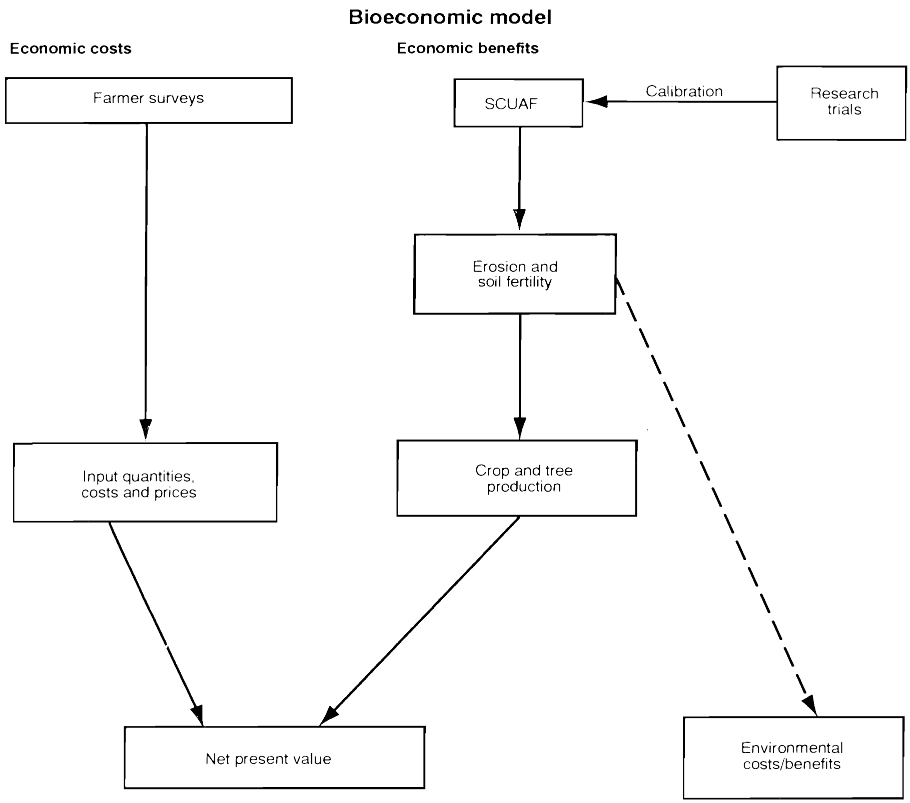


Figure 1. Processes of the bioeconomic model.

(from a 20-year initial point in the analysis). Economic returns fall with declines in land area availability. For fallow lengths below seven years, economic returns began to fall dramatically (Figure 2). The explanation is revealed in terms of total soil loss and soil carbon and nitrogen losses (not shown here), which are reflected in reductions in crop yield (Figure 3).

All fallow lengths below 20 years result in unsustainable rice yields — dramatically unsustainable for fallow lengths of seven years or less. However, for most smallholders, it is not an economic proposition to reduce cropped area to the low level required to maintain the 20-year fallow length associated with sustainable yields and soil parameters. For example, farms of five hectares can achieve four times the level of profitability with a two-year fallow as they can with a 20-year fallow (Table 1). This is so, despite the negative implications of the two-year fallow for biological sustainability.

Thus, an economic imperative exists for upland smallholders to engage in shifting cultivation systems that are patently unsustainable. In the absence of the application of new technology or inputs, most of

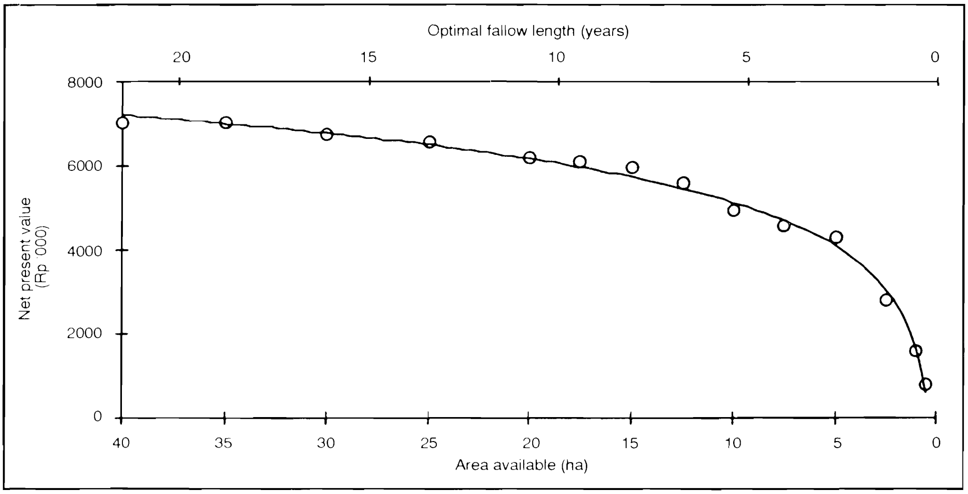


Figure 2. Net present value and the economically preferred fallow length corresponding to various land area availabilities.

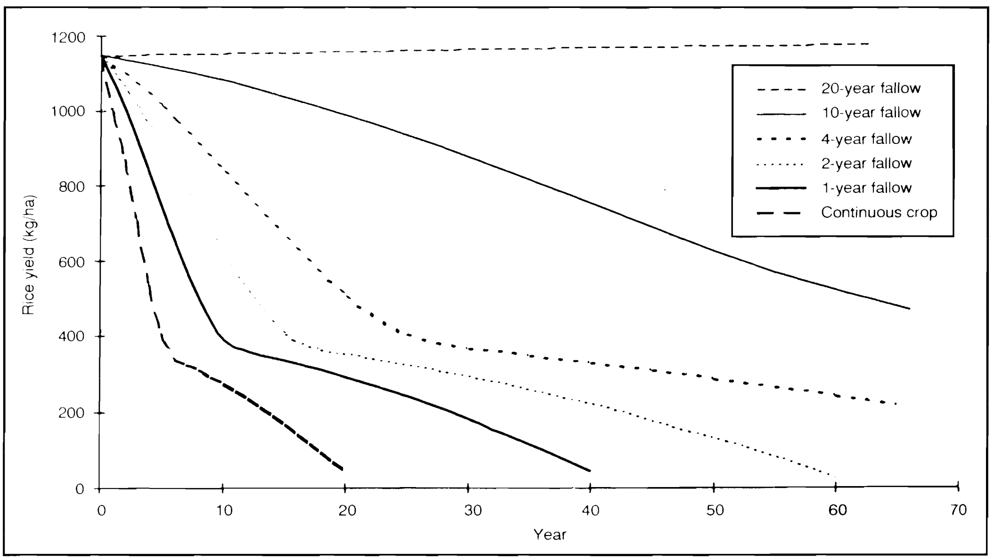


Figure 3. Annual rice yields corresponding to various *Imperata* fallow lengths.

these upland smallholder farms will cease to be viable.

Table 1. Profitability comparison between economically optimal fallow length and biologically sustainable fallow length (for a five hectare farm).

	Fallow length (years)	Profitability* (Rp '000)
Economically optimal	2	4260
Biologically sustainable	20	1065

*Profitability is the economic returns to land and labour — no costs have been assigned to either in the calculations. The interest rate used to discount future cost and revenue streams was 12%.

Improving Shifting Cultivation Systems — the Role of Fodder Crops and Animals (Northern Mindanao, Philippines)

Can sustainability *and* profitability of shifting cultivation systems be enhanced? This question was addressed via modelling a range of upland farming systems at Claveria, Northern Mindanao, Philippines.[2] Information on a range of possible interventions to improve fallows was available at that location. Only one particular form of intervention is examined here — a *Gliricidia* plantation fallow, with and without animals. Analyses of other systems are reported elsewhere (e.g., Nelson et al. 1996a, b).

The baseline: five-year *Imperata* fallow/one year maize cultivation, initially without fertiliser or animals

The baseline for comparison was a five-year *Imperata*/one-year maize shifting cultivation system. In traditional shifting cultivation systems, the fodder available for cattle consists mainly of grasses such as *Imperata* and crop residues. These are generally of poor quality, limiting the number of animals that can be supported (Nitis 1985). Without either an animal or fertiliser component, this system was found, using the modelling framework outlined above, to be marginally profitable at prevailing input and output prices (Table 2).

Table 2. Profitability of introducing cattle within a shifting cultivation regime for a 2 hectare farm, Claveria, N. Mindanao, Philippines[3]

Number of cattle	NPV per hectare ('000 pesos)
0	1950
1	8390
2	9850

In this case profitability was calculated net of labour costs (cf. Table 1). In both Tables 1 and 2, a discount rate of 12% was used to bring future values to present values.

Adding an animal (livestock) to a five-year *Imperata*/one-year upland rice system is quite profitable, while adding the second animal is less so (Table 2). A small-holding of about two hectares usually supports from zero to two animals (Franco et al. 1996), typically with low productivity (Moog 1991). The addition of the second animal reduces the soil-restoring capabilities of the *Imperata* fallow. This is reflected in a reduced crop yield and crop revenue.

Intervention via a *Gliricidia* plantation fallow for soil fertility improvement and fodder

The potential of an improved fallow component within a shifting cultivation system was recognised by Garrity (1993) and MacDickens (1990). Planting leguminous trees in fallow periods offers potential to

[2] Claveria is a municipality of Misamis Oriental, Mindanao, 40 km northeast of Cagayan de Oro. It lies in an undulating plateau between a coastal escarpment and a mountainous interior, ranging in elevation from 200 to 500 metres above mean sea level. Soil from Claveria is classified as acid-upland (fine mixed, isohyperthermic, Ultic Haplorthox) with a depth of more than one metre. There are two pronounced seasons in the area: wet season (May to October) and dry season (November to April). The majority (79%) of the upland farms in Claveria are situated on moderate to steeply sloping land, thus soil erosion is a concern of the farmers. The dominant crop planted is maize. Maize production has prospered in Claveria because of its adaptability to local conditions and also as it is considered a staple food.

[3] In cattle grazing trials in the Philippines, Payne (1985) and Calub (1995) reported low productivity in cattle grazing Imperata — annual gains of around 50 kg per animal per year, or approximately 0.15 kg per animal per day. At current beef prices in the Philippines of 40 pesos per kg, this annual beef production is worth P40 × 50 or 2000 pesos per year. In this analysis, an average body weight of cattle of 300 kg is assumed. The average feed requirement is 2.3% of body weight (seven kilograms of dry matter per day, or three tonnes of dry matter per animal per year). The quantity of manure produced by cattle is approximately 40% of the dry matter ingested. Thus, for an animal fed three tonnes of dry matter per year, the manure produced is approximately 1.2 tonnes. As fodder passes through the animal, there is a significant change in its composition. The Bureau of Soils at University of Philippines, Los Baños, found that the carbon:nitrogen ratio of manure is 2.8%, or 1.1% of the dry matter fed to animals. This information was used in the modelling of the animal component of the system.

improve soil fertility and to provide wood products. *Gliricidia* foliage also has potential as a feed supplement for cattle.

The effects of improved animal and soil nutrition were analysed within the context of the SCUAF model. A diet for cattle, composed of 50% *Gliricidia* and 50% *Imperata* was assumed to be provided from the on-farm production of *Imperata* and *Gliricidia* leaf from a *Gliricidia* plantation. A weight gain of 0.52 kg per animal per day was taken to be the result of feeding with this particular mixture (Morbella et al. 1979). A two hectare farm size was assumed to be divided into six plots, or parcels. The number of *Gliricidia* plots required to supply the animal feed requirements depends upon the number of animals to be carried (Table 3). Although SCUAF does not directly model the animal enterprise, the biophysical effect of animals can be simulated by harvesting (removing from the system) the animal fodder requirements.

Each plot is rotated on a six year cycle, and two maize crops (wet and dry season) are planted per plot per year. Figure 4 presents a schematic diagram of the improved fallow system. Resources flow between the three land use types — *Imperata* fallow, *Gliricidia* fallow and maize crop. Three products are derived — cattle, firewood and grain.

Table 4 presents a summary of unit costs and unit returns for the *Gliricidia* fallow system with animals. These numbers were derived from farm surveys.

Modelled Results from Introducing a *Gliricidia* Fallow

Biophysical aspects

Improvements in soil fertility from a *Gliricidia* fallow can be observed pictorially in the modelled levels of soil nutrients (carbon, nitrogen and phosphorus) in Figure 5. (The top lines of each graph represent the 'without animals' scenario). The improved maize yield associated with this increase in soil fertility can be seen in the top line of Figure 6.

Feeding *Gliricidia* prunings to animals, rather than using them as mulch, removes nutrients from the system. Three animals per two-hectare farm (organised as indicated in Table 3) have a significant impact on the sustainability of the farming system, as only a small amount of *Gliricidia* is available for mulching. Soil nutrients are predicted to fall to

Table 3. Partitioning of land use for a *Gliricidia* fallow system with animals, on a two-hectare farm.

Number of animals	Maize		*Imperata*		*Gliricidia*	
	Area (ha)	Plots	Area (ha)	Plots	Area (ha)	Plots
1	0.33	1	0.33	1	1.33	4
2	0.33	1	0.67	2	1.00	3
3	0.33	1	1.00	3	0.67	2

Table 4. Unit costs and returns used in the analysis.

Labour cost of smallholder		₱40 / day	
Maize seed cost		₱6.50 / kg	
Maize grain value	Wet season	₱5.60 / kg	
	Average season	₱5.90 / kg	
Firewood		₱1,000 / tonne	
Cattle	Initial purchase	₱6,000	(150 kg @ ₱40/kg)
	Annual maintenance cost	₱1,882	
	Net annual change in Inventory value of cattle	₱7,600	(190 kg @ ₱40/kg)
Interest rate	Social opportunity cost	12%	
	Market borrowing rate	25%	

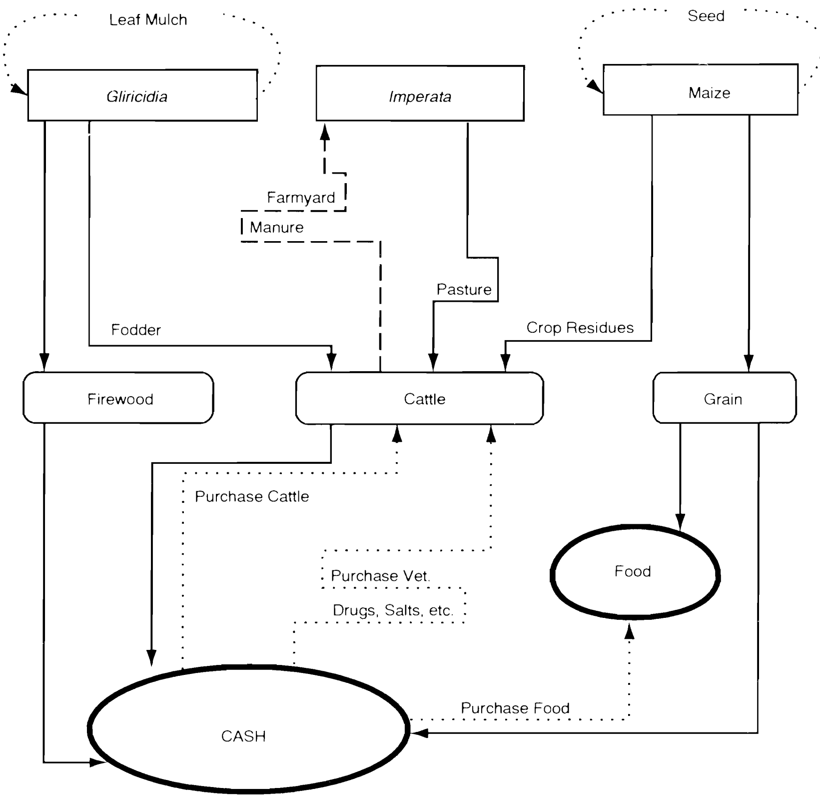


Figure 4. Flow of resources in the *Gliricidia* plantation fallow system with animals.

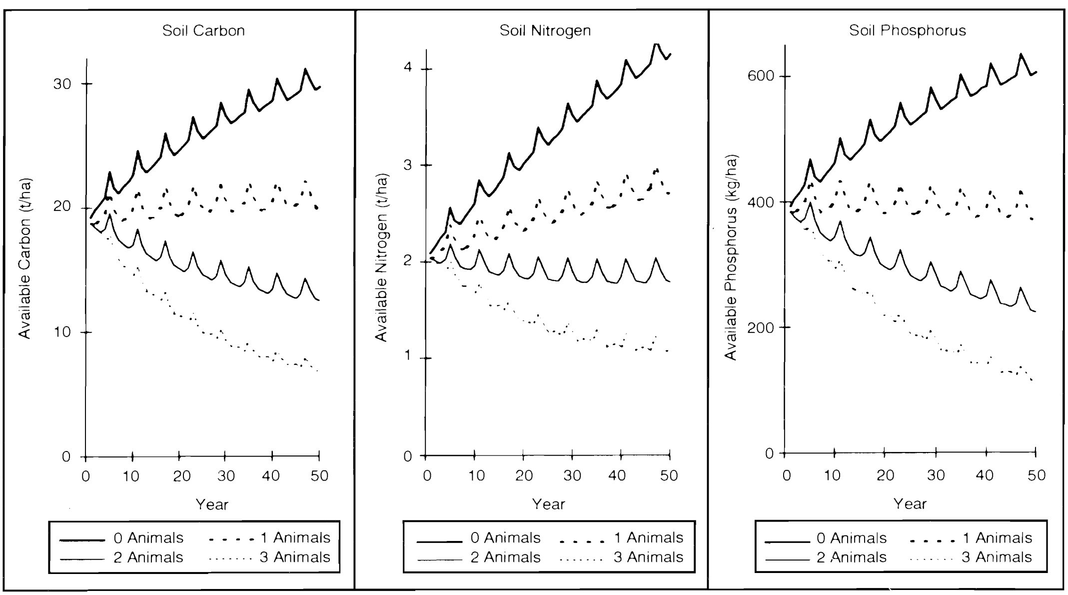


Figure 5. Change in soil nutrient levels with increasing animal numbers in the *Gliricidia* fallow system.

below 50% of their initial levels (Figure 5), and there is a 25% reduction in maize yield (Figure 6).

The introduction of cattle into the *Gliricidia* fallow system (with one crop per cycle) increases soil erosion by removing ground cover and nutrients from the system, making the soil more susceptible to erosion. Cumulative soil erosion, modelled over eight six-year cycles, is shown in Figure 7. The model predicts that each animal will increase total soil erosion by more than 75%. This effect of cattle on soil erosion is akin to the nutrient removal by crops — no direct effect of trampling by cattle was included in the model. The latter effect may be significant when stocking rates are high relative to feed supplies, but should not be an issue if stocking rates are within the limits set by feed supplies.

A comparison was made of the relative effects on soil erosion of cattle (Figure 7) and cropping (Figure 8). The latter shows that increasing cropping intensity has a greater effect on soil erosion than increasing cattle numbers. In Figure 8, 'number of

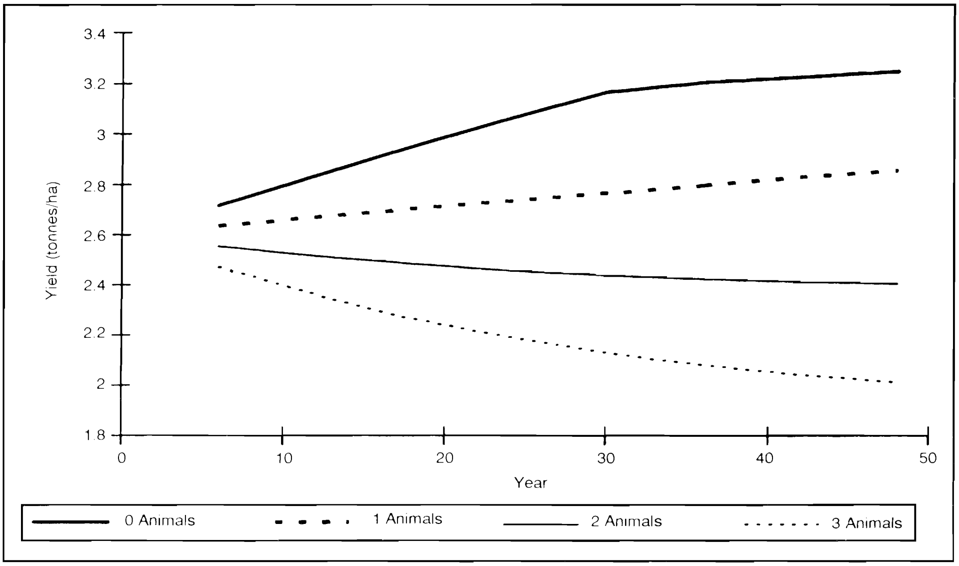
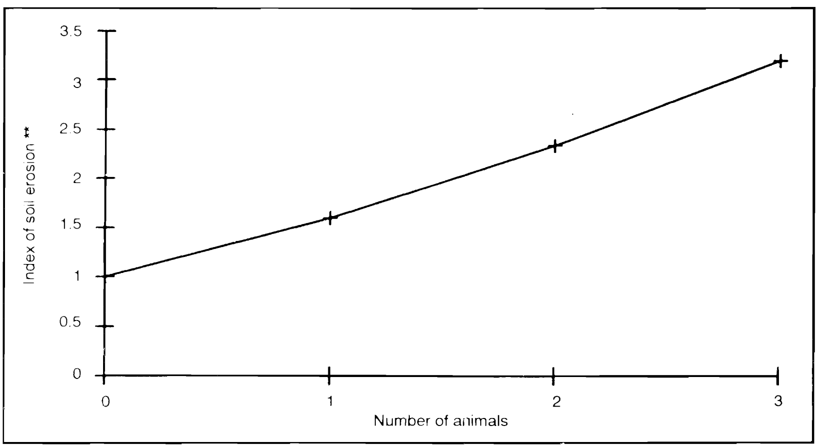
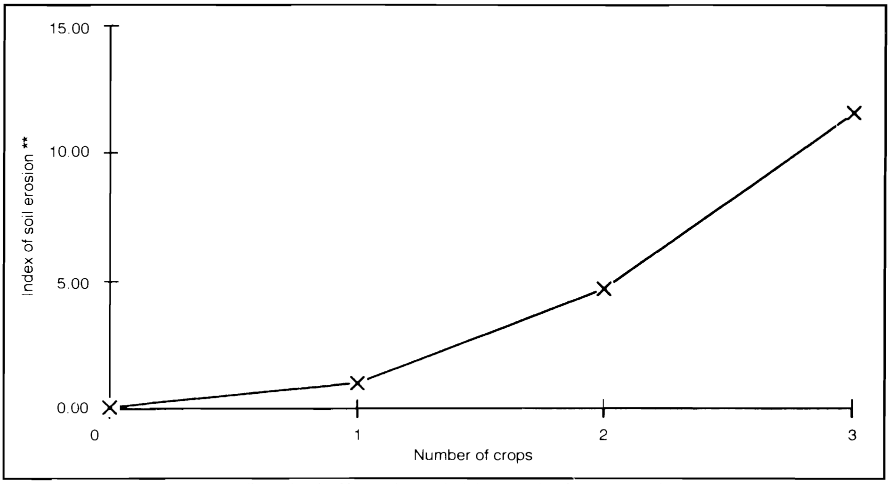


Figure 6. Change in maize yield with increasing animal numbers.



** Index = soil erosion for **X** cattle/soil erosion without cattle.

Figure 7. Relationship between the number of cattle and the level of soil erosion for the five year *Gliricidia* fallow/one year maize cropping system.



** Index = soil erosion for X cropping periods/soil erosion for one cropping period.

Figure 8. Relationship between the number of crops per crop/fallow cycle and the level of soil erosion for the five year *Gliricidia* fallow/one year maize cropping system.

crops' refers to the number of years of cropping (within a six-year crop/fallow cycle).

Economic analysis

The establishment of a *Gliricidia* plantation can increase revenue from the higher maize yield, complemented by returns from firewood. This result is relevant at prices currently perceived by smallholders in Claveria, and generally held even after simulating significant increases in the wage rate, or decreases in product prices (Grist et al. 1997).

Two discount rates were used in this analysis — a social opportunity cost and a market borrowing rate. An interest rate of 12% was chosen to represent the social opportunity cost of capital for the Philippine economy. A higher interest rate of 25% was also used. This was chosen to represent the market borrowing rate. It is based on an estimate of the borrowing interest rate, obtained from a farmer survey (Nelson et al. 1996b).

Given beef prices of ₱40/kg and a discount rate of 12%, the *Gliricidia* fallow system is more profitable with animals included. When compared to the no animal case, net present value increased by 50% with one animal, 110% with two animals, and 170% with three animals. However, even without animals, a *Gliricidia* fallow is far more profitable than a shifting cultivation system based on an *Imperata* fallow (Table 2).

These calculations are based on a discount rate of 12%, which may approximate the social opportunity cost of capital. Actual interest rates facing farmers in Claveria are between 16% and 30%, with 25% seen as the most representative interest rate for borrowing (Nelson et al. 1996b). At this discount rate, the overall profitability of the *Gliricidia* fallow and of introducing animals into that system is reduced. However, the general trends shown in Table 5 are maintained.

A barrier to the adoption of the *Gliricidia* fallow system could be the initial income losses during the transition period. Analysis by Grist et al. (1997) indicated a loss of approximately ₱850 in the first year of the transition period between an *Imperata* fallow system and a *Gliricidia* fallow system (without animals). It would take four years for smallholders to recover this initial loss, and for cumulative profitability to become higher than with an *Imperata* fallow system. The inclusion of cattle within the *Gliricidia* fallow system increases these initial transition costs. Unless upland farmers can bear these initial losses, via using savings or borrowing money at reasonable rates, adoption of the *Gliricidia* fallow system will be difficult (more so with animals).

Summary and Conclusions

Shifting cultivation systems with short, unimproved fallows such as *Imperata*, are biologically unsustainable. Yet they are often undertaken for reasons of economic imperative. Animals can provide an economic return during the fallow period and seem capable of playing a positive economic role, even in an unimproved *Imperata* fallow situation.

Table 5. Total revenue, total costs and net present value for the Gliricidia fallow system, with and without animals.

Discount rate 12% Beef price, ₱40 kg		0 Animals (₱ '000)		1 Animal (₱ '000)		2 Animals (₱ '000)		3 Animals (₱ '000)	
Revenue									
	Firewood	47.4		37.4		27.7		18.3	
	Maize	57.0		48.8		46.1		43.4	
	Cattle	0.0		70.6		141.3		211.9	
	Total revenue		104.4		156.8		215.1		273.6
Costs									
	Maize/fallow system	46.9		44.4		41.9		39.4	
	Cattle	0.0		26.0		52.1		78.2	
	Total cost		46.9		70.4		94.0		117.6
Net present value			57.5		86.4		121.1		156.0

Improved fallows, such as *Gliricidia*, offer the prospect of income gains and enhanced biological sustainability. Those outcomes are enhanced by the introduction of cattle into the system (at a moderate level).

The introduction of cattle into a *Gliricidia* fallow system involves a trade-off between the amount of *Gliricidia* foliage used as mulch, and the amount fed to animals. Reducing mulch decreases soil fertility levels, and increases soil erosion (thus lowering plant yields). The rate of increase in erosion is approximately in proportion to the number of animals. Although at Claveria, erosion is low relative to other sites in the Philippines, maize and firewood yields are still affected. In other locations, where soils are more erodable, adding animals is expected to have more serious consequences for soil erosion and maize yields.

Limited availability of savings or restricted access to capital may make adoption of improved systems difficult. To encourage adoption by upland farmers, governments could consider policies that facilitate long term loans, or otherwise lower the cost of credit to upland farmers. However, even at prevailing interest rates of around 25%, the *Gliricidia* fallow system with cattle appears to be superior to traditional shifting cultivation systems in *Imperata* areas.

The *Gliricidia* fallow system was chosen as an example of an improved fallow system. It has not been extensively practised and the results presented here would require verification, or pilot testing in particular environments, before being promoted as recommendations. However once model templates of the kind presented here have been established, promising systems and management strategies can be tested with relative ease. This can be done in a manner that is far less expensive, and can give earlier results than traditional field experimentation. It is suggested that modelling at this practical level be conducted simultaneously, or at least interactively, with biophysical experimentation, as a two-pronged attempt to improve shifting cultivation systems.

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Problems and Opportunities for Livestock Production in Xieng Khouang Province: Field Observations 1993–1995

T.A. Gibson[1]

Abstract

The major problem with large livestock production in the infertile, pine-tree grasslands of the Xieng Khouang Province is extreme phosphorus deficiency. Symptoms and procedures for identification and correction of phosphorus deficiency are outlined. The applicability of locally made bone-char and readily available fertilisers are discussed. Opportunities for the immediate improvement of large and small livestock at the village level in both the infertile and fertile areas of the province are outlined.

THIS PAPER reports on some aspects of the livestock component of the LAO/UNDCP/IFAD Xieng Khouang Highland Development Program. The period covered is November, 1993 to May, 1995. The Program was executed by UNDP/OPS.

The major initiative of the livestock component was a Cattle Bank. Native cattle cows were distributed to villagers; mature females weigh 150–180 kg and are more fully described by Bouahom (1993). The rationale for the Cattle Bank was to replenish cattle numbers which had been greatly reduced in the Province as a result of the Vietnam War. Xieng Khouang is a Government priority area for cattle development.

Other initiatives were the enhancement of the animal health service, the trialling of improved forages and farmer and technician training.

This paper is mainly concerned with the discovery and correction of extreme phosphorus deficiency in parts of the province. The improved forage programme is described elsewhere (Gibson 1996; Horne, these Proceedings). Other aspects of the project may be found in project reports. The paper concludes by listing some perceived opportunities for an immediate improvement in livestock production at the village level. The environment of Xieng Khouang is briefly described.

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Environment, Land-use and Animal Husbandry

Long-term climatic data are available for one station only in Xieng Khouang, that of Phonsavanh town (19° 53′ N, 102° 08′ E; 1100 m elevation). The average annual rainfall in Phonsavanh is 1484 mm, 89% of which falls in the six months from April to September. The average daily maximum and minimum temperatures are 25.6 °C and 15.3 °C. Frosts occur in the higher valleys during the middle of the dry-season. There are four major, obvious agro-ecological zones in the province:

The pine-tree grassland zone

This zone occurs mainly in the central west of the province between about 1000 and 1400 metres elevation. The zone is characterised by the presence of pine trees (*mai pek*) and by extensive grassland areas. The grasses are collectively known locally as acid grasses (*ya som*); they consist mainly of *Themeda* spp. (*ya chin chik*). Soils are mostly derived from siltstone, sandstone and shale. Soils are acid with a surface pH (in water) of about 5.0.

The main agricultural activity is rain-fed, paddy rice-growing in the shallow valleys. The uplands are not cultivated, but are used extensively for cattle grazing. The cattle are returned to sheds in the village each night. Manure from the sheds is placed onto the rice paddies. Villagers report rice yields of about two tonnes per hectare with manure and less without it.

The fertile valleys

This zone occurs throughout the province in non-pine tree areas from about 600 m to1300m elevation. The zone is characterised by the absence of pine trees; there are no extensive grassland areas. *Themeda* is not obvious. Oak and chestnut trees (*mai kor*) and bamboo occur. However, the non-cultivated areas are often covered with unpalatable semi-woody weeds e.g. *Chromolaena odorata*. Soils are generally derived from basic rocks (mainly limestone). Soils are slightly acid to alkaline (surface pH 6-8.5).

Rain-fed or irrigated paddi is grown in the valleys. The uplands are intensively used for shifting cultivation; maize and dry-land rice are the main crops grown. Cattle and buffalo are reared but are not generally brought back to sheds at night. Manure is generally not placed on paddies and the yield of unmanured paddi is reported to be 3–4 t/ha.

The high, fertile mountains

This zone occurs mainly near the borders of the province from about 1400 m to 1700 m elevation. This zone is similar to the fertile valley zone. *Bauhinia* trees are often obvious and there are often grassland areas sometimes with *Imperata cylindrica* (*ya kha*) grass dominance. Opium growing is generally an important cash-crop in backyard and shifting cultivation fields.

The dense forest

This zone occurs to 2600 m altitude. There is little agriculture or animal husbandry in this zone.

Strange Diseases of Cattle and Buffalo

Informal interviews were conducted in several villages in 1993–94. In pine-tree grassland areas, villagers often reported strange disease symptoms of cattle and buffalo for which there was apparently no cure.

Cattle, and more especially buffalo, sometimes developed lameness (*kha han*). Lameness was generally more obvious towards the end of the dry season. Lameness could be so extreme that animals could not walk and sometimes died. This was particularly important in ploughing buffalo which were needed in the early wet season for paddy preparation. Lameness was characterised by long hooves whereby the ends of the hooves would overlap. Lameness did not respond to antibiotic treatment. Lameness was also occasionally reported in pigs.

In the dry-season in pine-tree grassland areas, cattle and buffalo can often be seen eating or chewing non-food items such as rope, plastic shoes, rocks, scrap iron, cardboard, bones, etc. The rumen of dead animals will often contain large amounts of undigested rope, plastic, etc.

Farmers in the pine-tree grassland areas often reported an abnormal incidence of broken bones in cattle and buffalo. Animals would break bones while shoving one another, while jumping across small gullies and even while ploughing.

Cattle and buffalo were reported to sometimes suddenly die (within a few days) without any apparent symptoms except for lethargy. Even animals routinely vaccinated against *Haemorrhagic septicaemia* and blackleg died; antibiotics did not seem to be effective.

Calves born in the middle of the dry-season often died. Such calves were often born small in size and weak. Their mothers were thin and often produced little or no milk. Sometimes cows aborted. Cattle often had hunched backs (*lang kong*).

These diseases and symptoms were not reported from the fertile agro-ecological zones. Generally, there was more native grass available in both the wet and dry-seasons in the pine-tree grasslands than in the fertile areas so that lack of forage per se could not explain the incidence of the diseases. Farmers generally reported a calving percentage in cattle of about 80% and a weaning percentage of about 70% in fertile areas. By contrast, farmers from pine-tree grassland areas often reported calving and weaning percentages of about 60% and 40%. The production parameters actually achieved seemed to depend on the proportional access cattle had to surrounding fertile areas. Cattle banks operated by three projects in the pine-tree grassland areas also reported similarly poor production parameters. At May, 1995, the four oldest cattle bank villages of the Xieng Khouang Project which had been operating for 17–31 months had yearly average calving and weaning percentages of 42% and 33% (total 192 breeders). Twenty per cent of calves had died during this period.

Evidence of Extreme Phosphorus Deficiency

All of the above symptoms can be explained by severe phosphorus deficiency (Morrison 1959; Hall 1977; Minson 1990). The unexplained deaths may well be due to botulism poisoning from the ingestion of putrefied bones. Further evidence for extreme phosphorus deficiency includes the following:

Bone thickness

The long leg bones of about 10 cattle and buffalo cows that were killed at Phonsavanh abattoirs or in villages were cut transversely. The proportion of the bone cross-sectional area that was true bone was determined by measuring diameters of the whole bone and of the lumen (the hole in the centre of the bone). True (cortical)/whole bone ratios for animals known to be reared in pine-tree grassland areas were markedly less than those of animals reared in fertile areas. Ratios were as low as 0.54, indicating very severe phosphorus deficiency by the criteria of Little (1984). Animals reared in fertile areas had ratios of 0.7–0.8 which indicate very satisfactory phosphorus status.

Soil phosphorus content

Soil (0–15 cm depth) was analysed at the Incitec Laboratory in Brisbane from three sites. Two sites were in typical pine-tree grasslands. The third was in an abandoned opium field on limestone. Pertinent results are shown in the Table 1.

The grassland soils had much lower extractable phosphorus than the limestone soil. This was related to lower pH and exchangeable calcium in the grassland soils and a very high exchangeable aluminium content. In tropical Australia, Kerridge et al. (1990) reported that cattle liveweight gains were greatly decreased in areas of extractable phosphorus (0.5M Na bicarb) content less than 5 ppm.

Observations of forage introduction trials support the conclusion of very low available soil phosphorus in pine-tree grasslands. In pine-tree grasslands, renowned low soil phosphorus tolerant species such as *Andropogon gayanus* and *Stylosanthes guianensis* did not make satisfactory growth unless fertilised with phosphorus fertiliser. Unfertilised native and introduced forages in pine-tree grasslands often have an intense purple coloration on the older leaves suggestive of soil phosphorus deficiency. By contrast, the phosphorus demanding forage, *Desmodium intortum* cv. Greenleaf, made excellent growth in a limestone soil without phosphorus fertiliser.

Animal response

No quantitative measurements have been made on animal response to phosphorus supplementation. However, there have been numerous anecdotal responses.

Several farmers have been given either bone-char or triple-super-phosphate (TSP) fertiliser to feed to buffalo and cattle. Farmers consistently report that feeding 12 grams of phosphorus per day to buffalo as either bone-char for about 14 days or TSP for about 10 days results in a marked improvement in lameness. Buffalo that could not walk previous to feeding phosphorus supplement could graze in the field after been fed phosphorus. Feeding 6 grams of phosphorus supplement per day resulted in similar benefit to lame cattle. There are also anecdotal reports of phosphorus supplementation being of benefit to lame pigs and to the condition of cattle and buffalo when fed for longer periods over the dry-season.

Recent Occurrence of Extreme Phosphorus Deficiency

The pine-tree grasslands were greatly depopulated (of villagers and livestock) during the Vietnam War ending in 1975. Villagers report that the symptoms of extreme phosphorus deficiency have only occurred since resettlement. Villagers attribute symptoms to residues and ordnance from the War. However, since resettlement after the War, the human population density is much greater and much of the wetter and more fertile shallow valleys have been developed for wet-rice growing. Previously, cattle and buffalo made intensive use of the greener and better quality forage in the valleys in the dry-season. But now, the valleys consist mainly of dead rice stubble in the dry-season which may be assumed to be of greatly reduced phosphorus content. This is a possible explanation for the recent occurrence of very obvious deficiency symptoms.

Animal Phosphorus Supplements

Cheap, waste bones are available in Phonsavanh from either the abattoirs or from noodle shops (where the bones are used to make soup). The most practicable method of preparing bone-char appears

Table 1. Some soil analytical data (0–15 cm).

Zone	$pH_{1:5}$ soil:water	Extractable P (ppm) 0.5 M Na bicarb	Extractable P (ppm) 0.01 N H_2SO_4	Exch. Al (% ECEC*)	Exch. Ca (meq/100 g)
Grassland	4.8	5	3	74	0.36
Limestone	5.7	23	43	0	5.52

* Effective cation exchange capacity.

to be the charring of bones in open fires (for example, during whisky distillation in villages). The charred bones can be easily crushed in traditional wooden rice-dehullers and passed through fly-screen mesh to obtain the bone-char.

The most readily available chemical phosphorus supplements in Xieng Khouang are TSP from Thailand and SSP (single-super-phosphate) from Vietnam. All three sources of phosphorus have been analysed at the Incitec Laboratory (with cadmium analysed by the Queensland Department of Primary Industries) and the results are presented in Table 2.

Table 2. Laboratory analyses of some phosphorus supplements.*

Supplement	N (%)	P (%)	Ca (%)	S (%)	F (%)	Cd (ppm)
Bone-char	2.8	12.4	26.4	0.04	NA	NA
TSP	NA**	20.3	16.0	1.3	1.9	11
SSP	NA	8.9	20.1	10.0	0.8	8

* Only one sample of bone-char was analysed. Two samples of TSP were analysed; each sample was a composite of grab samples from a few 50 kg bags of TSP. Only one sample of SSP was analysed; it was a composite of grab samples from 2 × 25 kg bags. The variation between batches is not known.
** Not available.

Villagers normally feed phosphorus supplement wrapped with a little salt in a banana leaf.

Fully charred bone may be expected to contain about 17% phosphorus (and negligible nitrogen) so that phosphorus content of locally made bone-char will be variable depending on the amount of heating. All three supplements contain appreciable phosphorus and calcium; SSP also contains appreciable sulphur which will be important especially for dry-season urea supplementation of cattle and buffalo.

A 300 kg cattle, either lactating or gaining a moderate amount of liveweight per day, requires about 6 grams of supplemental phosphorus per day to maintain body phosphorus content if reared in areas of acute phosphorus deficiency (McCosker and Winks 1994).

Excess fluorine is harmful to cattle and buffalo if fed for long periods of time (Morrison 1959; McCosker and Winks 1994). The recommended long-term maximum daily intake is 1 mg F/kg liveweight. A 300 kg buffalo, fed at 6 grams phosphorus supplement per day would ingest about 2 mg F/kg liveweight per day from either TSP or SSP. Thus, either TSP or SSP should not be fed alone at 6 grams of phosphorus per day per adult buffalo (or 3 grams for adult native cattle) for more than 6 months of the year. The safe level of TSP and SSP feeding is further reduced by the amount of fluorine in drinking water (and in other components of the feed).

Cadmium accumulates in kidneys and liver and is harmful to human health. The recommended maximum level of cadmium in supplements is 100 mg Cd/kg of phosphorus (McCosker and Winks 1994). SSP contains about 90 mg Cd/kg of phosphorus and TSP contains about 55 mg Cd/kg of phosphorus. Thus cadmium content in TSP and SSP should not cause serious harm to human health.

Bone-char does not contain significant contents of either fluorine or cadmium.

To May, 1995, farmers had fed about 1.5 tonnes of TSP and about 500 kg of bone-char to cattle and buffalo in Xieng Khouang. Some of the TSP had been purchased from retail outlets established by the project. However, farmers only readily paid for phosphorus when their animals showed very obvious symptoms of phosphorus deficiency (i.e., limping). Farmers were reluctant to purchase phosphorus (or to make bone-char) for routine supplementation.

Opportunities for Development

Clearly, no livestock nor forage development can be contemplated in the pine-tree grassland areas without phosphorus fertilisation of forages or phosphorus supplementation of grazing animals and pigs. Locally prepared bone-char and easily obtained SSP are the most practicable phosphorus sources. Routine phosphorus supplementation can be vigorously extended.

Once the phosphorus supply to animals is satisfactory, other improvements may be profitably promoted. Cattle numbers may be most conveniently increased in areas of few cattle by an improvement in weaning percentages which should result from improved phosphorus nutrition.

Soils of the province are very low in sodium (unpublished data) and a marked improvement in cattle and buffalo productivity can be expected from feeding salt routinely (Falvey and Mikled 1980). Twenty grams of iodised salt (39 ppm iodine) per adult cattle cow per day would supply adequate supplementary sodium and iodine.

The project successfully demonstrated the making of urea-treated-rice-straw in several villages. This may be usefully promoted in the dry-season for recently calved cows which would normally be fed untreated rice-straw. The feeding of urea-treated-straw may result in improved survival and growth of calves. Otherwise, the economic benefits of urea treatment may not be obvious to villagers.

Buffalo and cattle calf survival and growth should be greatly improved by routine anthelmintic drenching soon after birth. Kingston (1992) applied data from the Thai-German Animal Health Project to northern Laos and concluded that drenching with piperazine had a benefit/cost ratio of 79:1 for cattle and 69:1 for buffalo. Pigs and poultry would also probably greatly benefit from routine drenching.

The best opportunities for immediate extension of improved forages appear to be (Gibson 1996): back-yard plots of Gamba grass, Calliandra, Glenn joint vetch and Greenleaf desmodium as higher quality dry-season feed supplements in the infertile savannah zone (other species are also applicable in the fertile zones); rehabilitation of abandoned opium/resting shifting cultivation fields in fertile areas by oversowing with Greenleaf desmodium (see also Gibson 1983); establishment of dry-season areas of oats, vetch and persian clover in rice paddies with dry-season water (or, in high altitude fertile soils, in resting cultivation fields) to provide a high quality feed supplement.

The death rate of pigs and poultry is very high. There is great opportunity to greatly improve animal productivity by an improved vaccination program. Previous attempts by several projects to improve vaccination in Xieng Khouang have generally not been very successful. It is suggested that extension methodologies could be improved by following successful strategies adopted in other parts of Laos and in neighbouring countries.

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Animal Diseases in Upland Areas — The Development of an Animal Health Information System for Lao PDR

Angus Cameron[1]

INFORMATION on the disease status of livestock is critically important for a number of reasons. An understanding of the types of disease present and the levels of their occurrence is needed to help establish priorities for animal health programs. Measures of the economic impact of diseases are needed to justify expenditure on control programs. Knowledge of the distribution and epidemiology of diseases is needed to formulate sound disease control programs. Information on the presence and levels of major diseases is necessary to meet international disease reporting obligations of the OIE as well as to provide information to neighbours and potential trading partners. Reliable information on the number of livestock and the major problems present is needed for the targeting of governmental resources to those people that need them most.

An information system for animal health is therefore very important to enable government animal health policy decision-makers to be better informed and to have a clearer understanding of the disease situation. However, different forms of animal health information are needed not only at the upper levels of government but also at all levels of society, from the livestock owners to village veterinary workers (VVWs), district officers, provincial staff, central government veterinary authorities and the wider international community.

Animal health problems faced by livestock owners in upland farming systems are likely to be more significant, but this group has access to fewer veterinary services to address these problems due to their generally remote location. Information on the problems faced in upland farming systems is an important component of the national animal health picture, but it is more difficult to obtain.

Currently in Lao PDR, the amount and quality of information on diseases affecting animals from many parts of the country are inadequate to developing a realistic idea of the impact of diseases, or to formulating effective disease control programs. Efforts are currently underway to improve the quantity and quality of disease information.

Passive Surveillance

Two keys to the current system of information collection are the use of disease outbreak reports from the provinces, and the use of information from diagnostic laboratory submissions sent to the Central Research and Diagnostic Laboratory in Vientiane. Due to infrastructure problems, these diagnostic samples are received almost exclusively from Vientiane Municipality. Outbreak reports appear from around the country, but are usually late and contain inadequate detail. The majority of disease outbreaks go unreported.

This type of reporting system uses passive surveillance, in which animal health authorities make no active efforts to discover the presence and levels of disease. Instead, they depend on the livestock owner or VVW to report a disease problem to district staff. This type of system is used by countries worldwide as the main source of disease incidence data. If working effectively, it can provide a great deal of useful information. However, all such systems suffer from a level of under-reporting, and as a result, they invariably underestimate the amount of disease present. In the case of upland farming, communications are often difficult and disease outbreaks may be impossible to report. The result is that passive surveillance figures may falsely indicate that there are few disease problems in these areas, compared to areas that are more accessible.

Factors that need to be addressed to improve the passive reporting system include:

- increasing the reporting rate;
- improving the quality of information contained in disease reports;

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- increasing the number of laboratory specimen submissions to allow definitive laboratory diagnosis of disease problems.

Livestock owners, VVWs and district veterinary officers are the key links in the information chain. Public education campaigns on the importance of livestock diseases and the value of reporting them are needed for owners and VVWs. In addition, district officers need more training in disease outbreak investigation, specimen submission and disease reporting. To this end, a new disease report and specimen submission form has been developed for use by district officers to clarify what information is required when reporting.

Active Surveillance

Passive surveillance can provide information on which diseases are present in which parts of the country. It cannot provide reliable measures of the levels of disease (such as prevalence or incidence), nor can it provide any basis for claims of the *absence* of disease from a certain area. In order to gather reliable population-based information about disease prevalence or incidence, active surveillance based on statistically valid epidemiological surveys is needed. As its name implies, active surveillance means that veterinary authorities actively investigate the levels of disease in the livestock population. Information gathered in this way is much more reliable, and can give valid measures of the prevalence, incidence and economic impact of diseases. Surveys of this sort may be more expensive than passive surveillance systems.

Appropriate techniques for active surveillance have been developed in Thailand and Lao PDR. These techniques use a two-stage random sampling scheme to select animals. Blood is collected and analysed to produce estimates of seroprevalence to relevant diseases. A new technique using retrospective participatory village interviews and survival analysis allows incidence of village outbreaks of major diseases to be quickly and cheaply estimated. These active surveillance techniques have been successfully piloted in Vientiane Municipality, and there are plans to train provincial and district staff and to implement the techniques in three further provinces later in 1997.

Active surveillance requires a greater expenditure of effort, and higher skill levels by more staff than a passive reporting system, but gathers much better information. The main challenges to the national implementation of such a system are provincial and district staff training, and funding and infrastructure constraints. Survey teams need to be able to access remote areas for interviews and blood collection.

Information Management

Another constraint to the establishment of an effective animal health information system in Lao PDR has been problems with information management. Until recently, this has been conducted in an inefficient paper-based system. A new computer system has been developed for the entry, storage, analysis and reporting of a broad range of animal health information. The system is inexpensive and able to run on virtually any IBM-compatible computer. It integrates data on livestock populations, field disease reports, laboratory submissions, vaccination production and distribution, the village veterinary worker network, active surveillance, and livestock movement. It is also linked to a simple mapping program for the production of disease maps, and is able to be linked to a more sophisticated geographical information system.

With final implementation of this program, the management of disease information will no longer be a constraint. Instead, the challenge of the collection of disease information from the field will be the main obstacle for the future.

Conclusion

In this paper, there has been no reference to specific livestock disease problems in upland farming systems. The reason is that no reliable specific information on the levels and impact of these problems is available to the central veterinary services. To maintain and to improve the health and productivity of livestock in upland farming systems, it is necessary to understand the disease problems that exist. The collection of animal health information from remote areas will be a continuing challenge. However, it is hoped that the combination of improved passive reporting systems and effective active surveillance may soon provide a source of reliable, population-based information — information that will provide a basis for the formulation of a sound disease control program.

Summary and Recommendations

Summary

'Controlled grazing practices (timing, numbers of livestock etc.) which are optimal for both fallow management and livestock production have not yet been determined. On-farm studies are needed to develop grazing systems utilising improved fallows. Livestock and crop scientists will need to work together with farmers and village leaders to find systems that work'.

Keith Fahrney, Soulasith Maniphone and Onechanh Boonnaphol (in these Proceedings)

THIS Workshop was designed to be a review of progress at both research project and development project levels, towards the achievement of increased livestock production in the uplands of the Lao PDR. To this end, the Organising Committee brought together more than 70 invited participants from different scientific backgrounds and with different research and development project experience in Lao PDR and neighbouring countries. The Workshop was characterised by continuing lively discussions in the formal sessions, at coffee breaks, over meals and during the two days spent in the field in three working groups. The summary below is an attempt to record the main issues from these wide-ranging discussions.

As the Workshop proceeded, there was ready recognition of the challenges now confronting the Lao authorities in the uplands. In his opening speech, the Minister for Agriculture and Forestry, H.E. Dr Siene Saphangthong, emphasised his Government's concern with both the alleviation of poverty in upland farming communities and with the eventual elimination of 'slash and burn' cultivation. At the same time, the Government was concerned about long-term food security, the protection of natural resources, soil conservation and about sustainability in all its aspects. In subsequent discussions, participants recognised many considerations which influence the frame within which proposals and plans must be formulated. They include:

- The continuing rapid growth of the Lao population at 2.2–2.5% per annum, implying a near-doubling of the national population to about 8 million in the next 30 years; upland communities are likely to have even higher growth rates, with consequent increasing pressure on land resources and farming systems, unless massive net out-migration occurs.
- The extreme ethnic and linguistic heterogeneity of the Lao population (more than 60 separate ethnic groups), particularly in upland areas. The problems of cultural isolation for more remote communities are often compounded by their physical isolation, due to the mountainous terrain in much of rural Laos and the limited road system.
- The current transitional situation of swidden farming in the uplands, particularly in the northern region. In the past 20–30 years, the traditional rice-dominant swidden economy has come under a combination of pressures, leading to reduction in fallow length, declining soil fertility and lower yields. But now there is convincing evidence of ways in which many farmers are adapting their farming systems in order to achieve increased productivity, notably in areas favoured by better transport access.
- Even as upland farming is now gradually changing from subsistence-centred shifting cultivation towards small scale, subsistence-and-commercial agriculture involving livestock as a main component, food security remains a constant concern of farm households, as it does for regional and national authorities. In consequence, proposals relating to livestock production, rice production or any other on-farm developments (e.g., orcharding, vegetable production or the planting of teak trees) need to be considered within a 'household livelihood' or 'whole farming systems' approach (see Demaine in these Proceedings).
- The Lao PDR has experienced remarkable growth in its livestock sector in the 1990s and there is continuing promise for the years ahead, following implementation of the market-oriented New Economic Mechanism (1986) and in response to both domestic and export demand. Warr (these Proceedings), emphasised that in the period 1990–1995 the value of livestock production grew at an average annual rate of 6.4%, far outstripping the rate of population growth (2.2%), the growth of the crops sector (1.4%) and of rice production (1%). The future of the uplands looks even more promising, given the increasing changeover in the lowlands from animal power to hand tractors, and reduction in the numbers of cattle and buffalo.

Discussions of many issues continued after the Workshop. Staff from the Livestock Development Division, Department of Livestock and Fisheries (DLF) visited Luang Prabang, Xieng Khouang and

Oudomxai Provinces for discussions at district level, particularly about on-farm research (see below) and the possibilities for expansion of small livestock production among poorer households. Later in 1997, there were consultations with headquarters staff of the Lao Women's Union about their role in village-level small livestock production. Later also, there was discussion of the early progress being made in the ACIAR-funded 'animal diseases' project (ACIAR Project # 9438, noted further below), now being developed in conjunction with DLF.

In the conclusions below, references to particular authors are all to papers in these Proceedings unless otherwise stated.

Conclusions

Policy Issues

1. The World Bank's review (1995: 55–57) of the agricultural sector in Lao PDR drew attention to the proliferation of uncoordinated donor projects, the lack of a national strategy to guide donor projects and the weakness of the Ministry of Agriculture and Forestry (MAF) in policy formulation and the development of coherent sector strategies. Several years have passed since the World Bank Mission investigating the agricultural sector was in the Lao PDR (1993). By 1997, there was a firm Ministry policy for upland development and a sectoral 'Livestock Sub-Sector Policy Framework for Upland Farming Systems', both outlined at the opening session of this Workshop (Saphangthong; Phonvisay). Government approval has also been given (with the endorsement of the World Bank, the EU and several other foreign donors and NGOs) for an 'area-based' upland development strategy which will take account of particular combinations of opportunities and constraints in different geographic situations (Mr P. Parisak Pravongviengkham, Deputy Permanent Secretary, MAF, pers. comm.). Accessibility will be a critical factor.

Upland Farming in Transition

2. Laos, like Thailand and Vietnam in recent decades, is seeing its traditional, rice-dominant, swidden farming system in the uplands changing under a combination of pressures, as evidenced by increasing weed problems (with higher demands on farm labour), declining rice yields and shortening fallow periods. In consequence, many upland farmers are diversifying their farm production in various ways, including tree planting (notably teak in the northern provinces), the production of maize and other crops, and more emphasis on the production of buffalo, beef cattle, pigs, goats, poultry and fish. In doing so, they are using small-scale commercial livestock production as a means of intensifying land use and supporting increasing farm populations. As the process continues, feed resources are becoming critical. With respect to large ruminants (buffalo and cattle) this is leading towards increased 'backyard' fodder production and indigenous fallow management, and also to the risk of over-grazing in communal rangelands. There is scope for greater emphasis on small livestock, notably pigs, goats, chickens and fish, in the smallholder farm economy (Bouahom; Carson; Cheva-Isarakul; Rerkasem; Rambo and Cue in the Proceedings), but much depends on the effectiveness of disease control and feed production.

'There are three requirements for expansion of upland livestock production: disease control, feed production and management.'

(Comment by a Workshop participant visiting Luang Prabang)

3. The first two requirements, specified above, are not in dispute. Villagers strongly agree with them (Pravongviengkham). They are both technological improvements, but the issues of 'management' are wide-ranging and more problematic. Certainly the first priority, if increased numbers of large and small livestock are to be produced, is the establishment of a more effective disease-control program, through vaccination and worming. High mortality rates of pigs and chickens are common, usually attributed (normally without laboratory verification) to Hog Cholera (HC) and Newcastle Disease (ND) respectively. Mortality rates are commonly much lower for buffalo and cattle, in outbreaks of *Haemorrhagic septicaemia* (HS) and Foot-and-Mouth Disease (FMD), but any deaths of the relatively high-valued large livestock are often immensely significant for smallholders having only a few head.

4. The national vaccination program, managed by DLF, clearly needs comprehensive reconstruction, province by province. Vaccines are produced in Vientiane and supplied on a cost-recovery basis, but cost is only one of a complex of factors that continues to limit the effectiveness of the program. Delivery of vaccine to the 17 provinces and then to districts and villages in good condition is the chronic problem. The main factor is the poor (but gradually improving) rural infrastructure, so that more distant villages are not well served. In addition, the cold chain delivery systems are sometimes broken down, particularly at the village end of the delivery system; para-veterinary staff (Village Veterinary Workers, VVWs) are inadequately trained and often poorly equipped. Moreover, inadequate farmer education

about livestock diseases leads to low vaccination rates (Stöber; Hansen; World Bank, 1995: 67).

5. Of equal priority, if livestock production in the uplands is to be expanded, is the development of feed resources to offset the dry season decline in communal grasslands and to meet the fodder needs of an increasing population of ruminants. Where survival rates of buffalo and cattle are improving, many households in northern Laos are turning to forage production (e.g., napier grass, *Pennisetum purpureum*), to provide supplementary feed in the dry season. Communal grasslands are also coming under increasing pressure. The 'Forages for Smallholders' project is a timely effort which encourages farmers to make their own decisions towards intensifying farm production, but it remains uncertain how significant fallow improvement of this kind will prove to be for village communities in the immediate future (Fahrney et al.; Horne; Pravongviengkham).

6. The implications of the shift towards livestock-centred upland farming are likely to be significant. Fodder production requires the farmer's labour and also requires fencing to keep buffalo, cattle and goats *in* or *out*. As the human population of villages increases, fodder production is likely to lead to competition with crops for the available land, leading sooner or later to alienation of communal grazing land and to individual land ownership. One consequence, already happening, is the breakdown of the traditional village regulatory systems which have managed land resources with a strong concern for equity between households (Pravongviengkham).

7. It is doubtful whether the intensification of upland farming will benefit the poorer 50% (or more) of households in most villages, unless special efforts are made. A major policy objective of the Lao Government is the alleviation of poverty in upland communities. Already there are marked economic disparities between households in many upland villages, with the wealthier households commonly owning a disproportionate part of the village herd of buffalo and cattle (Chapman 1995; Cohen; McLaren). In this context, it is inevitable that the main beneficiaries of an effective livestock vaccination program will be the relatively wealthy, rather than the poor. Similarly, poor households are unlikely to be keenly interested in fodder production opportunities, because they lack the means to own or buy buffalo and cattle and have more difficulty in obtaining access to farm credit. The repayment of loans is also a major problem, as project experience in Luang Prabang Province since 1991 has demonstrated (Sodarak; Va Ya; Souliyavongsy; Ditsaphone and Hansen).

8. It is clear that efforts to intensify production of large livestock in upland swidden systems are likely, sooner or later, to have complex economic and social implications. The problems may be less if more attention is given to pigs, goats, poultry and fish. Many upland smallholders now recognise the potential of small livestock, not least because of the lower capital investment required. In his four-district study area, investigated in 1996, Pravongviengkham (these Proceedings) found a strong preference for future household farming systems combining upland rice and fish (for subsistence), small livestock, maize and other cash crops. And yet, as Stöber found in village vaccination campaigns in Bokeo Province in 1996 (and others have found also), average vaccination rates for pigs and chickens were low. Despite vaccination campaigns, 7 out of 14 villages did not vaccinate any animals at all (Stöber).

The Significance of Foreign-funded Development Projects to Livestock Production?

9. In this decade, there have been more than 110 donor-assisted projects working in the agriculture and forestry sector in Lao PDR, commonly for 3–5 year periods in one or more provinces, rather than throughout the whole country. Some focused on livestock and improvements to the vaccination delivery system in particular provinces or districts, mainly in the early 1990s. Few projects focused on shifting cultivation, or the development of upland farming. Often the long-term legacy of these projects appears to have been small, but this is not an unusual situation. In three Workshop papers concerned with highland development in northern Thailand in the 1970s, 1980s and 1990s foreign-assisted projects are considered to have ignored opportunities for livestock in the earlier years; and it is reported that only recently villagers themselves have reassessed the importance of livestock in the rural economy (particularly cattle, pigs and chickens), often with the help of NGOs (Carson; Cheva-Isarakul; Rerkasem).

10. In the Lao PDR, in 1997, five continuing donor-funded projects appeared to have special significance for future upland livestock production. These were:

- the Shifting Cultivation Research Sub-Program (SCRS) in Luang Prabang, supported by the Swedish International Development Co-operation Agency (SIDA), described by Sodarak et al. (these Proceedings);
- the Lao-IRRI Northern Region Upland Crops Research Centre in Luang Prabang Province (Fahrney, Maniphone and Boonnaphol in these Proceedings);

- the CIAT/CSIRO 'Forages for Smallholders' Project funded by AusAID (Horne in these Proceedings);
- the ACIAR-funded project for 'Improved Diagnostic and Control Methodologies for Two Major Diseases (FMD and HC) in Lao PDR and Yunnan Province, PRC' (Cameron; also Westbury and Blacksell in these Proceedings);
- and the EU-funded project for ' Strengthening of Livestock Services and Extension Activities', approved in October 1997.

11. The EU-funded project (1998–2004) has seven components. Its central components provide for the establishment, nation-wide in Lao PDR, of an Animal Health Information System, together with support for three diagnostic laboratories, including the central laboratory set up by ACIAR-DLF in Vientiane in 1997. The project plans to reconstruct the vaccine delivery system in 30 districts of the northern provinces, mainly in Luang Prabang and Luang Namtha Provinces, before expanding about threefold in the last two years of the project. The combined effect of the EU and ACIAR projects should be to reduce dramatically the disease problem which plagues livestock production throughout the Lao PDR. Improvement of the delivery system for vaccines, including the further training of VVWs, will be critical.

12. Of the five major projects listed above, only two are clearly *national* in scope and both (the ACIAR-funded 'Animal Health' project and the EU-funded project) are focused on the reduction of livestock diseases. Within the next few years, the combined impact of these two projects could be reflected in large increases in the numbers of livestock throughout the Lao PDR. If so, how will these animals be fed? In the uplands, the 'Fodder for Smallholders' Project is directed specifically at more innovative farmers who are feeding ruminants, mainly in Luang Prabang and Xieng Khouang Provinces (Horne). The prospects, nationally, of reduced mortality rates for livestock are that over-grazing by large livestock may become a serious risk in some areas and that the potential growth of pig and chicken production (with special benefit for poorer households) will be curtailed if feed supplies are inadequate. There will be exceptions, of course: in favourable situations, notably in many Hmong communities at higher elevations (for example, in Nong Het District visited by a group of Workshop participants) a maize-pig farming system is already well established. More widely in the uplands, there is much less opportunity for cereal grain production to feed pigs and chickens. A satisfactory low-cost alternative which Gibson (1997) has recommended in Bokeo Province, with enthusiastic responses by Lao Soung smallholders, is the preparation of high-protein meal for pigs and poultry, using legume grains such as pigeon pea (*Cajanus cajan*) and black bean (*Vigna unguiculata*), supplemented by high-protein leaf (cassava, leucaena and sweet potato leaves), tubers (cassava and sweet potato) and rice bran. Pigeon pea and black bean (a vine) are easily grown on fallows after rice.

Beyond the Lao PDR: Reports on Livestock in Upland Farming Systems

13. The need for more attention to forage crop production in upland farming systems, as outlined above, was a common strand in Workshop papers reporting experience from other Southeast Asian countries, as well as the Lao PDR. In their papers on northern Thailand (Carson, Cheva-Isarakul, Rerkasem), on Vietnam (Rambo and Cuc) and on Indonesia (Potter and Lee), the role of livestock in livestock-and-crop farming systems in the uplands was seen as being 'squeezed' by the expansion of food crops and forestry, by mechanisation following the advent of 'walking tractors' and by the effects of globalisation leading towards a reduction of smallholder production of pigs and chickens. Nonetheless, as Dr Suchint Simaraks concluded in his valuable overview of the role of animals in farming systems in Southeast Asia 'the key to sustainable upland farming is maintenance of soil fertility' and this is best achieved by the 'integration of crops and livestock where manure can be used in combination with nitrogen-fixing crops (which) can sustain soil fertility while at the same time the nitrogen-fixing crops contribute fodder for livestock'. Dr Simaraks' emphasis on fodder crop production as a key area for applied research in the uplands, both on-farm and off-farm, was made in the first session of the Vientiane Workshop. His recommendation was reinforced in subsequent discussions, in several other presentations by participants and by field observations of Workshop groups visiting Luang Prabang District (Luang Prabang Province), Poukout District and Nong Het District (both in Xieng Khouang Province).

14. Implicit in the Workshop's recognition of the importance of increased feed production was optimism concerning the long-term future of livestock production in the uplands, notably for beef cattle and to a lesser extent for pigs, goats and chickens. Buffalo are now seen as a gradually diminishing breed, being displaced by 'walking tractors' in the lowlands and to a small extent in the uplands. This trend was first evident in Thailand in the mid-1980s, in southwest Yunnan in the early 1990s (Chapman

1995) and in Laos since the mid-1990s. Apart from the region-wide decline in buffalo numbers, better control of livestock diseases is of course essential if significant increases in other livestock are to be achieved. In that case, however, there is no doubt about the strong demand now and in the foreseeable future for beef, pork, chicken and goat. This is reflected, in the Lao PDR, in the continuing stability (1994–1997) of farm-gate prices for cattle and buffalo, in US$ terms; it is evident again in the persistent strength of the Vientiane market for meat; and it is evident in recent efforts by Luang Prabang, Luang Namtha and other northern provinces to restrict the 'informal' export of cattle and buffalo (or meat) to Thailand and Yunnan, in order to ensure continued supplies for local consumption. Even more spectacularly, the region-wide demand is evident in Thailand's massive cattle imports (mostly illegal) from Myanmar, believed now to be in excess of 500 000 head annually; and evident again in the smaller, legal movements of cattle across the Myanmar-Yunnan border, to help supply towns in western and southwestern Yunnan, and Kunming.

15. Workshop participants from Laos and neighbouring countries recognised that upland farming systems have been changing throughout the region in the 1990s, more in some areas than in others, and in response to a range of causal factors. Dr Kanok Rerkasem's paper is particularly interesting in this regard, tracing the transformation of mountain land use in northern Thailand over the past 20 years as intensification (including intensification of livestock production) has proceeded. At the other end of the 'transformation spectrum', Ramsay and Maclean reported the 'pioneer' level of livestock production in Ratanakiri Province, Cambodia, where those animals which survive the high incidence of disease are often destined for sacrifice. The livestock components of different farming systems vary greatly, often between and within villages. In this context, there was keen interest at the Workshop in the individual project and research reports for different areas of the Lao PDR, from Bokeo Province (Stöber), Luang Namtha Province (McLaren), Luang Prabang Province (Fahrney et al.; Hansen; Sodarak et al.; Pravongviengkham), Xieng Khouang Province (Gibson) and Huaphan Province (Bott). These reports differed in their focus and scale, but taken with the reports from regions outside the Lao PDR they emphasised *how little is known in detail of farming systems in the uplands as a whole, and of changes taking place from Myanmar to Vietnam and from Yunnan to Cambodia. The Lao PDR is central to this broad region.*

16. Recognising the important role that the uplands are likely to play in future livestock production in the countries of Indochina, under increasingly more intensive farming systems, it seems timely to begin a *Farming Systems Database (FSD) and Mapping Program*, centred on the Lao PDR. The database might begin in the Lao PDR by collecting primary and secondary information on farming systems and then be expanded using Participatory Rapid Rural Appraisal (PRRA) methods. The relevance of the database to an expanded 'Fodder for Smallholders' project, for example, would be to indicate areas where farming systems are under greater or less pressure, together with information on population and ethnic groups, livestock numbers and ownership, the incidence of health problems (for human and animal populations), ranges of household incomes and the movements of both people and livestock. It would become a basic tool for planning purposes. If, on first consideration, this concept seems altogether too difficult to implement, it may be appropriate to examine the *Agricultural Systems-Land Management Project for Papua New Guinea (PNG)*, funded by ACIAR, carried out mainly by the Department of Human Geography at the Australian National University, and largely completed in the 1990s. The description and analysis of agricultural systems and agricultural intensification in PNG began in a modest fashion in the 1970s and 1980s. A less ambitious and less detailed project is currently being planned for Vanuatu (Dr Michael Bourke, pers. comm.). There are broad similarities between the Lao PDR and PNG in area, difficulty of terrain, population numbers, population growth, ethnic complexity etc. There are major differences also, not least in the greater importance of livestock in the uplands of the Lao PDR.

17. The early value of a *Farming Systems Database* prepared in the 5 years 2000–2004 for the Lao PDR is seen to be:

- As a planning tool, indicating where farming systems are under special pressure (areas where there are relatively few livestock, few households with livestock, high livestock mortality, low yields of upland rice, low median household incomes etc.);
- As an information source for Government authorities on the progress of land use intensification, so leading to the reduction of swidden (shifting) cultivation;
- As an information source for Government authorities on the geographic incidence of rural poverty, and so helping development planning at local and national levels.

Tasks Ahead for Intensifying Livestock Production in the Uplands of the Lao PDR

18. In the next few years, the effect of the hoped-for technical advances for livestock production in upland areas, namely increased disease control and the development of feed supplies, will be to offer many smallholders financial rewards and greater security for intensifying livestock production. But what hope is there for smallholders who do not have the capital to buy buffalo or cattle, or even goats, do not have surplus cereal grain to feed to pigs, are not familiar with the preparation of high-protein meal for feeding to pigs and poultry (as described above) and are long accustomed to their chickens dying from Newcastle Disease and other causes?

To cope with these problems, who will advise smallholders on their farming options and services (e.g., farm credit) that will be needed? Who will monitor over-grazing and soil erosion, when livestock numbers build up? Who will be alert to market opportunities, even in relatively remote locations? Who will have contact with providers of better quality livestock for breeding purposes and in all these respects provide links between village chiefs, local communities and district-level services. To meet these needs a small force of Farming Advisers (extension agents) should be recruited, trained and supported, to work closely at district level with provincial veterinary staff, local communities, village leaders and VVWs.

Priorities

19. The Workshop's sponsors asked for guidance as to priorities for livestock development in the uplands in the next 5–10 years. In the Workshop discussions and in field visits, there was no attempt by participants to develop a rank order of priorities, although the first and second below would probably have topped any list. Other proposals, for example, proposals for breed improvement of cattle and pigs in the provinces before the disease and feed problems have been greatly reduced, and using animals untried in Laos, would certainly have been questioned.

- **Improving animal health and survival.** Earlier paragraphs in this Summary noted the necessity for an effective disease-control program through the improvement of vaccination for buffalo, cattle, pigs, goats and poultry. It was noted also that the ACIAR-funded animal diseases project is establishing the systematic diagnosis of strains of Foot-and-Mouth Disease (FMD) and classical hog cholera (HC), nation-wide; and that the EU-funded project (1998–2004) promises to improve the delivery system for vaccines and to improve the training of VVWs, again nation-wide in Lao PDR.

  Even with these improvements, however, there will still be major gaps in knowledge. Workshop participants pointed out that relationships between animal nutrition and morbidity/mortality from major diseases need to be researched; that the benefits of non-fodder mineral supplements (e.g., sodium and phosphorus, as reported by Gibson from project experience in Xieng Khouang, in these Proceedings) need wider consideration; the vaccination of poultry against Newcastle Disease, using heat-stable vaccine, is seen to have immense potential; and smallholders need to be convinced of the benefits accruing from better management of livestock, including better housing (penning of pigs and goats) and drenching for buffalo, cattle, calves, pigs and poultry.
- **Improving feed production.** Workshop participants repeatedly emphasised the constraint on buffalo and cattle production from the seasonal decline of native pastures, and in this context applauded the work of the pilot-scale 'Fodder for Smallholders' Project (FSP) outlined by Horne (these Proceedings). The benefits of the FSP have initially been limited to ruminants, particularly buffalo and cattle, and to this extent may be seen as contributing to the continuing 'large livestock bias' in the development of livestock production in the Lao PDR. Some goat-raising smallholders are also benefiting from the FSP's encouragement of backyard forage production.

The apparent challenge for this project after 1999 (assuming its continuation by AusAID and/or other donors, in conjunction with DLF) is, firstly, its up-scaling to new localities in Luang Prabang, Xieng Khouang and Oudomxai Provinces, as proposed, and secondly, its greater project emphasis on feed supplies for small livestock, particularly goats, pigs and chickens.

- **Applied Research: alternative upland farming systems.** In discussions at the Workshop, it was recognised that in the 1990s the relatively attractive financial returns from buffalo and cattle have encouraged many smallholders to build up their small herds, using communal grazing-lands and often supplementary fodder production. On the other hand, there are now pressures for the de-stocking of cattle in some areas, because of damage to crops and because small livestock and other enterprises sometimes give higher financial returns on land, on labour and on the capital invested. The recommendation was made that in further on-farm agricultural research in the uplands (perhaps by DLF/ACIAR in conjunction with Lao-IRRI) attention should be given to intensive, diverse combinations of livestock with field crops, pastures, tree crops and forestry.

- **Applied Research: Managing fallows with livestock.** The upland agricultural systems of Laos will continue to involve combinations of livestock with crops (notably rice), and it is assumed that when fallows are re-cultivated the crops will benefit from the dung deposited in fields, or spread there by smallholders. Research personnel argued that too little is known about the synergism of cropping and livestock in the wet-and-dry tropics, particularly on the significance of dung to maintenance of levels of organic matter and consequent soil fertility. (See the quotation from Fahrney et al. at the heading of this summary). It was recognised that dung retrieval will be advanced at some cost in labour by rotational location of feeding pens and other aspects of livestock management (e.g., tethering). In this respect, there may be scope for modelling studies of alternative on-farm management strategies (Menz and Grist). In the context of fallow management also, investigations of suitable tree species providing both feed supplements and timber were warranted (Lowry) and tree-planting could also provide 'living fences' (Fahrney et al.).
- **Achieving and maintaining sustainability in upland agricultural systems.** In theory, smallholders who develop 'backyard' fodder production, including legumes to feed livestock, will be better placed to maintain the fertility of their fields when fallows are re-cultivated. As just noted, a critical factor also will be dung deposition and livestock management. But if the uncontrolled grazing of buffalo and cattle continues on communal grazing land, it is likely that over-grazing will become more evident. In both these respects — and others — an important responsibility of Farming Advisers working at village level should be to monitor land-use changes taking place as intensification proceeds, with particular concern for over-grazing, erosion risks, soil conservation and the long-term sustainability of the upland farm economy.
- **Farming Systems Database.** In Paragraph 16 above, commenting on the lack of a comprehensive body of relevant data on upland farming systems in the Lao PDR, the suggestion was made for setting up (under MAF?) a Farming Systems Database and Mapping Program, using existing primary and secondary data which would then be extended and brought up-to-date by reconnaissance surveys (Participatory Rapid Rural Appraisal) in the field.

References

In addition to references to papers included in the Workshop Proceedings (authors in brackets), the following have also been cited:

ACIAR Project ASI/1994/038. Improved diagnostic and control methodologies for two major livestock diseases in Lao PDR and Yunnan Province, PRC. Project Documentation ACIAR, Canberra. 65 p.

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European Communities, 1997. Strengthening of Livestock Services and Extension Activities (Financial Agreement between the European Communities and the Lao People's Democratic Republic) signed at Brussels, 13 October 1997.

Gibson, T. 1997. Consultancy report: Livestock and Veterinary Services. A report for the Rural Development Project (Lao-GTZ), Bokeo Province, Lao PDR. 91 p.

The World Bank, Agriculture and Environment Operations Division. 1995. Lao PDR. Agricultural sector memorandum: an agricultural sector strategy, Washington. 192 p.

Recommendations

The final session of the Workshop addressed recommendations drafted by a working group of participants. After discussion then and much more discussion subsequently, including consultations with the two sponsors of the Workshop (DLF and ACIAR), the following were seen to encompass key proposals:

1. Upland Development Strategy of the Lao PDR. *Discussions should be undertaken with the responsible Government authorities as to ways in which the Government's upland development strategy can be advanced, employing an area-based (or 'focal site') farming systems approach to guide research and development activities.* It is envisaged that expansion of the existing 'Fodder for Smallholders' project or any new projects should take closely into account the work of government agencies such as the Shifting Cultivation Program of the Ministry of Agriculture and Forests (MAF), other agencies and departments under MAF, the Lao Women's Union, and donor-funded projects notably Lao-IRRI, the ACIAR-funded 'Animal Health' project and the EU project for 'Strengthening of Livestock Services and Extension Activities'.

2. Intensification of Livestock Production. This Workshop noted that smallholders in some upland areas of the Lao PDR are already pursuing opportunities for the intensification of land use, for both subsistence production and to generate higher cash incomes. Livestock production is playing a major role which has good prospects of continuing. The immediate benefits are in higher cash incomes for better-off households owning buffalo, cattle and pigs. If the intensification of livestock production continues at a rapid pace, it has the potential to contribute significantly to major objectives of the Lao Government, notably the reduction of shifting cultivation and the alleviation of poverty in upland communities. The challenge to the MAF and DLF in the next decade, with donor support, is to implement widely at village level the opportunities which are now emerging for more effective control of major livestock diseases in buffalo, cattle, goats, pigs and chickens, together with opportunities for expanded feed production.

Recommendation: That the government authorities of the Lao PDR (particularly MAF and DLF), recognising the prospects for significant expansion of livestock production following early improvements in disease control and feed production, should now plan a wider program for the intensification of smallholder livestock production in the uplands, beginning in 2000–2004 in 3–4 provinces where changes are already taking place or there are special opportunities (e.g., Luang Prabang, Oudomxai, Xieng Khouang and Bokeo or Luang Namtha) and invite the support of foreign donors for its implementation.

3. Farming Advisers. If the intensification of livestock production in the uplands of Lao PDR is to be achieved, in the first instance through the combination of an effective disease-control program and an effective feed production program, it will require a major 'extension' effort at province, district and community levels. The strengthening of vaccine delivery services to villages through VVWs (according to the EU-funded project) is essential, but by itself it will not be enough. Much more will be needed, if smallholders are to receive practical and continuing advice on a range of matters such as alternative approaches to feed production for pigs and chickens, suitable grass and legume species for 'cut-and-carry' feed production, alternative fallow management systems involving livestock, pasture species, shrubs and trees, and a range of other important matters such as advice on credit facilities and animal banks.

Recommendation: It is recommended that the formation and training of a team of Farming Advisers (extension officers) be considered by MAF and DLF, to work in conjunction with provincial staff and VVWs. Farming Advisers will also have an important role in monitoring the sustainability of upland production.

4. Applied Research: In discussions during the Workshop (reported in Paragraph 19 of the preceding Summary), a number of problems for research were identified which have critical effects on the existing levels of livestock production and on the transition from swidden cultivation in the uplands:

- ***Environmental constraints.*** Workshop participants emphasised that the relationships between seasonal aspects of animal nutrition and morbidity/mortality from major diseases need to be thoroughly investigated; and that the benefits of non-fodder mineral supplements (e.g., sodium and phosphorus, as reported by Gibson) deserve wider consideration;
- ***Alternative upland farming systems.*** The focus of this Workshop was on 'problems and opportunities for livestock' to the extent that they affect the

intensification of land use and so affect the shift from swidden cultivation towards permanent farming systems. It was argued that there was need for more research into crop combinations, crop-livestock combinations, crop-livestock-forestry combinations etc., in which livestock might play an ancillary, but critical role;

- ***Managing fallows with livestock.*** In different presentations (e.g., Simaraks; Fahrney et al.) and a number of discussions, Workshop participants emphasised the importance of future on-farm investigations into the synergism of cropping and livestock in the wet-and-dry tropical environment (see particularly under Paragraph 19).

Recommendation: That in any future Review and Planning Mission which ACIAR and AusAID may consider appropriate to conduct, jointly with DLF, other elements of MAF and with other possible donors in the livestock sector, consideration be given to these and other research investigations where the outcomes promise to be significant for the intensification of land-use and the reduction of smallholder poverty in the uplands.

5. Farming Systems Database (FSD) Program. The value of a Farming Systems Database (with maps) for upland areas in individual provinces in the Lao PDR, later to be extended to include upland areas in northern Thailand, Vietnam and Cambodia, has been discussed under Paragraphs 16 and 17 above. It is envisaged that compilation of the database from primary and secondary sources, supplemented by field reconnaissance surveys, might begin in the Lao PDR in the period 2000–2004 and be extended as a co-operative task involving professional colleagues in other countries of the Greater Mekong Sub-Region (GMS).

Recommendation: That the establishment of a Farming Systems Database Program be discussed with the MAF and DLF authorities most likely to be involved in the core area of this undertaking, with ACIAR as a possible donor and with possible Australia-based executing agents. At an appropriate time, discussions should then follow with authorities in the other five GMS countries (Thailand, Vietnam, Cambodia, Myanmar and Yunnan Province, PRC).

6. Timing and Scope of a Subsequent Workshop. Participants at the Vientiane Workshop expressed warm appreciation of the hospitality and enterprise of the organisers of this meeting, including the efforts made to make the field visits so successful. The many participants from particular projects in the Lao PDR and neighbouring countries (Thailand, Vietnam, Malaysia and Cambodia) welcomed the possibility of a further Workshop and suggested that the meeting might be scheduled for early in the Year 2000. It was suggested that objectives might then be narrower than for the 1997 Vientiane Workshop. In particular, the next Workshop might focus on:

- exchange of information between project personnel and research staff on the on-going intensification of livestock production, particularly concerning feed production (related to Recommendation 2 above);
- a review of the progress being made at province, district and community level in the program for control of livestock diseases, and of plans for its further development;
- how a planned progam of applied research, on-farm and off-farm, would be developed (Recommendation 4 above); and
- a review of plans for the Farming Systems Database Program.

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Acknowledgment

In concluding this volume it is appropriate for us to acknowledge the generous support provided by ACIAR for the funding of the Vientiane Workshop and publication of these conference papers. Many participants were also assisted by supplementary funding from different sources. In this context one editor (E.C. Chapman) wishes to acknowledge supplementary assistance provided by a large grant project of the Australian Research Council (1995–97), concerned with trans-Mekong development. Beyond financial assistance however, the success of the Workshop and the publication of this volume reflect the vision, support and patience of the co-Chairmen, Director-General Singkham Phonvisay (DLF) and Dr John Copland (ACIAR).

The Editors

Appendix

ACIAR Project ASI/1994/038

Improved Diagnostic and Control Methodologies for Two Major Livestock Diseases in Lao PDR and Yunnan Province, PRC

Harvey Westbury and Stuart Blacksell[1]

AN animal health laboratory able to undertake modern diagnostic and surveillance techniques for foot and mouth disease (FMD) and classical swine fever (CSF), and potentially other diseases, was established in Vientiane in 1997. Technologies currently practised include direct detection of virus and antibody using the enzyme-linked immunoassay (ELISA) technique, virus isolation by cell culture and molecular epidemiology. A provincial diagnostic sample delivery network was developed progressively with 12 provinces participating. Those involved in 1997 and to mid-1998 are Phongsali, Bokeo, Xieng Khouang, Vientiane Province, Vientiane Municipality, Borikhamxai, Khammouan, Savannakhet, Saravan, Xekong, Attapu and Champasak. Planning to bring the remaining provinces into the sample delivery network is underway.

Diagnostic samples – tissues or blood – are collected in villages and farms and sent in special transport containers to the Vientiane laboratory through the post. More than 30 strains for CSF virus have been collected from throughout the country in this way and these are currently being characterised in Lao PDR and Australia. Some samples for FMD testing have also been received, though this will increase with the onset of the 1998 wet season, the customary peak season for FMD outbreaks.

A statistically valid survey of the prevalence of FMD was conducted in 1997–98 in Vientiane Municipality, Borikhamxai, Khammouan and Champasak with over 3000 sera collected from cattle, buffalo and pigs. The survey showed, not unexpectedly, that FMD is endemic, though there are differences between provinces in the main FMD virus serotype circulating at the time of the survey; and some provinces recorded a very low occurrence of FMD. A similar survey for the occurrence of CSF is being undertaken in 1998.

Project work in China has concentrated on establishing diagnostic technologies at the Yunnan Tropical and Sub-Tropical Animal Virus Disease Laboratory (YTSTAVDL) in Kunming, and on the training of staff at YTSTAVDL and the Yunnan General Veterinary Station (YGVS), Kunming in these technologies. Training sessions have been held at YTSTAVDL for FMD and CSF ELISA tests and four staff from YTSYAVDL and YGVS have visited the Vientiane laboratory for more prolonged training in laboratory practice and methodology.

Work in the next phase of the project in Yunnan Province, to the end of 1999, will concentrate on assessing the effectiveness of immunisation using the FMD vaccine produced at the Baoshan Vaccine Plant in Yunnan, diagnostic investigation of suspect outbreaks of CSF, analysis of CSF virus strains isolated in Yunnan and comparison of these strains with others obtained from the region.

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Lao People's Democratic Republic
Peace Independence Democracy Unity Prosperity

LaoBase Animal Health Information System

DISEASE REPORT FORM

Report date / /

Report Number (Lab use only)

Part 1: Submission Information

Location	Reason	Form completed by	Disease reported by
Village District Province Owner Name Address	❑ Disease Report ❑ Diagnostic ❑ Surveillance ❑ Export ❑ Accreditation ❑ Research ❑ Regulatory ❑ Disease Control ❑ Eradication	Name Address ❑ District Officer ❑ Provincial Officer ❑ Central Officer ❑ VVW ❑ Owner ❑ Other	Name ❑ District Officer ❑ Provincial Officer ❑ Central Officer ❑ VVW ❑ Owner ❑ Other
Previous report ID			

Part 2: Animal Information

Species	Sex	Number of Animals
❑ Cattle ❑ Buffalo ❑ Pig ❑ Chicken ❑ Goat ❑ Sheep ❑ Horse ❑ Shrimp ❑ Fish ❑ Dog ❑ Cat	❑ Male ❑ Female ❑ Castrated male ❑ Speyed female ❑ Mixed ❑ Unknown **Age** ❑ Days ❑ Weeks ❑ Months ❑ Years	Sick Dead Total in Village **History and clinical symptoms**

Part 3: Specimen information

Specimens No.	Lab tests
❑ Whole Blood ❑ Serum ❑ Faeces ❑ Fresh tissue ❑ Fixed tissue ❑ Swab	❑ Serology ❑ Bacteriology ❑ Histology ❑ Virology ❑ Parasitology ❑ Haematology

Laboratory use only

Test type	Test results	Pos	Neg	?

Final Diagnosis

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