The Amarasi Farming System, its Economic Aspects and the Adoption of Improved Cattle Feeding and Group Pen Systems

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EAST NUSA Tenggara (Nusa Tenggara Timur/NTT) Province is located in the eastern part of Indonesia (KTI). The climate is quite extreme with a pronounced long dry season (8–9 months) and having soil of neutral to high alkalinity. Uplift hill and mountain zones (Nulik et al. 1999), dominate the physiography of the region and thus there is a need for agricultural development to take into account soil and water conservation aspects. Nulik (1998) has described the detail characteristics of the region.

The Amarasi sub-district covers about 737.5 km^2 and is the fourth largest of the 17 sub-districts in Kupang on Timor Island of NTT Province. *Leucaena leucocephala* had been introduced into the area by the 1930s and in the 1970s most of the area was thickly covered with the legume (Nulik 1998; Nulik and Bamualim 1998). Since the introduction of a cattle fattening program by the Livestock Services in the 1970s, the area has been an important beef cattle producing area.

Cattle Husbandry in East Nusa Tenggara

NTT has been well known in Indonesia as an area for animal production, especially for beef cattle. The animal industry in NTT contributes about 11.4% to the gross regional income in general and about 21%–23% to the agricultural sector in the region. The largest contribution comes from cattle industries. However, cattle productivity in the region is still considered to be low. The problem is related to the traditional farming of cattle that relied much on the native grasslands with a free grazing system. As experienced in other semi-arid areas, the productivity of cattle raised under the system fluctuates greatly, depending on both forage production and nutritive value. On average, the native grasslands in the region would only be able to support 1.4 to 2.8 head of Bali cattle/ha/year (Nulik and Bamualim 1998).

Beef Cattle Husbandry in the Amarasi Farming System

Existing cattle husbandry

Starting in the 1970s with a scheme for intensification of cattle raising, the government of NTT, through the Livestock Services, promoted a program of cattle fattening in the Amarasi area. This was known as 'Panca Usaha Ternak Potong (PUTP)' or the Five Efforts in Beef Cattle Husbandry. The cattle raising system in Amarasi in general is in the form of cut-and-carry of forage for fattening.

In the fattening system, animals are tethered all the time in stalls or under very simple sheds and fed forages that consist mainly of *Leucaena. leucocephala* leaf. There are also some farmers who raise cattle for breeding. In this case, the animals are tethered in an area where forage is available and the animal will be moved two to three times a day to let it graze sufficiently, depending on forage availability.

Amarasi, however, is currently well known as a transit area for animals in Timor, before being marketted. Usually, farmers in Amarasi buy steers from other places outside the area to fatten for about 6 to 12 months, before selling at the market. In general, one family at Amarasi fatten 2–3 steers or more in a year.

Cattle husbandry in the area is still considered to be an important extra activity to obtain relative large amounts of cash. The money would pay for certain purposes such as to buy material for house building, to pay for children to go to school, and other needs such as parties and traditional ceremonies. In this case, cattle husbandry may contribute 40% to 70% to the large cash needed.

Forage potential and the existing farming system

From the 1930s to the 1970s, most of the Amarasi area became thickly covered by the small variety of

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L. leucocephala, before farmers started to replace it with the giant variety in the 1970s (Nulik 1988; Nulik and Bamualim 1998).

Following experience with the psyllid (*Heteropsylla cubana*) outbreak in 1986, farmers are currently planting other legume species such as *Sesbania grandiflora* and *Gliricidia sepium*. Although *G. sepium* has been grown in many places within the region, especially as live fencing, it has not yet been utilised very much as fodder. The lack of *G. sepium* usage is related to the belief of farmers that the forage is not palatable to the animal, although in practice free-grazing animals browse on the legume when native grasses start to die off during the dry season. There are, however, some farmers in the area who say they utilise *G. sepium* as a forage, mixing it with other tree leaves.

Currently, the rate of the psyllid attack seems to be significantly reduced, probably as a result of the spreading of biological predators following the outbreak. Early in the development of leucaena in the local farming system, it was planted in rows 2–3 m apart. However, as the management of the row was not properly carried out, the species spread throughout the farmers' lands. The stands of leucaena were then slashed and burnt before dryland food crops were planted. This land is normally be cultivated for 2–3 years, after a which the land is fallowed to let the leucaena cover the area again.

The fallow periods in the early practice was around 5–6 years. Currently, however, with the increasing population and as the land become scarce, the fallow period is reduced and in many instances the lands continue to be cultivated each year. The result is that the leucaena becomes sparse and allows weeds to invade the dryland cropping area formerly covered by leucaena. Thus, one may expect that there could be increasing risk of soil erosion problems, especially on the sloping lands.

The use of leucaena in the area can be considered to be suitable for the slash-and-burn farming system practised as the leucaena contributes to weed control, which is the greatest problem encountered in the dryland farming system in NTT. Besides that, leucaena can be considered as a nutrient pumping tool to extract leached nutrients from the lower soil layers on to the surface to be used by other crops.

However, there is an urgent need to make the farmers aware of the danger of the leucaena disappearing when the lands are cropped each year. It is important, therefore, to get the farmers to spread the seeds of leucaena during the growing season to ensure the best cover of the land after harvesting the dryland food crops.

During the rainy season, native grasses such as *Sorghum nitidum*, annual *Pennisetum* sp., and various other native species (such as *Heteropogon contortus* and *Bothriochloa* sp.) contribute an important part of cattle rations in Amarasi. The grasses can be found under the legume trees in the farmers' forage gardens (1 to 2 ha/household), along roadside and in the communal natural grasslands, outside the villages. There are also some farmers who plant king grass (*Pennisetum purpureum* × *P. glaucum*) or elephant grass (*P. purpureum*).

During the dry season, little forage is available. During this time, *L. leucocephala* trees may lose their leaves, especially if trees are allowed to grow with infrequent cutting. *G. sepium* trees lose their leaves in the dry season and produce seed. Although *S. grandiflora* is still green during this time the production is not abundant.

During the dry season, farmers in Amarasi also rely on the use of large tree leaves, both from leguminous and non-leguminous trees. The well-known native species of large tree legume used in the region is *Acacia leucophloea*. Surprisingly, the tree produces new green leaves at the peak of the dry season (September–October) when most other trees have lost their leaves and native grassland has hayed off and fires are frequent. Forage is also obtained from large non-leguminous trees such as from *Ficus* spp. and *Macaranga tanarius*.

Existing Feed and Feeding System and the Adoption of Improved Feeding System

After the arrival of the psyllid, farmers had to rely on various sources of forage in addition to the existing leucaena. Soon after the early arrival of the psyllid, it was recorded (Sudjana and Talib 1989) that farmers in the area used forage from various sources such as: *L. leucocephala* (54%), native grasses (17%), *S. grandiflora* (10%), legume straw (8%), leaf of banana (5%), corn straw (2%), rice straw (8%), cassava leaf (1%) and leaf of sweet potato (0.4%). More recently it was recorded (Keban et al. 1999) that forage sources included: *Sesbania grandiflora* (turi), *Ceiba petandra* (kapuk), leaf and stem of. banana/ *Musa paradisiaca* (pisang), *Hibiscus rosa-sinensis* (kembang sepatu), the leaf of *Ziziphus mauritiana* (bidara), the leaf of Ficus spp. (beringin), *Mutingia calabura* (kersen) and native annual grasses such as *Sorghum nitidum* and *Pennisetum* sp. There are some farmers who grow and use introduced grasses such as *Pennisetum purpureum* (rumput gajah) and king grass (rumput raja). Recent observations indicate that the condition of the leucaena has significantly improved and that during the rainy season, when forage is abundant, leucaena comprises the dominant part of livestock feed.

In the Amarasi, fattening system the average daily weight gain normally ranges from 0.2 to 0.4 kg/hd/day. Farmers usually need 12–14 months for fattening the cattle before being sold at the market. However, the fattening program introduced by the Research Institute of BPTP (The Assessment Institute for Agricultural Technologies), Naibonat, can obtain 0.5 to 0.8 kg/hd/day, and cattle may be ready to market in only 3 to 4 months. The ration recommended by BPTP consisted of 60% grasses, 40% legumes and mineral block (formulated by BPTP) and a digestion bacterial starter called 'Starbio' (20 g/hd/day) added to the animals' drinking water. The mineral is served in the form of block of 10 cm × 10 cm × 10 cm. The formula of the mineral block consists of: triple superphosphate (TSP) 1.5 kg (15%), urea 1.7 kg (17%), ammonium sulphate 1.5 kg (15%), cement 0.3 kg (3%), lime 1 kg (10%), salt 3.7 kg (37%) and tapioca 0.3 kg (3%). It was observed that an animal would consume around 4–5 g mineral block/day. The starbio can be obtained commercially in the market.

Farmers normally fatten their cattle in an individual pen system. In the fattening program introduced by BPTP, the farmers are grouped and introduced to a pen-group system. By the grouping arrangement, where the monitoring of the body weight gain is done every 2 weeks by weighing their cattle, farmers are motivated to feed their cattle in a better way in order to obtain a higher body weight gain in the next weighing period, to compete with other farmers in the group. Thus, it is inducing a positive competition between the farmers in the group. The grouping of farmers has also strengthened the bargaining position of the farmers against animal traders.

BPTP is also involved in the marketing aspects of the fattened cattle. In this case, BPTP is responsible for finding investors to buy the cattle from the farmers at a fair price. BPTP also conducts extension activities to enable the farmers to obtain capital, such as to obtain credit from local banks and share arrangements with local traders. All of these are done to ensure that the farmers get their fair share of the profit. As a result, farmers in the area are becoming more aware of the economic aspects in the fattening activities, including the value of forage as an input.

In the three villages in Amarasi where BPTP has been introducing the innovative feeding system, farmers have become more aware of the benefit of better feeding and the cost in terms of labour of collecting forage and tending the animals. The farmers have also adopted the use of mineral block and starbio. In many cases, it can be observed that at present farmers are buying the starbio of their own initiative.

Socio-economic aspects

The contribution of cattle husbandry to the income of the farmers varies depending on the.agroclimatic zone of the location. The drier the area (lack of water availability) the larger the contribution from the livestock sector. Sobang (1997), in his research in Kupang district, found that cattle husbandry contribute around 30%–70% to the farmers' income. The contribution is influenced by the number of stock owned, the type and the availability of forage and dry matter consumption. Furthermore, land tenure (the farmer being the owner or profit sharing) also determined the size of the contribution (Lole 1997). In this case the, type of profit sharing also determines the contribution to the farmer's income. In general, it was found that there are about three types of profit sharing for cattle fattening: (i) profit sharing with outside investor, (ii) profit sharing with local (Amarasi) investor, and (iii) profit sharing with government support. The different types of profit sharing were brought about by the different sources of steers obtained by the farmers for the fattening activities. There are also farmers who raise their own cattle, and these farmers obtain the highest income.

According to Keban et al. (1999), there are about five types of cattle raising farmers in Amarasi, i.e.:

(i) **Breeding program:** in many cases the cows belong to the farmer, who will receive the whole price when they are sold. If the cows belong to investors, profit-sharing will be as follows:
   - *The cow is sold because she was sterile (unproductive)*: In this case, the owner receives the initial price, while the farmer receives the whole margin (the selling price minus the initial price).
   - *The cow produces a calf and the calf is sold*: The owner then obtains 40% of the selling price, 40% goes to the farmer, 3% to the local government, 2% to the farmers group, 5% to APPKD and 6% to Livestock Services.

(ii) **Fattening cattle** (3 months): the owner receives the initial price plus 42% of the margin, the farmer receives 42% of the margin and the Livestock Services receives 16% of the margin price. If the cattle belonged to the farmer, he/she will receive the whole price (the initial price + the margin).

(iii) **Government support** for the under-developed village farmers (IDT) (12 months): farmers receive all of the gross margin, while the initial price is allocated to other farmers who have not received support before.

(iv) **Fattening where the steers are provided by investors outside the area** (12–14 months): In this case, the steers are provided by the investor and the farmers provide forage and simple pens. The profit sharing is as follows: the farmer receives Rp. 2000 (predetermined) for every kilogram of body weight gained. The investor receives the rest of the margin plus the initial price of the steers.

(v) **Steers provided by a local investor** (in the Amarasi area): in this case, the farmer is paid Rp. 100 000 to 150 000 for each steer raised when sold. Usually, the steer is fed for 12–14 months.

If the forage fed during the fattening period is counted as a cash input, the highest income is usually obtained from the type 1 (breeding) program, if the cows belong to the farmer. The second highest income is obtained from type 3 (government support type), followed by type 4 cattle raising. In type 5 enterprises, farmers experience a loss. However, as the forage was free of charge and collected by the labour in the family, farmers still practise type 5 fattening, benefiting from the relatively large amount of money received on sale of the steers.

All five types of cattle raising have been running well for quite a long time. This may be because farmers only conduct the activity as a sideline to obtain extra cash, while their main income comes from selling farm produces such as coconut, corn, cassava, bananas and other dryland crops. Thus, the smaller the income from the food crops, the higher the income derived from cattle husbandry activities.

Future Expectations

By the introduction of the ‘business fattening cattle program’, with its emphasis on improvement of feeding as well as economic aspects, farmers in the Amarasi area have been receiving better incomes from their cattle farming. However, there are still opportunities to improve the system. These include the introduction of psyllid-resistant *Leucaena* spp. with reasonable forage production, other important leguminous trees, such as *G. sepium*, and developing combinations of leguminous forages to obtain better digestion and body weight gain. Possible examples are the combination of leucaena leaf and leaf of calliandra, *G. sepium* or *Acacia leucophloea*. There is also a need to introduce more exotic annual and perennial species of grasses suited to dry climates, and to introduce techniques of forage cultivation to the farmers. It is also important to introduce effective methods of preserving excess forage produced during the rainy season for feeding during the dry season.

Continuing extension activities are required, especially to encourage and to train the farmers to make use of animal manure. There are opportunities to promote compost-making techniques and use of compost on crops as well as for marketing in the Kupang region. There is also a need to settle a fair profit-sharing model to help the livestock farmers obtain a better income as well as giving a fair return to the investors. This profit-sharing model could be issued as a written regulation and be reinforced by the local government.

Conclusions

- The use of leucaena is a normal practice in the cattle husbandry of Amarasi farmers, but there is a need to promote more diversity of tree legumes, to continue extension activities promoting better feeding techniques, to introduce other exotic grasses and their techniques of cultivation and use.
- Cattle husbandry provides relatively large sums of cash compared to other sources of income from the farming system, which are used to cover occasional needs of the farmers, such as to build a better house, to pay for the children to go to school and some ceremonial parties.
- Although there are variations in income obtained by livestock farmers under different types of profit-sharing, farmers have been raising and fattening cattle for quite a long time as they also earn money from selling other farm commodities, and forage is freely available.
- It is possible to shorten the period for cattle fattening needed by the farmers by provision of a properly balanced forage diet, additional minerals, a digestion bacterial starter as well as group pens. However, there is an urgent need to improve forage diversity, cultivation and feeding as well as the pen system practised by the farmers.
- When farmers themselves have experienced the benefit of the technologies, they will willingly adopt them, even if they have to pay extra for buying the starbio.
- To ensure the sustainability of the dryland farming in the Amarasi area by making use of the leucaena, there is an urgent need to encourage farmers to always keep their dryland copping area covered with the legume (i.e. by spreading the seeds of leucaena during the planting season to establish sufficient cover crops).
- There is a need to issue a written regulation by the local government concerning the profit-sharing model to ensure fair profit for the farmers.

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Growth Performance of *Arachis Pintoi* under Shade of a Dense Oil Palm Plantation

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THE POTENTIAL of livestock-tree integration production systems has been well documented and reviewed (Chen et al. 1991; Shelton and Stür 1991; Tajuddin and Chong 1994) in terms of land sustainability, security of income and environmental protection from land erosion and indiscriminate use of herbicides. The existing cover crops and legumes used in plantations do not persist well under grazing and increasing shade density. *Arachis pintoi* cv. Amarillo exhibited tolerance to heavy grazing and good compatibility with aggressive grasses of the genus *Brachiaria* (Grof 1985).

Further, grazing studies using oesophageal fistulated animals showed that *A. pintoi*, in association with several grasses, was selected in high proportions and that the legume contributed significantly to improving the quality of the diet selected (Lascano and Thomas 1988; Lascano 1994). Studies also confirmed that *A. pintoi* is a high-quality legume and that it is well consumed by previously adapted animals (Carula et al. 1991).

Materials and Methods

The experiment was carried out under 15-year old oil palms in the Experimental Farm of the Department of Veterinary Services at Padan Hijau, Johor, Malaysia. The experimental design was a simple complete randomised block with three replications. Plots measured 8.5 m × 32 m, each with a binary grass/legume mixture. The selected forages were *Paspalum notatum*, *Paspalum wettsteinii*, *Stenotaphrum secundatum*, *Panicum maximum* cv. Vencedor, *Dichanthium aristatum* cv. Floren, and *Paspalum atratum*. (The locally abundant weed species Asystasia intrusa was also included as a sown forage treatment but it rapidly spread and became dominant in the other treatments plots). The interrows of the oil palm were first disc ploughed and harrowed twice prior to establishment of the forages.

The *Arachis pintoi* cv. Amarillo and the selected grasses were initially planted in polybags using three cuttings/polybag. When they were successfully established, they were transplanted in the field at 50 cm spacing within rows and 1 m between rows in January 1997. Each row of *A. pintoi* alternated with a grass row. Every experimental interrow in the oil palm plantation alternated with an interrow used for placement of pruned palm fronds. The whole experimental area was fenced with cyclone fencing to keep out wild boars and other grazing animals.

A basal fertiliser comprising dolomite (1 tonne/ha), phosphorus (15 kg/ha as triple superphosphate) and potassium (30 kg/ha as muriate of potash was applied. The dolomite was applied more than a month before transplanting. The other fertilisers were applied after completion of transplanting. Maintenance fertilisers were applied at 50 kg/ha/year P, as triple superphosphate, and 100 kg/ha/year K, as muriate of potash, in three split applications.

Data collected were:

- dry matter yield and species composition of experimental area before planting in October 1996;
- plant survival one year after transplanting for each species;
- light transmission on 22 August 1997 and 9 June 1998, at distances of 1, 3, 5 and 8 m from the palm bole, using a light linear quantum sensor;
- dry matter yield at 2-monthly intervals. Three 1 m × 0.5 m quadrats were randomly harvested in each plot. Stoloniferous species were defoliated at 5 cm above ground level while erect species were defoliated at a height of 15 cm. The harvested materials were weighed and separated into *Asystasia intrusa* (a major shade-tolerant 'weed' under oil palm), *A. pintoi*, monocot species and

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other dicot species. Subsamples were dried overnight in an oven at 70ºC and weighed; dry matter yield and botanical composition were calculated;

- chemical composition of *A. pintoi* (AOAC 1984)
- nutritive quality of *A. pintoi* (Minson and Mcleod 1972);
- Acceptability of the forages to cattle, scored as the proportion of herbaceous vegetation left behind by cattle grazing for 2–3 days over the whole experimental area.

Data on dry matter yield and botanical composition of the forages were statistically analysed using the completely randomised block design.

Results and Discussion

Light transmission

The light transmission was low, <15% of full sunlight, with maximum light levels in the interrow (Table 1). This was expected, as the 15-year old oil palm canopy, being closed, intercepted most of the sun's radiation. The light profile of the plantation shade confirmed the earlier reports of light measurement undertaken by Chen et al. (1991). Unless alternative planting patterns of oil palms are adopted, low light will still limit forage growth, even with shade tolerance species.

Table 1. Light transmission (% of full sunlight) under a 15-year old oil palm plantation at Padang Hijau.

Distance from palm	Light transmission % (22/8/97)	Light transmission % (9/6/98)
1 m	10.6	6.7
3 m	8.4	14.6
5 m	10.0	14.5
7 m	12.4	13.6

Table 2. Dry matter yield (kg/ha) and botanical composition of ground vegetation under oil palm at Padang Hijau prior to commencement of experiment.

Species	DM yield (kg/ha)	Botanical composition
Clidemia hirta	606	53.6
Asystasia intrusa	212	18.8
Ottochloa nodosa	73	6.5
Axonopus compressus	73	6.6
Ferns	70	6.2
Others	63	5.5
Total	1130	100

Dry matter yield of the ground cover species before the experiment

Due to the low light transmission, standing dry matter yield of the ground vegetation prior to commencement of the experiment was about one tonne per ha (Table 2).

The species comprised mainly the unpalatable *Clidemia hirta* and the edible *Asystasia intrusa*.

Establishment of shade tolerant forages

Since all the shade tolerant grasses and legumes were planted from established cuttings in polybags, there was no constraint to the early establishment of the selected forages in the dense plantation shade. All mixture plots recorded over 90% survival of the planted grasses and legumes, including *A. pintoi*, but the growth of the planted forages was slow, due to the low light level. Commencement of the defoliation treatment was therefore delayed for six months. A uniform cut was imposed in 30 October 1997 prior to commencement of harvest at about 10 weekly cutting interval. The first harvest was initiated on 16 January 1998.

Yield and botanical composition of sown forages and other herbaceous vegetation

Total dry matter yield was 730 kg/ha at the first harvest, with *Arachis pintoi* and monocots being the most abundant species. Total dry matter yield increased in the second harvest and then declined to as low as 450 kg/ha of available dry matter for grazing. Due to the dense canopy cover of oil palms, sown grasses did not persist well and many of the species died out over the first three defoliation cycles. Planted grass species were therefore incorporated into the monocot weed component as shown in Figure 1.

Overall, dry matter production of the monocot species component generally declined significantly ($p<0.05$) to a low level. A similar trend was observed in dicot species (excluding the sown legume *A. pintoi*, and *A. intrusa*). These two species were selected for special consideration because of their major contribution to dry matter yield, as compared with the other dicot species. The only dicot species that established and persisted under defoliation and increased in density was the *A. pintoi*. Dry matter yield of *A. intrusa*, known for its shade tolerance, also declined with defoliation (Figure 1).

It appeared that, under the 2-monthly cutting interval, the shade-tolerant *A. intrusa* could not even sustain itself to remain productive. In contrast, the *A. pintoi* showed a slight increase in terms of dry matter production and botanical composition. This was probably attributable to its prostrate growth habit which enabled it to escape close defoliation. Such a characteristic had been highlighted as a positive mechanism for strong persistence in forages (Jones 1993).

The prostrate growth habit of *A. pintoi* had indirectly contributed to its persistence. It was

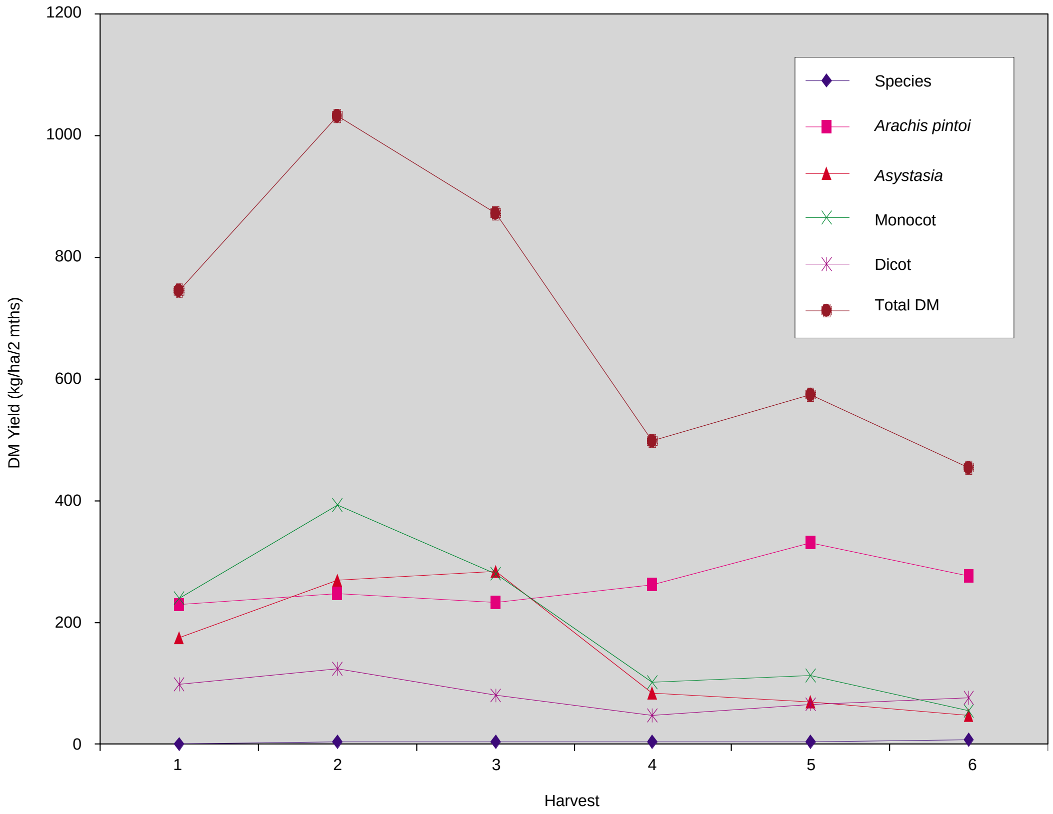

Figure 1. Dry matter yield of ground vegetation.

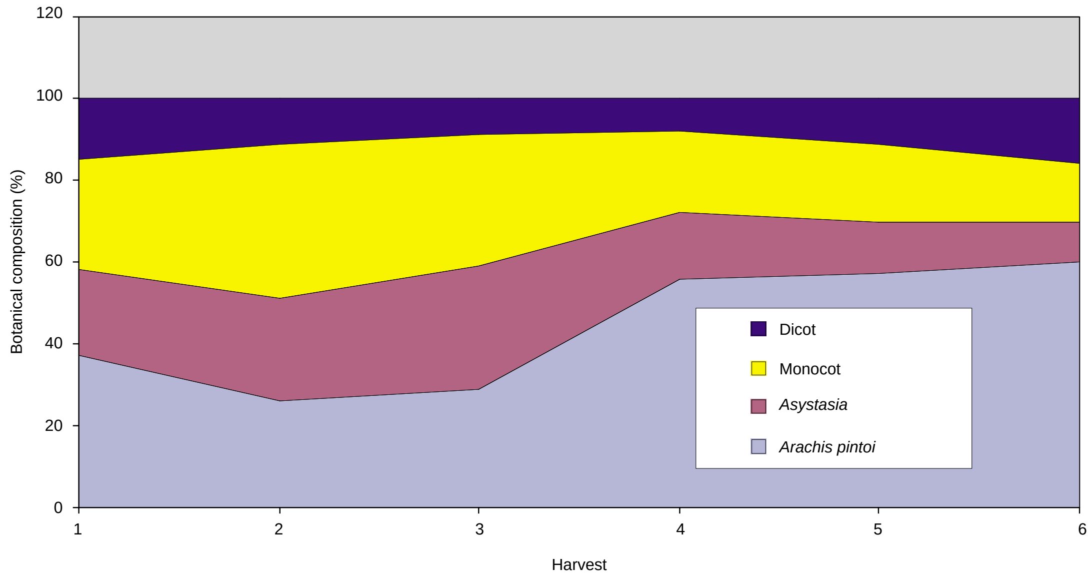

Figure 2. Botanical changes (as % DM) of ground cover species in oil palm plantation.

therefore not surprising to obtain from this experiment an increase in botanical composition of *A. pintoi* significantly ($p<0.05$) from 26% in harvest 2 to over 62% in the harvest 6 under the 2-monthly cutting interval system (Figure 2).

A. intrusa, which was considered a weed in oil palm plantations, increased slightly but subsequently declined significantly to as low as 11.3% in harvest 6. The sown grasses, which were selected for their shade tolerance, also declined over the six harvests in botanical composition. Other moncot species, like the native grasses, also declined with harvesting. On the other hand, dicot species, excluding *A. pintoi* and *A. intrusa*, and comprisng mainly unpalatable broad-leaved weeds, increased gradually from as low as 10% to as high as 18%.

The chemical composition and the in vitro dry matter digestibility (IVDMD%) of *A. pintoi* (combination of harvests 3 and 4 only) are presented in Table 3.

Table 3. Chemical composition (DM%) and in vitro DM digestibility of combined Arachis pintoi herbage from harvests and 4.

Composition	(%)
Crude protein	21.3
Ether extract	2.3
Crude fibre	23.9
Ash	13.5
Calcium	0.77
Nitrogen –free extract	39.0
ME (MJ/kg)	7.18
IVDMD	63

The crude protein and the overall IVDMD were relatively high and this indicated the suitability of the herbaceous vegetation in the oil palm plantation for ruminant production. Carulla et al. 1991) reported that the crude protein and IVDMD of *A. pintoi* leaves on offer were 18.4% and 61.2%, respectively.

In this experiment, the legume component increased over time but the sown grasses declined and died out in 2–3 grazing cycles. The quantity of grass on offer was low and so was that of *A. pintoi*, initially. Nevertheless, the proportion of *A. pintoi* in the forage on offer increased from 38% to 63% in the 6th harvest. The reduction of grasses was associated with heavy defoliation, especially during the dry periods. The proportion of senescent material was generally small.

Conclusions

The results obtained in this experiment confirmed the overall poor performance of shade tolerant grasses under dense plantation shade. In contrast, *A. pintoi* established slowly in dense shade, increasing as a proportion of forage on offer and also, albeit slightly, in terms of dry matter production. It was also found to have high crude protein and IVDMD percentage. However, its low dry matter productivity under dense shade could pose a constraint to provision of feed supply to grazing animals in mature oil palm plantations. In contrast, the dicot weed, *A. intrusa* established readily in dense shade but continual defoliation at the 2-monthly intervals was also detrimental to its persistence. The importance of proper management of the pasture for long term persistence of forages in mature plantations is emphasised.

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Direct Seeding for Leucaena Leaf Meal Production

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FORAGE legumes are an excellent source of protein for livestock. Mostly they are fed fresh as fodder or grazed, but can also be ensiled, made into hay, pellets, chaff, wafers or meal. The meal is often mixed with other feed ingredients to form a complete feed for livestock.

Leaf meal from leucaena (*Leucaena leucocephala*) is comparable to alfalfa forage, with crude protein content of about 27–34% and amino acids present in well-balanced proportions, much as in alfalfa (NAS 1977). Leucaena is also a rich source of carotene and vitamins (NAS 1977). Utilisation of leucaena is usually restricted due to the presence of mimosine, an uncommon amino acid which is toxic to non-ruminants.

In the diet of poultry, it is recommended that diets include only 2–5% of leucaena leaf meal, as higher levels have been proven to affect the growth of broiler chickens and reduce egg production (Yeong 1986).

For ruminants, it is recommended that diets with more than 30% leucaena should not be fed for prolonged periods. Dairy heifers fed with leucaena leaf meal at 35% level of the total diet suffered a 19% decline in live weight gain but increased milk yield (Gupta et al. 1992).

The leaf meal production program in Malaysia aims to produce leaf meal from leucaena with emphasis on productivity and quality, as affected by agronomic practices, mechanical harvesting and processing (Aminah et al. 1997). For leaf meal production, the harvested materials have to be dried in a drier for 10–15 hours at about 65°C or under the sun for the same duration to produce dried leaves green in colour. The meal produced has about 91% dry matter content.

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To obtain good establishment, leucaena is normally planted using seedlings raised in polythene bags and transplanted when the seedling reaches more than 15–30 cm in height. The plants raised in a nursery normally develop faster where moisture, nutrition and pests are controlled, but the operational cost is higher than direct-seeding.

Using transplants, there is a greater chance of obtaining higher field stands and uniformity in plant growth. The high cost of transplanting is inadvisable for large-scale planting. Effective large-scale leucaena establishment in Central Queensland, Australia, is achieved under a 5 point plan: clean fallow, good soil moisture profile up to 1 m prior to planting; quick effective germination within about 7 to 10 days; good insect control over emerging seedlings and good weed control until the leucaea is 2 m tall (Larsen 1998).

This paper discusses the potential of leaf meal production from leucaena and the possibility of establishing leucaena by direct seeding for leaf meal production in Malaysia.

Materials and Methods

Two lines of leucaena namely, 40-1-18 (line 1) and 62-6-8 (line 2) were used in the present studies, based on their superiority to the existing line ML1 (Wong et al. 1998).

Experiment 1

Prior to planting, basal fertiliser at 30 kg/ha P and 30 kg/ha K was applied. Seedlings of Lines 1 and 2 were planted at 50 cm intervals with six rows in one block. Blocks were spaced 250 cm apart for ease in plant harvest and maintenance. Maintenance fertiliser at 40 kg/ha P and 50 kg/ha K was applied annually in three split applications. One year after planting, the plants were cut back at 50 cm above the ground level and manually harvested at 12-weekly intervals and thereafter. Harvested material, including leaf and stem, was weighed and dried in a drier or under the sun before thrashing to separate the leaf and stem portion.

The fresh weight, dry matter yield of leaf and stems from two harvests were recorded. Fresh samples from random plants were taken for dry matter content.

Experiment 2

To support the leaf meal production program, an experiment was designed to determine the possibility of direct seeding leucaena.

Two treatments were imposed:

A) Seedbed covered with an impermeable plastic sheet which acts as a mulch, suppressing weeds and conserving moisture. The plastic sheet was laid down and holes made with a planting stick at appropriate distances apart. Two seeds were placed inside each hole; and

B) Seedbed without a plastic cover and hand-weeded when required.

Prior to planting, the area was ploughed, and basal fertiliser applied at the same rate as in Experiment 1. Seeds of a uniform size (Line 1) were scarified in hot water for 3 minutes and sown at a spacing of 50 cm × 50 cm, at the onset of the rainy season. Plant heights were measured 6-months after sowing. Twelve months after sowing, plant height was measured from ground level to the shoot tips, girth was measured at 50 cm above ground level and branching was scored on a 1 to 5 scale, with 5 the best.

One hundred plants were harvested from each treatment to obtain the dry matter yield and samples were taken for determination of dry matter content. The dried leaf and stem were weighed before milling, using a hammer mill to produce leaf meal.

Results and Discussion

Experiment 1

The mean fresh weight and mean leaf dry matter productivity of the two harvests for Line 1 was higher than Line 2 (Table 1). These results were comparable to dry matter productivity of leucaena lines ML 1 and ML 2 earlier reported with their respective leaf yield of 6 and 8 t/ha/year when harvested at 12-weekly intervals (Izham et al. 1983).

It is anticipated that higher yields could be obtained as plants grow older and branching increases. The mean dry matter contents for both lines were 40.6% and 38.4%, respectively. Line 2 had a higher yield of dried leaf per unit fresh harvested weight than Line 1, and a lower yield of dried stem (Table 1). This was associated with a higher leaf:stem ratio for Line 2.

Table 1. The fresh weight, dry matter productivity of leaf and stem and other agronomic parameters of two hybrid leucaena lines harvested at 12-weekly intervals (2 harvests).

Line	Harvest	Total fresh wt (t/ha)	Dry matter wt. of leaf (t/ha)	Dry matter wt. of stem (kg/ha)	DM % of Total	Leaf DM as % of total fresh wt	Stem DM as % of total fresh wt	Leaf:Stem ratio
1	H1	15.7	1.81	4.47	40	11.5	28.5	0.31:1
	H2	21.9	2.45	6.49	41	11.2	29.6	0.38:1
	Av	18.8	2.13	5.48	41	11.3	29.0	0.35:1
2	H1	13.8	1.84	3.37	39	13.3	24.5	0.55:1
	H2	20.5	2.25	5.01	38	11.0	24.5	0.54:1
	Av	17.1	2.04	4.19	38	12.2	24.5	0.55:1

Table 2. Plant height, girth, branching, DM% and dry weight after 12 months of establishment of leucaena with seedbed covered or not covered with a plastic sheet.

Treatment	6 months	12 months				
	Height (cm)	Height (cm)	Girth (cm)	Branches[1] (rating)	Dry wt/plant (kg)	Dry matter (%)
Covered	117.4	221.6	1.17	2.10	0.32	42.2
Not covered	107.9	247.4	1.48	2.20	0.36	42.0

[1] Score 1 to 5, with 5 being the best.

Further research could investigate opportunities for increasing proportion of the good quality leaf component as well as increasing leaf yield.

Experiment 2

For both treatments, the percentage of plant survival for 12 months was about 70%. Plants in the 'covered' treatment were taller than plants in the 'uncovered treatment six months after sowing, but shorter after 12 months (Table 2). The early benefit of the 'covered' treatment could have been due to conservation of moisture and nutrients under the plastic, as there were few weeds in either treatment.

The height obtained in this trial was much higher than ML 1 (50 cm) measured at 6 months after establishment when mulched with dried grass (Aminah and Mohd Najib 1984). This could be due to the presence of weeds that still managed to grow through the planting holes but were not removed.

The height attained at 12 months was comparable to the expected height of 1.5–2 m of 12–18 month old leucaena (Piggin et al. 1994). Stem girth, branching score and dry matter/plant also showed a small benefit of the 'uncovered' treatment.

It is possible that the poorer performance of the leucaena (after 12 months) when the seedbed was covered with plastic was due to heating of the soil and deficiency of water. This possibility is supported by the observation that some plants were seen to have been scorched shortly after emergence.

Conclusions

The results obtained show that both lines of leucaena could contribute to high dry matter yield for leaf meal production. For larger scale planting, leucaena could be direct seeded in weed-free cultivated areas. From the evidence presented in this paper, there appears to be little benefit in covering the seed bed with a plastic cover if weeding is a viable option.

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Selecting New Stylos for Anthracnose Resistance in Hainan, China

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THE genus *Stylosanthes* is the most important forage legume for South China and for all tropical regions in the world. It is a very important feed resource for livestock and is usually used either to improve natural pasture or as a component in fully-sown pastures; it is also used for producing leaf meal (Figure 1).

Utilisation of *Stylosanthes* (stylo) is now extending to interplanting under fruit trees (Figure 2), including coconut, lychee and rubber in Hainan, and growing on slopes to prevent water loss and soil erosion. In Hainan, some State Farms and companies return cropland to pasture to raise livestock, and some smallholders plant *Stylosanthes* for feeding chickens, ducks, pigs and other animals.

The most successful cultivar in Hainan, and elsewhere in the humid tropics, is *S. guianensis* CIAT 184 (‘Stylo 184’), which has been released in Hainan as cv. Reyan II Zhuhuacao. This cultivar is extremely productive in a wide range of conditions, and has shown good resistance to anthracnose in Hainan and elsewhere in Southeast Asia.

The anthracnose disease has had a devastating effect on various Stylosanthes cultivars elsewhere in the world, and ‘Stylo 184’ is known to be susceptible to strains of anthracnose occurring in South America. There is a danger that some time in the future, virulent strains of anthracnose may appear in southern China and attack ‘Stylo 184’. Selection of new stylos with anthracnose resistance and high yield is therefore a critical research objective.

In this paper, we describe an experiment aimed at identifying accessions of *S. guianensis* with high yield and anthracnose resistance.

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Materials and Methods

Accessions

In 1996, 34 accessions of *S. guianensis* from CIAT (Colombia and the Philippines) CSIRO (Australia) and EMBRAPA (Brazil) and CATAS (Hainan, China) were grown in small plots and visually rated for anthracnose damage, dry matter yield and seed production potential. Another set of accessions was grown by CIAT at Los Baños, the Philippines.

The best 11 accessions were selected for evaluation in larger plots at CATAS, Hainan, in comparison with ‘Stylo 184’ and the selection cv. Semilla Negra.

The experimental design was a randomised complete block experiment, with four replicates. Plots were 5 × 2 m, with plots 2 m apart. Forty plants were planted in each plot. Three replicates were harvested and used for measuring dry matter yield, and the other for making observations and collecting seed. Plots were cut at a height of 20–25 cm once in 1998 and three times in 1999, the last cut being August 1999. Harvested material was weighed fresh and sampled for measuring dry matter content.

For assessing anthracnose damage, we adopted the visual rating method developed by Chakraborty (1990), using a 0–9 severity scale:

0 no visible disease symptoms;
1 1–3% tissue necrotic;
2 4–6% tissue necrotic;
3 7–12% tissue necrotic;
4 13–25% tissue necrotic;
5 26–50% tissue necrotic;
6 51–75% tissue necrotic;
7 76–87% tissue necrotic;
8 88–94% tissue necrotic;
9 95–100% tissue necrotic.

The first observations were made five weeks after sowing and observations were continued at three weekly intervals. A total of 16 observations were made during 1998 and 1999.

Figure 1. Harvested *S. guianensis* ‘Stylo 184’ is harvested for leaf meal production in Hainan.

Figure 2. *S. guianensis* ‘Stylo 184’ grown as a groundcover and for feed in a lychee orchard.

For assessing insect damage, we adopted the following visual scale:

0 no damage;
1 some plants damaged by insects;
2 many plants damaged by insects;

The first observations were made three weeks after sowing in the nursery, and thereafter at three weekly intervals. The type of insect causing damage was also noted.

Soils and climate

The soil at the experimental site is lateritic, and is moderately acidic. Soil phosphorus levels are low (Table 1).

Table 1. Soil characteristics at the experimental site.

Depth	Total N (%)	Organic matter (%)	Available P (mg/kg)	Available K (mg/kg)	pH (H_2O)
0–20	0.07	1.01	0.9	31.5	5.8
21–40	0.05	0.67	0.5	20.0	6.0

Mean monthly temperature and rainfall during the period of the experiment are shown in Table 2. The dry season occurs during the cooler months, extending from December to April. Mean temperature and total rainfall during 1998 were 24.7°C and 1394.3 mm, respectively. Extreme maximum (April 1998) and minimum (January 1999) temperatures were 39.4°C and 9.3°C respectively.

Results

Four accessions had herbage yield which did not differ significantly from that of 'Stylo 184' — GC 1517, 1579, 1480 and 1463 (Table 3). Seed yield and flowering data indicated that these were later flowering than 'Stylo 184' but, in Hainan, they produced higher seed yields.

Although there were significant differences in mean anthracnose score (Table 3), all accessions were affected by anthracnose to a greater or lesser extent. Five accessions had an anthracnose score which did not differ significantly from that of 'Stylo 184'. They also had low mean scores for anthracnose damage (<2.5) and (excluding cv, Semilla Negra) maximum anthracnose scores not exceeding 5.

There was a close negative correlation between total dry matter yield and anthracnose score

Table 2. Mean monthly temperature and rainfall during the experiment.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Temperature (ºC)						
1998	19.0	20.1	24.3	26.8	27.3	29.8	29.2	28.1	26.1	24.6	22.3	18.8
1999	17.6	20.1	23.0	25.5	26.0	27.9	28.4	26.6				
						Rainfall (mm)						
1998	10.5	18.7	8.4	56.5	263.5	101.7	102.6	169.7	393.7	186.1	36.3	50.3
1999	38.9	3.6	17.1	157.6	436.5	406.5	273.9	263.4				

Table 3. Dry matter yield, anthracnose score, seed production and flowering of accessions of *S. guianensis* in Hainan, ranked according to mean anthracnose score.

Accession/cv.	Dry matter yield (tonnes/ha)	Anthracnose score		Flowering date	Seed yield (kg/ha)
		Mean	Maximum		
'STYLO 184'	5.84a[1]	2.10a	4	6/11	30
GC 1517	5.82a	2.15a	5	25/11	154
GC 1579	5.92a	2.23a	5	25/11	70
cv. Semilla Negra	4.48bcd	2.33ab	6	13/10	58
GC 1480	5.39ab	2.50ab	5	25/11	119
GC 1463	5.50ab	2.50ab	5	25/11	143
GC 1576	4.63bc	2.72b	6	15/11	169
GC 1528	3.50def	3.20c	7	25/11	140
FM 7–2	3.95cde	3.23c	6	13/10	89
GC 1524	3.62cde	3.33c	6	15/11	64
FM 7–3	3.27ef	3.43c	7	25/11	21
GC 1557	2.39fg	4.13d	7	6/11	130
GC 348	1.86g	4.97e	8	25/11	26

[1]values within columns followed by the same letter do not differ significantly (P>0.05)

($r^2 = 0.91$), and the four high-yielding accessions also had low mean anthracnose scores.

Most accessions in the trial were damaged to a greater or lesser extent by insects. During the wet season, and when temperatures were high, grasshoppers caused the most damage. At seed maturity, and when temperatures were lower, army worms damaged stylo inflorescences.

All accessions flowered and set seed normally. Six accessions had a seed yield exceeding 100 kg/ha, compared to 'Stylo 184' with 30 kg/ha.

Discussion

This is the first report of *S. guianensis* accessions with comparable dry matter yield and seed production to that of 'Stylo 184'. Although the accessions GC 1517 and 1579 are showing signs of anthracnose infection in Hainan, with 'Stylo 184' they had the lowest levels of infection; also, they are both known to have a high resistance to strains of anthracnose in South America. However, they are somewhat later flowering than 'Stylo 184' which may limit seed production in some Southeast Asian environments.

There is a need to extend the findings from this trial, to test the best accessions in a wider range of environments to provide further information on adaptation, dry matter yield potential, seed production and resistance to anthracnose.

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Integration of Adapted Forages on Farms in Southeast Asia – Experiences from the Forages For Smallholders Project

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Abstract

This paper presents the experiences of the Forages for Smallholders Project (FSP) in developing forage technologies with smallholder farmers in Southeast Asia. The work was done at 19 sites in four countries (Indonesia, Philippines, Laos and Vietnam), and revealed that technology development is a learning process for both farmers and development workers. Farmers started by identifying problems that they could address by planting forages. Then they planted different forage varieties in small areas near their houses to observe their growth and selected those that were adapted to their conditions. Their next consideration was the benefits they could obtain from the forages. When convinced of the benefits, they started to think about how to integrate the varieties in their farming systems. Farmers learned new ways of using the forages, developing more complex innovations as they gained experience with forages. With time, their preferences for forage varieties and characteristics changed. Farmers must be provided with a broad range of forage varieties and information on ways of growing, managing and using forages on farms right from the start. It is also important to look for entry points for forages that yield immediate impact and encourage farmers to develop innovative forage systems.

GROWING planted forages is a new concept for smallholder farmers in Southeast Asia. Traditionally, feed resources for ruminant livestock have been freely available and could be obtained easily from native vegetation. Introducing forages into smallholder systems is therefore different from introducing new rice varieties since farmers already grow rice and appreciate the value of 'superior' varieties.

The Forages for Smallholders Project (FSP) is developing forage technologies with smallholder farmers in Southeast Asia. The Project uses a participatory approach, which involves farmers in all aspects of the forage technology development process. This paper summarises our experiences of working with smallholder farmers to develop forage technologies for their resource-poor upland systems.

On-farm Sites of the FSP

The smallholder farms included in the Project were located in different farming systems ranging from extensive shifting cultivation areas to intensively cropped upland areas (Table 1). All farmers were resource-poor and dependent on family labour.

As work at each site progressed, it was realised that every farming system was immensely diverse, both between and within farms. For instance, at some sites, farmers had access to small areas of intensively cultivated lowland and a larger area of upland. Other farms in the same area only had access to upland areas. Similarly, access to communal grazing areas differed depending on location and traditional rights.

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Table 1. FSP on-farm sites.

Farming systems	Country			
	Indonesia	Philippines	Lao PDR	Vietnam
Short-duration slash and burn			3	
Grassland	2			1
Extensive upland	2	1		
Moderately intensive upland	1	3		1
Intensive upland	1	1		1
Rain-fed lowland	1	1		

Farmers located in vast expanses of grasslands or extensive coconut-growing areas used these for grazing but their main farm activity was concentrated in small areas of intensively-cultivated crops and fruit trees near their houses.

Problem Identification

One of the first activities in the forage technology development process was the identification of farmers' problems (Tuhulele et al. 2000). This enabled the farmers to identify their problems that could be addressed by forages. General feed shortage was a major problem identified in most sites (Table 2). At five sites, farmers considered feed insufficiency during the cropping season to be a major problem, equivalent to that of dry season feed insufficiency. Only at a few sites did farmers consider the planting of forage as a solution to resource management, for example, for controlling soil erosion, or suppressing weeds. In most cases, farmers saw forages primarily as a solution to animal feeding problems.

Table 2. Problems identified by farmers that could be addressed with forages.

Major problems	Number of sites
General feed shortage	8
Dry season feed shortage	5
Feed shortage during the cropping season	5
Poor feed quality	5
High demand for time and labor to feed animals	5
Grazing animals destroying crops or getting lost	4
Lack of grazing area	3
Weed invasion of cropping areas	3
Erosion of soils	3
Poor animal performance	1

The problems identified reflect the awareness of the farmers on how the forages could help solve their farm problems. They also reflect the situation of the farmers in the different sites.

A very important contribution of participatory diagnosis was that it served as a starting point in working with farmers in a participatory mode. Also, recognition of problems that can be addressed by planting forages was an important step for farmers to get interested in developing forage technologies.

Offering forage options

Before discussions were held with farmers, a range of forage grasses and legumes broadly adapted to the climate and soils of the region had been identified (Stür et al. 2000). After learning the farmers' problems, the issue of what varieties can be tested and how these could fit into the existing farming system was tackled. Deciding on the different options of how the varieties could be integrated on farms was done in discussion with farmers. This involved asking their ideas and discussing how forages had been integrated in other similar farming systems.

Deciding on what particular varieties could be tried was easier in cases where there was a nearby forage evaluation area. Farmers visited the evaluation site to see and select the varieties to try by themselves. In cases where there was no nearby forage evaluation site and farmers were not familiar with forages, choice of variety was based on the knowledge of the development worker.

It was initially thought that specific forage varieties or systems for integrating forages into the farm could be offered. However, it was later realised that each farm was different (in terms of resources and farmer's preferences) and required different forage options. Moreover, we found that our ideas about which forage options would be appropriate for each farming system differed from what farmers adopted (Table 3). The major reason for this was the complexity of factors governing farmers' decisions. These include land tenure, security, labour availability, importance of livestock and also farmers' prior experience with feeding animals and preferences. It was therefore not possible to 'photocopy' forage technology from one place to another.

We also learned that there was a need to keep the suite of varieties offered broad. Farmers often did not find difficulty in evaluating 5–8 forage varieties. However, we also found it to be important to offer farmers the best variety, not just any variety of a species. In one of the sites, farmers complained bitterly when they were given common Centrosema pubescens to try. Some of them had already tested the superior variety 'Barinas' (CIAT 15160), and were concerned when they were supplied with an 'inferior' variety.

In the course of time, the importance of active interaction and exchange of ideas with and between farmers about the different ways/options of integrating forages in the farms was realised. There were always some farmers who had tried a different way of growing and managing forages. Enabling them to share these ideas helped a lot in developing and spreading new forage options to other farmers. These interactions also served as a venue for encouraging other farmers to innovate themselves.

Process of integrating forages on farms

The rate of adoption of forage species and ways of using them varied between sites (Figure 1). This reflected the variation in the complexity of factors and opportunities affecting farmers' decisions with time. For instance, at one site, farmers found that Brachiaria humidicola was growing very well in areas that were not useful for crops because of the very low soil fertility. This provided them with an opportunity to utilise the poor soil areas more productively by establishing forages for livestock production.

Conversely, there were sites where there was very little opportunity for adopting forages. In these cases, very little or no forage adoption occurred. In all sites, farmers usually started testing a range of varieties in small areas. From there, they chose a lesser number of varieties to expand gradually. In this process, the farmers usually based their initial choice on adapted varieties (i.e. those that were growing well). They then started thinking of the benefits that they could gain from the variety, and started to try out ways of integrating the varieties in their farms.

Figure 2. Smallholder farmers mostly used planted forages to supplement other sources of feed.

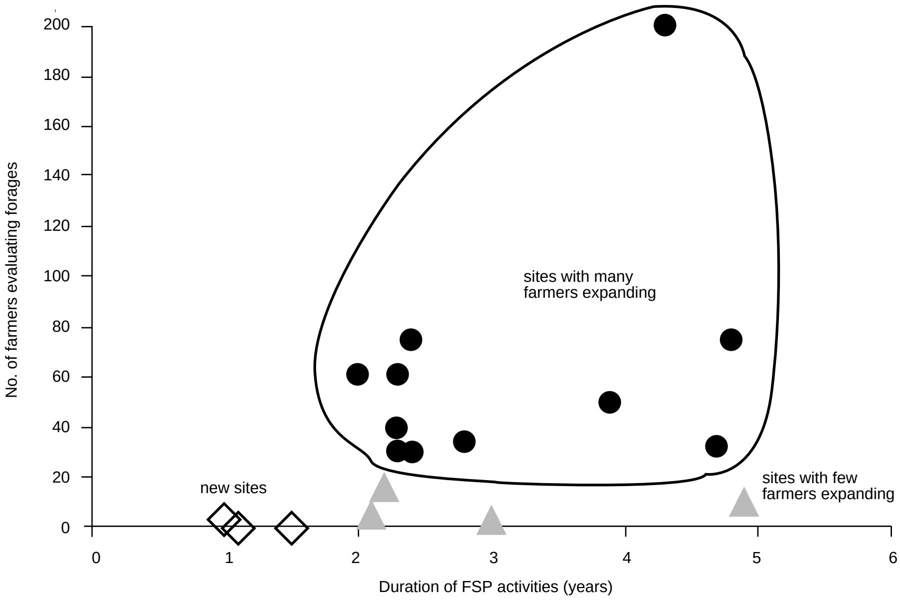

Figure 1. Rate of adoption of forage species at different sites.

Although the entry point was the need for feed, farmers used the planted forages as a supplement to the existing feed resources rather than as a substitute (Figure 2). Moreover, most farmers expanding their forage area did not do so by replacing their crop area but found other ways of fitting forages into their farms.

Among the forage types, the trend was that grasses were expanded and spread fastest. The herbaceous legumes were next while trees tended to be expanded and spread at the slowest pace. A major reason for this was the fact that grasses could be propagated vegetatively whereas herbaceous and shrub legumes mostly had to be propagated from seed. Vegetative propagation allowed the farmers to propagate grasses almost any time of the growing season and when convenient. In the case of forages propagated by seed, farmers were dependent on seed availability which was generally seasonal, and they had to sow early in the growing season.

Another reason was the fast establishment and growth of vegetatively propagated grasses, which provided more immediate impact than slower establishing legumes and trees. The value of herbaceous legumes was usually appreciated only after at least one year. Herbaceous legumes tended to establish more slowly and their performance only showed in the dry season, when they were more palatable and greener than grasses. Trees had the longest establishment period in addition to taking a long time to produce seed.

Another trend was the development of systems for using the forages. At all sites where farmers were expanding their forage areas, the cut-and-carry system was the first system adopted by most farmers (Table 4). This system was adopted even at the early

Table 3. Forage technology options for smallholder upland farms in Southeast Asia.

Farming systems	Forage technology options							
	Cut & carry plots	Grazed plots	Living fences	Hedgerows	Improved fallows	Cover crops in annual crops	Cover crops under trees	Ground covers for erosion control
Short-duration slash & burn	✓	✓	■ ✓	—	■	—	—	—
Grassland	✓	■ ✓	■ ✓	✓	—	—	—	—
Extensive upland	✓	■ ✓	—	✓	—	■ ✓	—	—
Moderately intensive upland	■ ✓	■ ✓	■ ✓	■ ✓	—	■ ✓	■ ✓	■ ✓
Intensive upland	■ ✓	—	■ ✓	■ ✓	—	—	■	■
Rain-fed lowland	■	—	■	—	■	—	—	—

✓ = forage technology adoption occurring.
■ = potential forage technologies originally identified.

Table 4. Diversity of adoption of forage options in different farming systems.

Farming systems	Total number of farmers evaluating	Years of farmer evaluation	Number of farmers expanding forages into systems	% of farmers expanding							
				Cut & carry plots	Grazed plots	Living fences	Hedgerows	Improved fallows	Cover crops in annual crops	Cover crops under trees	Ground covers for erosion control
Short duration slash-and-burn	395	1–3	93	100	1	2	0	0	0	0	0
Grassland	240	2–4	104	88	9	29	21	0	0	0	0
Extensive upland	268	3–4	87	99	1	0	13	1	0	0	0
Moderately intensive upland	452	2–4	29	73	4	27	16	0	6	6	6
Intensive upland	385	2–4	46	63	0	6	35	0	0	0	0
Rainfed lowland	19	1[1]	0	0	0	0	0	0	0	0	0

[1]Forage development activity was stopped after 1 year.

stages when farmers were still testing the forages for the first time.

With time and experience, farmers then tried out and discovered other systems for using forages. For instance, the number of farmers adopting hedgerows and living fences has already started to increase. The use of forages for improved fallow, grazing and cover crops has just started.

These examples all highlight the importance of allowing time for farmers' experience to build up before forage use systems could be developed. The major task of development workers therefore was to provide active input in terms of encouraging farmer innovations (in using the forages) as well as creating an environment where there is a free exchange of ideas with and between farmers.

Farmers' Criteria for Selecting Forage Varieties

In the process of testing and using the forages, farmers developed criteria for selecting varieties best suited to their needs (Table 5). The trend was that farmers first selected varieties based on their growth (well adapted species) plus the most important characteristic relating to his or her perceived need. The main criterion therefore often was whether the variety established and grew well, as well as being palatable to animals (since feed was the primary intended use).

Table 5. Farmers' criteria for selecting forage species.

Criteria	Forage system	
	Cut & carry	Contour hedgerows
Easy to establish*	✓	✓
Grows well*	✓	✓
Palatable to animals*	✓	✓
Fast regrowth*	✓	✓
Persistence*	✓	✓
Easy to cut	✓	
Easy to carry	✓	
High edible yield	✓	
Fattens animals	✓	
Holds the soil		✓
Does not compete with main crop		✓
Grows densely in a narrow row		✓
Not itchy (hairs, sharp leaf)		✓

*Primary criteria for selecting species.

As farmers developed other systems of forage use, a new set of criteria emerged, for example, ease of cutting. These were all related to the characteristics of the forage that would fit their intended use (this intended use could well have been different from the use identified when the farmer started planting forages). However, the farmers only applied these criteria after the species passed the previous set of criteria.

Moreover, farmers differed in the importance they attributed to some criteria. For example, some farmers disliked *Panicum maximum* 'Tobiata' because of its very sharp hairs that made cutting difficult. However, there were other farmers who preferred this cultivar (despite the sharp hairs) because of its high edible yield and fast regrowth.

As farmers gained experience with growing forages they changed their ranking of selection criteria. For instance, some farmers initially favoured and planted *Pennisetum purpureum* as a cut-and-carry species. After some time, they realised that it was difficult for them to go into the plots to cut the grass because of the long stems and leaves that were entangled with each other when plants had not been cut for a long time. They then shifted to using shorter species like *Setaria sphacelata* 'Lampung'.

What Forage Varieties do Farmers Adopt?

As the farmers gained experience, they selected one or more forage varieties for planting in larger areas. Often farmers selected several varieties, not just one. Moreover, they tended to maintain a few other varieties, usually by maintaining the initial testing area.

Some varieties were adopted by many farmers at most sites (Table 6). However, there were also varieties that were adopted by a majority of farmers at only few sites. In addition, some varieties have been expanded or adopted just recently. This change in variety preference was brought about by changes in farmers' recognised problems, their intended use of the forage as well as new opportunities that developed overb time. This once again highlighted the need for providing farmers access to a broad range of varieties.

Farmers' Innovations and Feedback to Research

The farmers developed innovations as they gained more experience with forages. These could be classified into: (a) new uses, and (b) new ways of propagating and managing forages.

One of the new uses that emerged was the use of forages to feed fish (grass carp) in Vietnam. These fish were traditionally fed with native grasses which had become scarce with time. Farmers discovered that some of the new forage varieties could be used for feeding fish. These include *Panicum maximum*

(‘Simuang’), *Paspalum atratum* (‘Terenos’) and *Setaria sphacelata* (‘Solander’). An important characteristic of foliage of these species (aside from being eaten by the fish) was that they floated when thrown in the water, since the grass carps are surface feeders.

Table 6. Forage varieties adopted by farmers.

Species	Adopted by many farmers at	
	many sites	some sites
A. Grasses		
Pennisetum purpureum (Napier) and *P*. hybrids	✓	
Panicum maximum (Simuang)	✓	
Setaria sphacelata (Lampung, Solander)	✓	
Paspalum atratum (Terenos)	✓	
Brachiaria brizantha (Marandu)	✓	
Brachiaria hymidicola (Yanero, Tully)	✓	
Panicum maximum (Tobiata)		✓
Brachiaria decumbens (Basilisk)		✓
B. Legumes		
Gliricidia sepium (local)	✓	
Stylosanthes guianensis (Stylo 184)	✓	
Centrosema pubescens (Barinas)	✓	
Arachis pintoi (Itacambira, Amarillo)		✓
Gliricidia sepium (Retalhuleu, Belen Rivas)		✓
Leucaena leucocephala (K636)		✓
Calliandra calothyrsus (Besakih)		✓

Another use of forage was for feeding chickens, ducks and pigs. This use evolved through farmers having observed that several legume varieties were eaten by these animals when they were let loose. These legumes include *Arachis pintoi* (‘Itacambira’ and ‘Amarillo’) and *Stylo*santhes *guianensis* (‘Stylo 184’).

Some farmers also planted *Arachis pintoi* around their houses and on the roadsides as an ornamental. Likewise, some farmers planted ‘King’ grass (*Pennisetum* hybrid) as a fence since it could grow densely and prevent entry of small animals like chickens.

Other innovations related to the propagation and management of forages. These included sowing of forage seeds in a seedbed to be later transplanted into the farm. This procedure provided savings in labour for maintenance and establishment as well as ensuring survival of the plants. Farmers in areas infested with *Imperata cylindrica* also learned that they could save labour and time by establishing grasses such as *Paspalum atratum* ‘Terenos’ using vegetative propagation directly into the *Imperata* area without land preparation. Subsequent weeding was done to assure survival.

All these innovations demonstrate that farmers innovate as they gain experience with forages. The trend was that they developed more complex ways of planting, managing and using forages with time. The evolution of these innovations also has implications for supporting research.

Lessons Learned

The experiences presented in this paper demonstrate that developing forage technologies with smallholder farmers was, for us, a learning process. This learning process involved both the farmer and the development workers. It was clearly shown that farmers tried out and learned new things. On the other hand, extension workers and researchers involved learned about the importance of facilitating the process of technology development and gained a better understanding of adoption.

It also became evident that technologies that were successful at one site could not be ‘photocopied’ to other sites due the existence of variability not only between sites but also between individual farmers. Farmers’ problems, priorities and preferences changed with time. What is therefore implied is the need to provide a broad range of options (such as forage varieties) for farmers to try and encourage them to innovate as well as exchange ideas with other innovators.

Working with farmers to develop appropriate technologies is rewarding but requires a long-term commitment from all people involved in the process. It requires nurturing and institutional support.

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Development of Fodder Tree Technologies through Participatory Research – Experiences from Central Kenya

R. Roothaert[1] and G. Karanja[2]

Abstract

The Diagnosis and Design method has long been used to identify problems in the farming systems in of the subhumid zone of central Kenya, and to design research proposals. In the semi-arid zone, more participatory tools were used. Although both methods identified fodder shortage and low quality fodder as major constraints to animal production, participatory rural appraisals enhanced a more dynamic research program in the semi-arid zone. Lessons were learned during on-farm and participatory research with exotic and indigenous fodder trees, and they are described in this paper. Adoption of a fodder technology involving the tree *Calliandra calothyrsus* was increased dramatically when farmers were involved in the propagation of the tree, through production of seed and the establishment of on-farm nurseries. Farmers were able to assess accurately the qualities of indigenous fodder trees through their own criteria, and significant differences were obtained among species, through the use of a participatory tool. It was concluded that there is a logical sequence of on-farm and on-station experiments in the development of fodder tree technologies. Training farmers in the propagation of fodder trees is essential for wide spread adoption.

IN THE subhumid highland of central Kenya, agriculture is the most important source of income, and livestock production contributes half of the household cash income from agricultural activities. There is still a vast room for higher income through increased milk production (Murithi 1998).

Major constraints to small-scale dairy production in the region are the low quality of available fodder and lack of fodder during the dry season. Trees can provide high quality fodder supplements and provide green fodder during the dry season when grasses have dried up.

The National Agroforestry Research Project in Embu, Kenya, has carried out research on fodder tree technologies. In order to ensure farmers' participation in the research process, the project's aim has always been to conduct at least 60% of the research on-farm. The objective of this paper is to review the research methodology, to discuss the lessons learned and to make recommendations for similar projects elsewhere in the tropics.

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The case studies are roughly divided into exotic fodder trees in general, *Calliandra calothyrsus*, and indigenous fodder trees.

Problem Diagnosis

In 1987, the International Council for Research in Agroforestry (ICRAF), together with USAID and national scientists, started a network for research in agroforestry in the highlands of eastern Africa. For the identification of areas for research, the Diagnosis and Design (D&D) method was used (Raintree 1987).

A macro D&D study was carried out for the whole bimodal rainfall highlands of eastern Africa (Minae and Akyeampong 1988), followed by a micro D&D study for the highlands of central Kenya (Minae et al. 1988). D&D studies are typically conducted by a team of scientists from multiple disciplines. They review previous diagnostic studies, talk to a few farmers and extension staff and then conduct a major formal survey. These D&D studies were able to identify problems in the farming system, and suggest areas for research to address these problems. However, the D&D studies lacked the flexibility to describe and address problems of non-modal households.

Researchers often know the problem areas before they start interviewing the farmers and the D&D exercise is then used to prioritise these problems. Farmers play a passive role and farmers' ownership of research is not stimulated. There is a high chance that important concerns of farmers are missed out.

In 1993, the Dryland Applied Research and Extension Project (DAREP) conducted broad-based diagnostic surveys in the semi-arid zone of central Kenya, consisting of many Participatory Rural Appraisal (PRA) tools. A comprehensive picture was obtained about the problems in the farming systems. Many stakeholders, such as farmers groups, women groups, NGOs, churches and Ministries, were involved in the PRAs, which enhanced the involvement of these stakeholders in following research activities.

During the exercise, it became apparent that in the region there was a development process going on which resulted in the intensification of the farming systems in the semi-arid lands. One of the features of this process was the adjudication of land by the Government to individuals, resulting in a reduction in communal uses, such as herding of livestock (Sutherland et al. 1995).

Another feature was the influx of people from the more densely populated higher altitude zones, and from regions across the Tana River, where climatic conditions have been much more adverse for farming. The intensification of the farming system also resulted in more intensive livestock production.

A shift was observed away from extensive grazing, with local cattle breeds, towards fencing of grazing land, tethering and cut and carry of fodder for cross-bred and improved dairy cattle breeds. Farmers were eager to experiment with improved fodder technologies, including fodder trees.

Exotic Fodder Trees

One of the first on-farm experiments of the project in the subhumid zone was designed to assess the ability of the fodder trees *Leucaena leucocephala*, *Calliandra calothyrsus* (calliandra), and *Sesbania sesban* (sesbania) to establish in existing plots of napier grass (*Pennisetum purpureum*) (ICRAF 1993). All species showed more than 64% survival in the first six months. Sesbania displayed the most vigorous growth in the first year. An unforeseen finding, however, was that most sesbania trees died after frequent cutting by farmers in subsequent years. In another on-farm experiment, rows of calliandra and napier grass were planted on contour bunds, either alone or together, to assess the biomass production potential (O'Neill et al. 1994). Technicians were to harvest the rows at scheduled times.

During the first few harvests, significant differences were found between yields of species grown alone and in combination. Later on, however, the fodder was harvested by farmers before the arrival of the technician. This finding stressed the significance of the problem of fodder shortage. The method would have to be revised if the original objectives were to be met.

Calliandra

Calliandra performs well in the subhumid zone of central Kenya and is one of the most wanted exotic fodder trees in this region. In order to assess the milk production potential of this tree, on-farm feeding trials were carried out, comparing supplemental feeds of calliandra and concentrates (Paterson et al. 1999).

The dietary treatments were determined in a workshop to which all participating farmers and their wives were invited. Heaps of fresh napier grass, the most common basal diet for cattle in the area, were provided, and farmers made their own heaps to represent the amounts they feed a cow each day. The same was done for calliandra. The average amount of fresh calliandra fed was 1.25 kg per day, but most farmers said they would feed more if they had more trees. The average weight of the napier heaps was 80 kg and this defined the basal ration for all cattle in the experiment.

The first treatment was agreed to be a supplement of 1.25 kg of calliandra per cow per day. The second treatment was an amount of concentrates with an equivalent amount of crude protein as in the amount of calliandra. The third treatment was twice as much calliandra as the first treatment. In this, way farmers' practices, farmers' ambitions and researchers' expertise were combined to obtain satisfactory and uniform treatments.

Based on the results of the experiment, it was calculated that 1 kg of concentrates could be replaced by 3 kg of fresh calliandra without affecting milk production. Franzel et al. (1996) calculated that, if a farmer replaced the amount of concentrates recommended by extensionists (2 kg per day per cow) with calliandra, his or her net profit would increase by US$143 per cow per year.[1] If this amount of calliandra were to be fed in addition to 2 kg of concentrates, the net profit would increase by US$98 per cow per year.

One way of assessing the adoption potential of a fodder technology is to study the spontaneous expansion of the technology by farmers. Farmers, who had received seedlings of calliandra from various

[1] 1 USD = 60 KES in 1999.

projects between 1988 and 1993, were asked whether they had expanded. Figure 1 shows that these farmers planted even more seedlings in subsequent plantings than in their first plantings.

A big constraint, which was frequently mentioned, was the shortage of seedlings. The National Agroforestry Research Project realised that it could never respond sufficiently to the great demand for calliandra seedlings. The project had unintentionally created a dependence on seedlings, which was stagnating further expansion of the technology. Since then, the project stimulated farmers to raise their own seedlings on-farm. They were also taught farmers how to produce good quality seeds from the trees, which was important because calliandra is not naturally a prolific seed producer. By mid 1995, 36% of the farmers had established their own nurseries. Adoption of calliandra further increased. Adoption cut across income classes, but was correlated with the importance of the dairy component in the farming system (Franzel et al. 1996).

The establishment of on-farm tree nurseries was considered to be the key to adoption of calliandra. A training expert was therefore hired to train trainers of various organisations to train farmers in the establishment of tree nurseries, and the management of calliandra for feeding livestock. Training of farmers took place in farmers groups, which pre-existed in most cases.

In the first six months of 1999, 160 new on-farm nurseries were developed, involving more than 2000 farmers in 6 districts, and 800 000 seedlings were raised in these nurseries.

This experience shows that, although a technology can spread from farmer to farmer, adoption in a region is greatly enhanced when well equipped extension staff help actively in the diffusion process.

If a technology has proved to be beneficial to farmers, and if any natural expansion has been observed, there would be a big loss of opportunity if the spreading of the technology was not actively facilitated by outsiders.

Indigenous Fodder Trees

In several surveys in the subhumid zone, farmers mentioned that they used indigenous trees to feed their cattle, goats and sheep. In the semi-arid zone, research planning workshops were organised with all stake holders, after the PRAs had finished. In these workshops farmers had expressed interest in planting indigenous fodder trees and shrubs.

A research framework was then developed to incorporate farmers' knowledge, laboratory analysis, feeding trials, literature review, scientists and key informants, on-farm evaluation, on-station evaluation, propagation studies and regular feedback meetings (Figure 2). During the survey on indigenous knowledge and practices of fodder trees, it was found that 160 different local species were used by farmers. The framework of research activities was used to screen these species, resulting in a list of the most promising species in each agroecological zone.

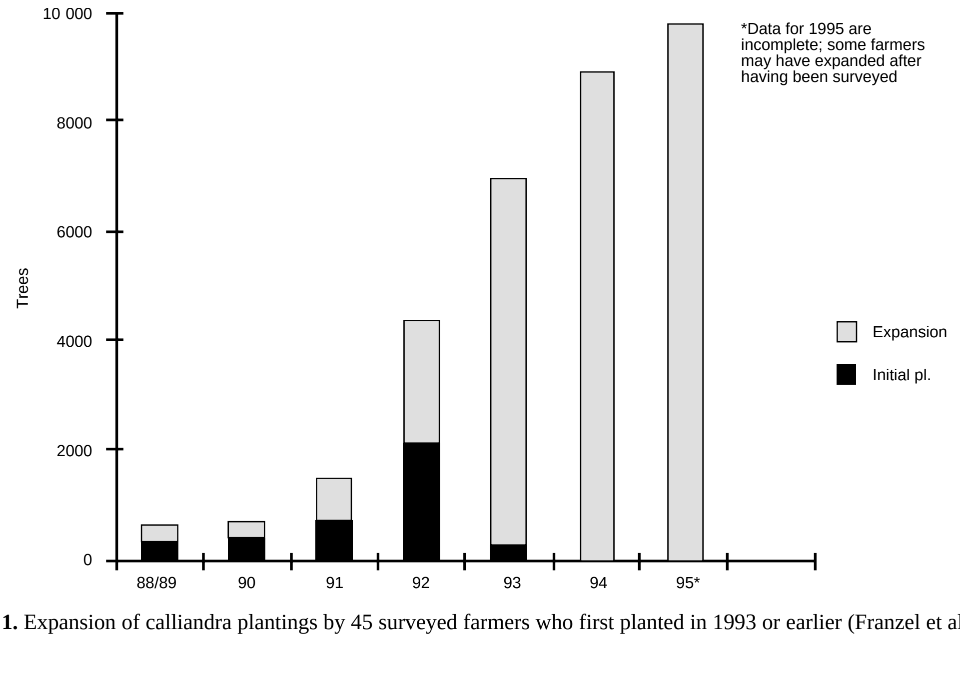

Figure 1. Expansion of calliandra plantings by 45 surveyed farmers who first planted in 1993 or earlier (Franzel et al. 1996).

A traditional wooden game, the *bao* game, was used as a participatory tool for farmers to rate different tree and shrub species for different parameters (Figure 3). These parameters were quality indicators of fodder trees, as defined by farmers, such as palatability to cattle, palatability to goats, effect on animal health, compatibility with crops and drought resistance.

Scientists added some parameters such as growth rate after establishment and rate of regrowth after harvesting. Farmers could allocate 1, 2, 3 or 0 seeds per pocket in the *bao* game, to indicate poor, medium, good or does not know, respectively, simulating matrix ranking. These data were analysed by chi square and significant differences among species were obtained (Table 1).

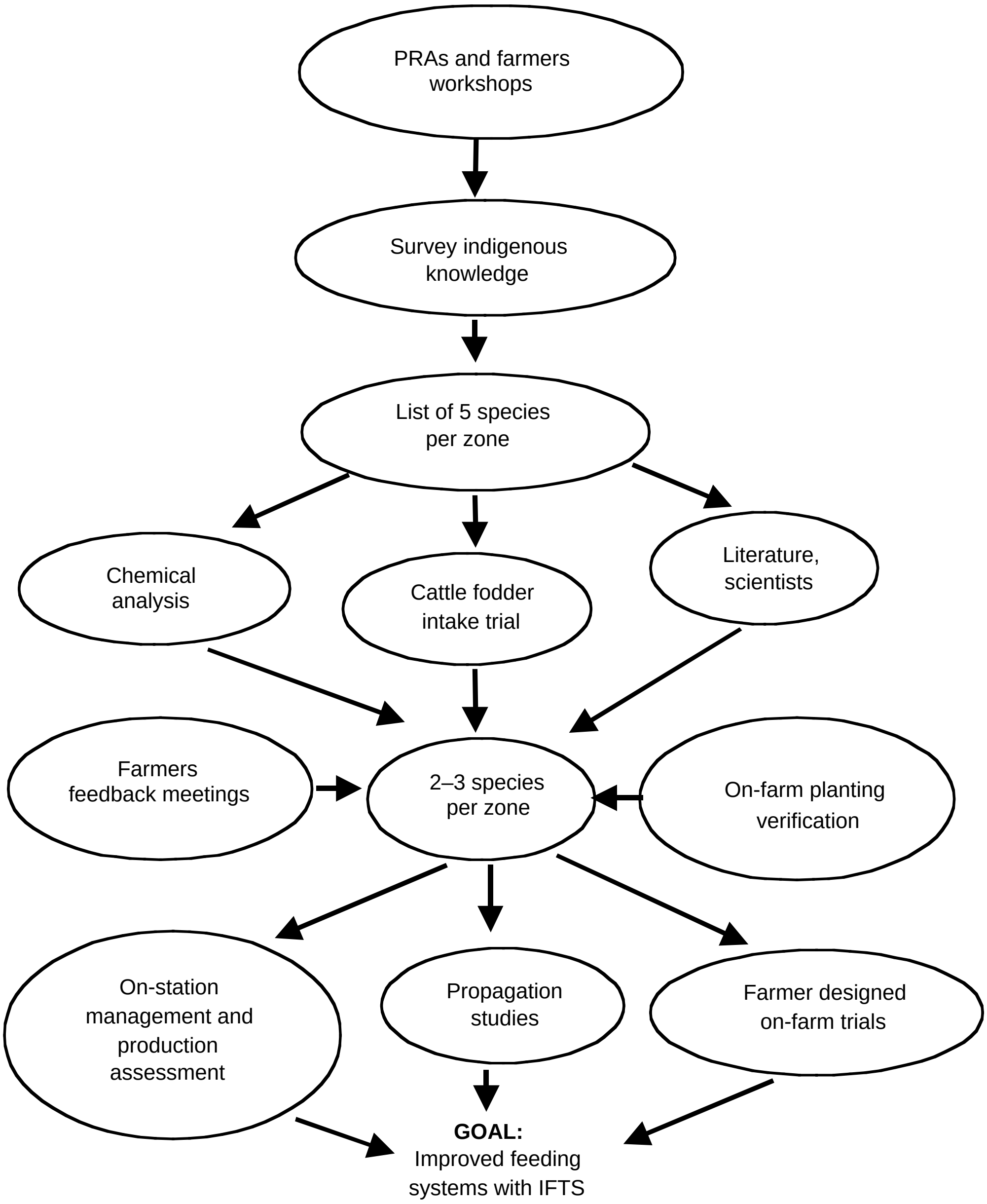

Figure 2. Framework of activities in the evaluation of indigenous fodder trees in different agroecological zones.

Table 1. Farmers' scoring of improved fodder tree species on selected criteria using the bao game, subhumid zone (Roothaert 2000).

	Growth after establishment	Regrowth	Palatability for cattle	Compatibility with crops	Health	Drought resistance
	(mean scores[a] and standard deviations in parentheses)					
Triumfetta tomentosa	2.2 (0.93)	2.3 (0.86)	2.1 (0.90)	1.9 (1.07)	2.4 (0.81)	2.3 (0.75)
Commiphora zimmerm	2.9 (0.34)	2.9 (0.33)	2.6 (0.53)	3.0 (0.00)	2.7 (0.65)	2.8 (0.45)
Bridelia micrantha	1.6 (0.73)	2.1 (0.90)	2.1 (0.69)	1.8 (0.98)	2.4 (0.73)	2.1 (0.99)
Vernonia lasiopus	2.4 (0.79)	2.5 (0.69)	2.1 (0.90)	2.2 (1.10)	2.5 (0.76)	2.3 (0.76)
Tithonia diversifolia	2.9 (0.33)	3.0 (0.00)	1.6 (0.98)	2.2 (1.00)	2.8 (0.50)	2.5 (0.93)
Lantana camara	2.7 (0.47)	2.8 (0.40)	2.7 (0.50)	1.6 (1.00)	3.0 (0.00)	2.1 (0.93)
Significance level	0.004	0.038	0.051	0.11	0.67	0.33

Notes: The number of farmers scoring each species on each criterion varied from 4 to 17.1 = poor, (s.d.).
[a]A rating of 3 indicates good, 2 indicates medium and 1 indicates poor.

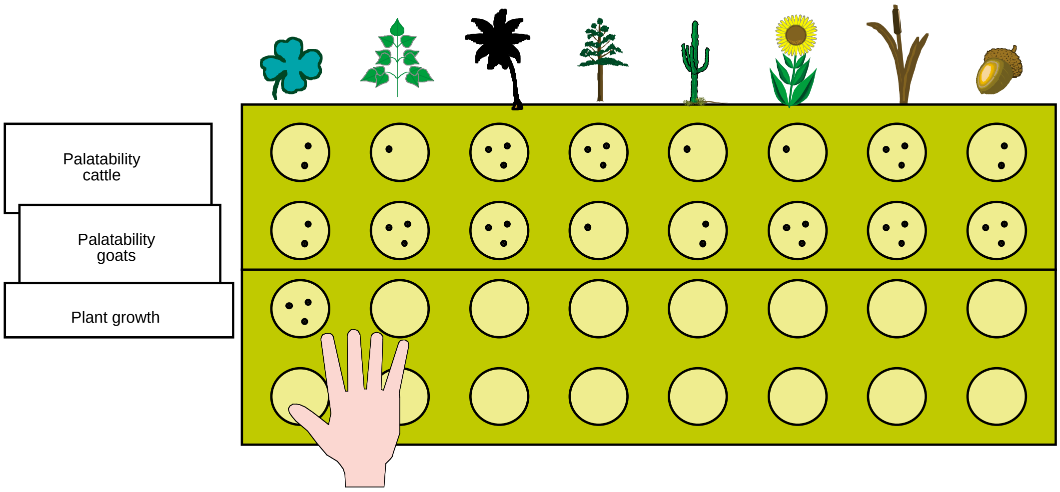

Figure 3. The traditional wooden bao game as a participatory tool for matrix ranking of fodder tree species.

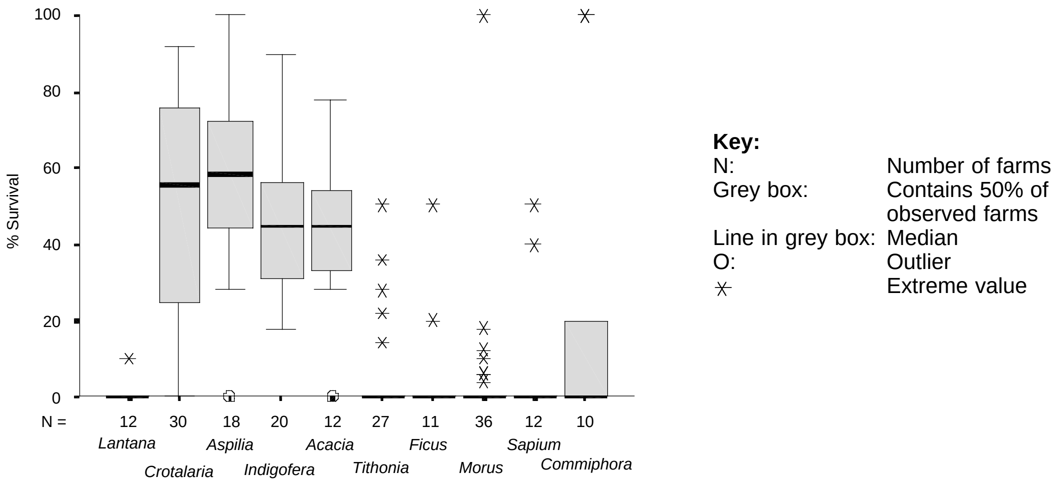

Figure 4. Survival of indigenous fodder trees and shrubs two months after first planting (Roothaert 2000).

Farmers feedback meetings were not only useful to confirm findings from the survey but also to review inaccurate information. For instance, during the survey it was found that in one particular zone, the same trees had different vernacular names from other zones. It was hypothesised that people from another area had migrated there. This was confirmed during the feedback meeting, and the finding had implications for the analysis. Additional information was obtained during the feedback meetings about species which were much used, but which would not be planted, such as *Lantana camara, Bridelia micrantha* and *Maytenus putterlickioides*.

Other examples of additional information obtained were that *Trema orientalis* improves the soil and can be intercropped with coffee, that cutting tree fodder saves time, and that mixing of species was considered positive in the dry area but negative in the subhumid area. The feedback meetings also boosted the confidence of farmers that there was a lot of value in their local practices.

Seedling of the most preferred trees and shrubs were raised in nurseries and selected by 70 farmers in three zones for planting on farm. Unfortunately, during the season of planting (November 1996) there were only 3 weeks of rain, followed by a severe drought. This unforeseen climatic event, however, showed clear differences in survivability of species (Figure 4). Other findings from the on-farm experiment were:

- Seedlings which had been planted in shady places had a higher percentage of survival ($p < 0.05$).
- Species which were common in the subhumid zone and which farmers wanted to try in the medium dry zone were severely affected by termites. This indicated that these particular species, *Tithonia diversifolia* and *Morus alba,* were outside their feasible habitat.
- Species which were given most manure by farmers were *Sapium ellipticum* in the subhumid zone and *Crotalaria goodiiformis* in the semi-arid zone. This practice stressed the preference for these species.
- Species which were more preferred by men than women were *Ficus* spp., *Indigofera lupatana* and *C. goodiiformis*. This finding has implications for the adoption potential among gender groups.
- Women were more persistent in caring for the trees.

The enthusiasm of farmers in the experiment indicated strong interest to intensify the use of indigenous trees and shrubs for fodder.

Conclusions

There is a logical sequence of PRAs, surveys and on-farm and on-station experiments in the development of fodder tree technologies. PRAs provide a fast, holistic and cost-effective way of identifying constraints and opportunities. Surveys are a useful tool to obtain detailed information on a particular subject. Farmers meetings are essential throughout the research process, to confirm earlier findings and to clarify obscurities. On-farm experiments provide practical information while the technology takes shape.

On-station research is needed at some stage to provide information on fodder production potential, which facilitates economic evaluation of the technology. For widespread adoption of a technology, it is essential that planting material is abundantly available.

In central Kenya a successful adoption has been achieved by training farmers to raise their own seedlings of calliandra. There is a big opportunity for the use of indigenous fodder tree species, backed up by a wealth of knowledge.

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Farmer Adoption and Adaptation of the Simple Agro-Livestock Technology (SALT 2) Farming System in Bacungan, Magsaysay, Davao del Sur: A Case Study of 'What happened?' and 'Why?' in Relation to Farmers and Participatory Technology Development and Implementation

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Abstract

Adoption and adaptation over a five-year period of an integrated livestock farming system known as Simple Agro-Livestock Technology (SALT 2) is outlined for a village in Mindanao, the Philippines. Adoption of the system as seen by the organisation, the extensionist and the farmers themselves is discussed. Observations are drawn from the farmers' subjective observations as well as on site-analysis. In addition, some simple principles and lessons about community development and participatory approaches are shared and conclusions made.

THE MINDANAO Baptist Rural Life Center (MBRLC) is a non-profit, non-government organisation dedicated to the benefit of the upland farmers of the Philippines. It was started in September 1971 by agriculturist Harold R. Watson in *barangay* (village) Kinuskusan, Bansalan, Davao del Sur on the island of Mindanao. The MBRLC is located on a 19 ha demonstration farm but has a strong focus in community development throughout many villages in the southern Philippines. Out of the current almost 100 staff members, about half are located outside of the main centre serving in village level development programs.

From its inception in 1971, a high emphasis has been given to helping Filipinos in the uplands develop sustainable farming systems for small, upland farm families and communities. Even though the extension methods used with farmers are holistic (including health care, infrastructure, etc.), a heavy response by communities has been in the area of agriculture production. To date, a number of internationally known agroforestry technologies utilising nitrogen-fixing trees and/or shrubs (NFT/S) have been developed by the MBRLC and farmers working together. These are primarily the Sloping Agricultural Land Technologies known generally as SALT (Watson and Laquihon 1985).

Four distinct SALT technologies have been developed (MBRLC 1989, 1991, 1995, 1997a, 1997b, 1997c). Brief descriptions of these follow:

(a) Sloping Agriculture Land Technology (SALT 1)
Since the mid-1970s, the SALT 1 technology has utilised a number of fast growing nitrogen-fixing trees and shrubs (NFT/S) for soil conservation and a biological fertiliser source in the uplands. These NFT/S are planted in double hedgerows along the contour of sloping areas four to five metres apart. These nitrogen-fixing hedges act as a physical barrier to soil erosion as well as providing a rich mulch which reduces soil erosion as well as providing a good source of organic nutrients for the system and a soil covering conditioner. The original SALT 1 model is situated on a one-hectare plot. To date, almost 100 species of NFT/S have been tested and screened by the MBRLC for use as erosion control, biological fertiliser and soil conditioner within the SALT 1 system. The major NFT/S

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hedgerow species utilised are *Desmodium cinerea* (= *'D. rensonii'*), *Flemingia macrophylla, Gliricidia sepium, Indigofera tyesmani, Leucaena* sp. and *Calliandra* sp.

(b) Simple Agro-Livestock Technology (SALT 2)
This technology is a variation of SALT 1 with a heavy emphasis being placed on an animal component. In the SALT 2 model, the main demonstration makes use of an integrated goat dairy on a half-hectare of land. Half of the land area is dedicated to agroforestry trees (mainly NFT/S) which are used solely as forage/fodder for the goats, while the other half is dedicated to growing food crops and generating income for the farm family. Again, the main agroforestry species mentioned above for SALT 1 are primarily used in this system.

(c) Sustainable Agroforest Land Technology (SALT 3)
Another variation of the SALT 1 technology is SALT 3, in which a heavier emphasis is placed on small-scale reforestation for the farm family. This is a two-hectare model in which one hectare is utilised as a regular SALT 1 project while the remaining hectare is planted with trees, as a small, farmer-managed forest. The majority of the agroforestry species utilised in the reforestation area are again NFT/S such as *Albizia saman, Pterocarpus indicus, Acacia auriculiformis, A. mangium,* and *Leucaena diversifolia*. However, a number of non-NFT/S are also used in this agroforestry model including *Swetinia macrophylla, Gmelina arborea* and *Eucalyptus* spp.

(d) Small Agrofruit Livelihood Technology (SALT 4)
Fruit trees often escape the attention of agroforesters, and these are the building block of the SALT 4 technology. Based on the idea that some farmers would prefer fruit production over other commodities, SALT 4 integrates durian (*Durio zibethinus*), lansones (*Lansium domesticum*), rambutan (*Nephelium lappaceum*), mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), coffee (*Coffea* spp.) and calamansi (*Citrus madurensis*) into a half-hectare demonstration with high returns on investment. The majority of agroforestry fruit trees utilised here are non-NFT/S but are supported by the presence of N-fixing hedgerows for erosion control and soil fertility management.

The main thrust of all SALT technologies is to: 1) Minimise soil erosion; 2) improve and maintain soil fertility; and 3) provide food and income for the farm family. In short, the SALT idea has sought to provide sustainable, balanced farming systems where the undesirable farm outputs (erosion, leaching, burning, etc.) are minimised and desired outputs (production) are maximised. All of this is done in a nitrogen-fixing framework where the main inputs to the system are from nitrogen-fixing plants which supply biological fertiliser and act as a soil conditioner (Palmer 1996).

This paper will focus on the adoption of the SALT 2 technology and its adaptation by a group of local farmers in a village. It will give MBRLC approaches, philosophy and principles of community development and make simple observations based upon our years of field experience. It is meant to be open ended, subjective and open for discussion with the group.

The MBRLC Approach to IMPACT Community Development

MBRLC sees development as a process and its approach to development is largely participatory. As a process, technologies and/or development projects are also viewed as practical training grounds for a community gradually to gain capability and control of managing its own development. As a participatory-based process, the community plays a direct and major role in the design, implementation and evaluation of a project.

The MBRLC technician takes the role of a facilitator – living in the village for a period of time and helping the community as they plan and implement community and/or individual projects. Village mapping and analysis of development constraints is done with a variety of tools involving the local people. The availability of local resources influences project design. Continuing education – on positive values and project management capability – marks the whole development effort. Linkage with the local government is a must in the MBRLC approach, recognising the local government as a key player in development.

The MBRLC approaches community development and extension with an IMPACT philosophy. In a village, we work with a small, manageable core-group (or multiple core groups) until they become the 'change agents' within the whole community. Attitudes, values, and capabilities are strengthened within the whole group to the point where they can clearly recognise the constraints to development and are able to analyse and choose ways to solve community problems that are just and fair to the whole community. In a truly successful community development project, in MBRLC's estimation, this core then becomes a 'ripple' to spread the capabilities and knowledge with the rest of the villagers and even to surrounding villages in order to have the greatest IMPACT for development.

The MBRLC Concept of Modeling for Teaching

Along with community development through IMPACT, providing visual models for development participants has been an integral part of the overall MBRLC development philosophy. Whether the modeling is in an actual technology or the quality of the life of our extensionist, we have felt from the beginning that 'teaching by showing' and 'learning by doing' is an integral part in the process of gaining peoples' confidence and respect in development work. Therefore, MBRLC has utilised models in technology development (such as the SALT models) to communicate principles to our farmer participants. Moreover, we have required our staff living in the villages to be incarnational models of development. In this way, we live as well as show what we are trying to teach.

The History of Participatory Extension Work in the Bacungan Impact Area

Demography

Magsaysay (formerly known as Kialeg) is a municipality of Davao del Sur with 22 barangays (villages). The 1995 census puts the total population at 41 979 people making up 8224 families with an average of 5.1 persons per household. Half of the Magsaysay barangays are lowland irrigated and the other half are upland communities ranging from moderate to steep slopes. The whole of Magsaysay is in a dry zone with a pronounced six-month wet and six-month dry season (National Statistics Office 1995).

When MBRLC moved into the area for community development work, the Local Government Unit's (LGU) Municipal Development Council (MDC) steered the MBRLC to work in the most critically impoverished areas of the municipality. These areas were narrowed to basically four barangays: Bacungan (population: 1764), Balnate (population: 979), Malawanit (population: 1365) and San Miguel (population: 1290) or 13% of the total population of Magsaysay. These areas were chosen by the LGU-MDC and MBRLC as primary targets because of their isolation, limited access to basic services, extremely steep topography and high incidence of poverty. The majority of peoples living in these villages are Visayans who have migrated into the uplands populated by mixed-tribal peoples of B'laan heritage.

History of MBRLC work in the area

The MBRLC started work in the area in 1991. From 1991 to 1992, MBRLC community development work was conducted with groups in Balnate and San Miguel. Work was then expanded to include Bacungan (1993 to 1995), Malawanit and Asbangilok (1995 to 1997). Initial contact in the area was made by MBRLC by Mr Rod Calixtro, Base Project Division Leader, and the first MBRLC extensionist assigned to the area was Mr Noel Elmundo. Other extension workers for the life of the project included Mr Ramonito Solana and Mr Jun Elegio.

The MBRLC project was strongly linked to the LGU through the Municipal Development Council and more particularly through relationships with the Barangay Councils, Captains and the Barangay Development Councils (BDCs). Also, a good linkage was established with the European Union (EU) project known as the Southern Mindanao Agriculture Programme (SMAP) through the Department of Agriculture (DA) which provided most of the monetary inputs into the initial projects.

Results of work to date

Overall, there have been more than 250 SALT farmer-adopters in the larger area (Table 1).

Table 1. Adopters of SALT technologies in the Bacungan area.

Barangay	SALT 1 adopters	SALT 2 adopters
Malawanit	60	50
San Miguel	60	20
Balnate	30	
Asbangilok	30	2
Total	180	72

The development work actually carried out in the village was more holistic than implied in this paper. While the agriculture projects were being implemented, a number of 'other' development projects relating to infrastructure, health care, community organising, water development (etc.) were being explored and implemented by the community, with moderate leadership by the MBRLC extensionists.

However, for the purpose of this paper, we will focus on the small group of SALT 2 adopters/adapters and their experience in and around the Bacungan area. We will try to look at what and why technology adoption/adaptation occurred from the eyes of the implementing organisation, the extensionist and, more importantly, the farmers themselves.

What Happened and Why

The technical/organisational perspective

Overall, the adoption and adaptation of the SALT 2 farming system in the Bacungan, Magsaysay area was good and eye opening from the MBRLC's perspective. From 1991 to 1997, more than 200 farm families adopted the technology in a relatively small

IMPACT project area. SALT 1 (primarily addressing soil conservation and food and income generation), SALT 2 (animals), SALT 3 (forestry) and SALT 4 (fruit) type systems were designed and implemented by the local people.

Even though unusually dry El Niño years came during this period, many farmers continued with their farming systems and still do so. Naturally, some farmers are better than others and have continued expanding, also coming up with their own variations to meet the needs of their farming systems. As an example, the SALT 2 model calls for placing manures generated by the animal systems back on the crop production area. Farmers chose rather to use the manures on high-value crops such as fruit trees and their vegetable gardens. Also, many farmers chose to cut their hedges and feed them to the animals rather than placing them on the soil for decomposition and soil fertility maintenance. However, a few did choose to follow the model recommendations of planting a separate area for forages called a 'forage garden' and use the hedges as recommended. Both the adopted and the adapted system were more sustainable than their previous systems.

A big change noticed was the improved quality of the goat breeding stock in the area from the early 1990s until today. The Nubian blood is evident in most of the village goats when compared with other areas in the southern Philippines. Also, a high percentage of farmers in the area have voluntarily gone to cut-and-carry forage systems or total confinement of their animals.

The field extensionist's perspective

The viewpoint of Mr Noel Elmundo, primary MBRLC extensionist working with the project, was explored in an interview and subsequent cross-check. He had worked in the general project area from 1991 to 1997 and in the Bacungan site from 1993 to 1996.

In his opinion, one of the keys to success was the funding by the government, and the organisation of the farmers themselves. He led the farmers in a participatory process by which they designed and implemented their own system.

The farmers themselves set criteria for participation in the government-funded SALT 2 distribution. These were:

- Had to be a SALT 1 farmer;
- Had to have an adequate barn to house the animals;
- Had to have adequate forages planted to feed the animals;
- Must be a full-time farmer to make avail of the dispersal.

According to the extensionist, over a one-year period the farmers formed an association for goat raising and management. They defined roles to be played by each of the participants in the development process (Table 2).

Table 2. Roles of participants in the SALT 2 project in Bacungan.

Farmers	Extensionist	Donor
Pay back for each animal unit (one for one)	Technical support	Nails for the barn
Labour/management materials	Forage seed	Goats
Materials	On-farm training	
Train neighbours	Training seminars	

The extensionist considered that good community development principles and processes were used in helping the farmers start their new animal projects, but the farmers did know about the incentives of receiving goats. Moreover, he said that the association of farmers was formed primarily out of a need to combat low prices of marketable items, even before there was a goat project proposed.

Overall, Mr Elmundo felt that this was a very effective community project, which also spread to other areas outside the primary impact site. He stressed the importance of the good relationships between farmers and the extensionist as a key to the success of projects such as this. He emphasised that it was initially hard to convince the farmers to apply soil conservation techniques such as SALT, but after trying and seeing the benefits, it became much more accepted. He also noted that inputs in the form of counterparts, even though small, were hard for the local people to do. Even so, it was important for the local farmers to have a counterpart and good linkages with the Local Government Unit (LGU) helped the people in the long run.

The farmers' perspective

An informal survey was conducted during August and September 1999 in the IMPACT project area. Farmers were interviewed to get their perceptions of the project.

Four different groups of farmers were interviewed:

- Original adopters who are still utilising the SALT 2 systems after 5 years – (5 interviewees). These were the first recipients of the government's animal dispersal in the area;
- Later-Adopters (second and third generation adopters) who are now utilising the SALT 2 systems (6 interviewees);
- Adopters who abandoned the system – (3 interviewees);
- Non-Adopters/native goat raisers – (5 interviewees).

They were asked various questions about their adoption or failure to adopt the SALT 2 system. In

Table 3. Reasons why farmers went into a SALT 2 system (with frequency of response).

Original adopters	Later adopters	Adopters who abandoned SALT
Help in economic crises (3)	Have plenty forages (3)	Help in economic crises (2)
High income return (2)	Wanted goat milk (2)	High income return (1)
Attended seminar (2)	I wanted a goat (2)	Goats give milk (1)
Encouraged by extensionist	Help in economic crises (2)	To conserve soil (1)
Get goat manure (1)	Help improve my soil (1)	Had plenty of forages (1)
To breed more goats (1)	I wanted manure (1)	To have manure (1)
To get a goat (1)	High income return (1)	
	Easy to sell (1)	
	Encouraged by my father (1)	

questioning, a group process was used as well as individual interviews. MBRLC staff who were not primarily associated with the IMPACT project were utilised as interviewers to minimise bias in questioning.

When the first three groups were asked what factors helped them decide to go into a SALT 2 type farming system, they replied as follows (frequency of response in parentheses) (Table 3).

Most of the reasons seem to be focused on perceived benefits (e.g. 'I wanted a goat', 'Goats give milk', I wanted manure', etc.). The highest and most consistent response was 'Help in economic crises' which may reflect the recent passing of the El Niño phenomena.

When original adopters and later adopters were asked about their feed inputs into their goats, the response was:

Table 4. Feeds used for goats by SALT 2 adopters.

Feed	Original adopters	Later adopters
Rensonii (*Desmodium cinerea*)	5	6
Flemingia (*Flemingia macrophylla*)	5	5
Ipil-ipil (*Leucaena leucocephala*)	5	4
Madre de cacao (*Gliricidia sepium*)	1	1
Napier grass (*Pennisetum purpureum*)		2
Corn bran		1
Grazing	1	

The 'later' or second and third generation adopters included grasses in their feeding scheme and even a little corn bran. It should be noted that only rensonii and flemingia seeds were promoted as primary forages. The others (ipil-ipil, napier, madre de cacao, etc.) were the farmers' innovation. The area is rich in ipil-ipil and it should also be noted that this was the primary feed source (in most cases 100%) during the El Niño years.

In another question, original adopters and later adopters were asked their source of forages for their cut-and-carry SALT 2 systems. The response was:

Table 5. Source of cut-and-carry forages (and frequency of response).

Source	Original adopters	Later adopters
Contour hedgerows	5	6
Forage garden	3	1
Anywhere	1	

In the original SALT 2 model, it is taught that a separate forage garden should be planted and the contour hedge trimmings should be placed on the soil to 'feed' the soil and not be removed for animal feed. However, it is obvious from both groups of respondents that an easy source of feed to the farmer is the contour hedge. Possibly the benefits of the amelioration of the soil due to the application of plant biomass are not valued or understood by the farmers in this case.

When original adopters and later adopters were asked what systems they were currently using to raise their animals, five out of six original adopters and all six later adopters said they were using 'cut-and-carry'. Only one original adopter said he was using 'free grazing'.

After five years, this is a high rate of adoption and is possibly an indicator that this system is moving towards a sustainable system. Moreover, the housing used by both groups above was a raised barn type system for ease of manure removal. One good indicator of sustainability of this project, and that the local people feel ownership, is that three out of five original adopters have rebuilt their barns and continued with the cut-and-carry system. These new barns are located closer to their homes, for easier maintenance. On a side note, non-adopters also use a modified housing system for goat raising called the '*tugway*' system. The animal is tethered out and allowed to graze a defined area but is brought into some type of shelter when it rains.

In comparing the original livestock and barns started with between original adopters and later adopters, the data show:

Table 6. Livestock and barns owned by the original adopters and later adopters.

	Original adopters	Later adopters
Goat breed	Nubian (5); cross (1)	Nubian (1); cross (5)
Goats at start (mean and range)	5 (5–6)	3 (1–5)
Goats in 1999 (mean and range)	4 (0.5–7)	4.5 (3–5)
Mean barn area at start (m^2)	64	137
Mean barn area in 1999 (m^2)	75	137

The original adopters received a higher quality stock at the start of their project than did the later adopters. Five of the original adopters received pure-bred Nubians whereas only one of the later adopters did. Also, original adopters had an average of five animal units dispersed to them while the later adopters averaged only three animal units. The animal numbers have slightly decreased over the years (1995 to 1999) for the original adopters and slightly increased (1997 to 1999) for the later adopters. This may be due to the fact that the later adopters did not get fully started in their programs until after the full effect of El Niño had passed. Many of the original adopters sold some of their stock in order to survive during that crisis time. When interviewed, all farmers said they had plans to expand their flocks.

The barn size for original adopters was uniform and standard, as a requirement of the dispersal program. However, the later adopters opted to build larger barns even though many of them received no assistance in constructing their animal housing. In addition, the original adopters whose original barns became dilapidated built slightly bigger barns when they rebuilt and relocated.

When all four groups were asked about where they learned about SALT 2 or goat raising, the original adopters, later adopters and adopters who abandoned the program all responded 'the extensionist.' However, when non-adopters were asked the same question, they replied 'extensionist' as well as 'my father', 'my neighbour' and 'we've always raised goats.'

A most striking comparison surfaces when the various groups of SALT 2 implementers were asked how SALT 2 was introduced to them. The original adopters and later adopters said they went through a process of analysing their problems and were led by an extension worker in this analysis. However, the adopters who abandoned their SALT 2 projects, when asked the same question, replied: 'I went to a one-day meeting', or 'I was asked to try it.' This response is a far cry from process-oriented community development techniques, and would possibly have contributed to their rapid abandonment: they didn't pass through the process!

When the original group of adopters were asked to describe the process of how they came to choose the SALT 2 farming system, they gave the following responses:

- We started with establishing a farming system that would prevent soil erosion in our farmland.
- In one of our meetings, we discussed what were the possible livestock projects that would help us in times of economic crisis. We discussed choices.
- The MBRLC extensionist asked us if we would be interested in goat raising. We discussed projected income.
- We chose goats because forage for goats is easier to get. Also, because the expected income is

Table 7. Assistance given to start and continue a SALT 2 or goat project.

	Original adopters	Later adopters	Abandoned adopters	Non-adopters
Assistance at start of project				
Training	✔	✔	✔	
Nails	✔	✔	✔	✔
Initial stock	✔	✔	✔	
Building materials				✔
Forage seeds	✔	✔		✔
Mango seedlings	✔			
Assistance during project				
Tee seedlings	✔			
Farmer to farmer training		✔		
Follow-up visit			✔	
Monthly meetings	✔			
Visit from extensionist		✔	✔	
Marketing	✔			
How to worm/de-horn			✔	

higher than from the other livestock project we have discussed.
- We organised ourselves to make each one accountable to the agreement set in relation to the project.

Each group was asked if there was any assistance given to them to help start into a SALT 2 system or to start raising goats, and to continue in the project. Responses are given in Table 7.

All received nails and most received training and initial stock. It should be noted that the initial stock received by the second generation adopters were purebred whereas the third generation adopters received upgraded Nubians.

When original and later adopters were asked what, if any, was their counterpart to the project, the response came back as:

Table 8. Farmers' counterpart in implementing SALT 2 projects.

	Original adopters	Later adopters
Labour for barn construction	✔	✔
Barn materials (excluding nails)	✔	✔
Responsibility for project	✔	
Forage seeds		✔

When adopters who abandoned the system were asked 'why' they decided not to continue to utilise the system, they responded:
- Diseases (2);
- Bila is a dry area (2);
- Water is far away (1);
- Abnormalities in kids (1);
- Sold the goats during El Niño years (1).

The reasons listed by the farmers for abandoning their SALT 2 systems could be grouped into two categories: first would be physiological problems such as disease and kid abnormalities and the second is environmental conditions due to the El Nino crisis and lack of water.

When Non-adopters were asked why they did not choose to go into SALT 2, they replied:
- No area for forage due to limited land (2);
- My forage is not enough (1);
- Water source is very far (1).

Issues of land size and availability tended to be a major issue that discouraged non-adopters in the area from adopting SALT 2. Some raisers of native goats indicated that the SALT 2 system was attractive and were convinced of its advantages, but they were unable to avail themselves of breed-stock dispersals because of the qualifications required by the farmers' organisation. Farmers living on rented land were less able to meet the pre-dispersal qualification of being an established SALT farmer, having limited area to plant to forage and to build a raised-floor goat barn.

Principles and Lessons being Learned by MBRLC in Community Development

Briefly, a few general and subjective observations will be made here based on the data presented and the many other experiences of the MBRLC. In no way are we claiming to be experts in community development and participatory approaches, but we have learned and are still learning certain principles and lessons that are hopefully making us into better developers. These are in no way unique to the MBRLC and by no means all-inclusive. They are simply some of our experiences and thoughts to date.

The process is as important as the product. Outside change agents may stay only for a period of time due to budget, time and other constraints. It is thus strategic that we have highly involved influential and capable insiders to sustaining a development program. The process is a critical factor in strengthening the capability of the people in the community. For instance from the data presented, it is interesting to note that it seems those farmer participants who went through 'a process', which even they themselves could adequately describe after five years, were more likely to continue with the projects over the 'abandoners' who seemed not to have gone through a process.

Development is not done to or for people but rather with people. Created in the image of God, each person has the capacity to build something. We harness a God-given capacity when we work 'with' people instead of 'for' them. Trust is a key factor in development. Working 'with' signifies a high respect for what the people have. People are willing to trust and work with you as partners when they see that you truly hold their knowledge and experiences in high respect.

Ownership of the project from the beginning by the local people is essential for the sustainability of the project. People tend to protect and nurture the project when they have given a significant contribution to it. People's level of investment in the project naturally creates a corresponding degree of importance of the project. In the case of the Bacungan SALT 2 farmers, both original adopters and second and third generation adopters we are able clearly to state their counterparts in implementing their projects (Table 8). Moreover, the original adopters who are still implementing their systems, answered that 'responsibility for the project' as one of their counterparts. This may indicate a high level of awareness of their commitment.

Develop with impact; empower for the ripple effect. Beyond the numerical results, we find that development programs should be so designed as to consider how they will potentially change the life of the individual and the community holistically. People and communities are generally more open to a development project when they see for themselves how it can positively change their lives. Empowering then should be viewed as a crucial strategy to build within and to broaden the scope of participation over time. In the Bacungan case study, even though it is still early, a small ripple effect emerges in which we see second and third generation SALT 2 systems.

Partnerships are essential. As an old saying goes, 'Two are better than one, for together they can do more.' The community and the situations arising are so complex that there is a demand for pooling of resources. Organisations working together can create more impact in the lives of the people than when working alone. One of the observations of Mr Elmundo, MBRLC Extensionist for the project, was that the overall success of the project was directly related to the good relationships with the Local Government Unit (LGU) and the local farmers' organisation.

A key link in any development process is the change agent. It takes a special kind of change agent to produce results without compromising the process. A significant factor is the change agent's understanding that process and result are an integral part of each other. Another factor would be the change agent's wisdom and skills in working with people. The MBRLC heavily invests in staff because it believes that they are our front line change agents. The better we can make them (with physical, emotional, and educational support), the better they are able to work with communities in development and empower them with their own sustainable change agents.

Models can be good or bad but should be viewed as potential good teaching tools. It is important that people see models as an example of how a system can be potentially good. It is equally important to value the adaptation and its significance made by farmers. These models with adaptations become foundations to build upon as you continue to work together. For instance, none of the first generation adopters' SALT 2 project looked exactly like the MBRLC model. However, what they implemented also became a model for their neighbors who in turn 'adapted' to their needs. Second and third generation adopters built bigger barns, used a little different feed sources, etc. but also still held to the zero-grazing, cut-and-carry system, originally modeled forages, etc.

Some individuals are 'champions'. There are plenty of fine people in communities who have a vision and plenty of 'grit' to pursue their vision. Key in on them as a strategy and work with them and help them realise their dream. Many of these may become the sustainable change agents left in the village after the extensionist/catalyst moves on.

Work from where they are, with their own resources but don't be afraid to help them dream. In Bacungan, they had never seen a total confinement system for animal raising. After being given a long period of time to talk and discuss the advantages and disadvantages, they tried it. Today, they are continuing using the system even after five years. From seeing the benefits of confinement, they are also applying the system to other animals besides goats. Linking with the government and local funding agents, they were able to realise their new dreams.

Development takes time and commitment. Good development is not easy. It does not occur overnight. It is a continuing process. More often than not, it takes a relatively long time to see results. Patience and a high level of commitment would help a development worker to continue on.

Conclusions

Community development is largely a process-oriented discipline that works 'participatorily' with people in helping them have the ability and capability creatively to meet their needs. It basically takes place through growth in awareness, increased interaction in and outside the community, participation and interdependency in decision making and then use of resources available in a way that is just, fair and beneficial to the whole community. It is a long-term process with the overall aim of people assuming their own direction for their lives.

Participatory technology development can be seen as a tool in good community development. By allowing the people themselves to become involved and take responsibility for solving their problem, not only are projects and programs implemented but capabilities and abilities are developed. Through this, people are more likely to gain confidence to attack even larger problems. Remember the goal is not just the technology developed but the change in the people who gain skills in solving their own problems!

Too much emphasis on 'self-help' can be rather unfair. There are technologies, models and outside knowledge which can help the community. Sometimes people are poor and have problems not because of local constraints but because of regional, national and even global economic structures. However, too much reliance on ‘outside-help’ can be equally or even more devastating.

Lastly, we as developers are undergoing a process ourselves as we seek to work with local communities in the same process. As we enter into the lives of local people, our lives become entwined with theirs in the quest for better development. By the time the project is over and the people themselves are moving on to bigger and better things, hopefully we will come away as better developers, ourselves much better prepared for the next task before us. As we participate with people, we, as well as they, will hopefully be refined by the process. If we are truly committed to the community development process and participatory technology development, we will find some new tool, insight, methodology, etc., each time we work with a community.

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Forage Tree Adoption and Use in Asia

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Abstract

Fieldwork was conducted in Asia to examine potentials for adoption of fodder, especially tree legumes, among smallholder farmers with mixed crop and livestock systems. Analysis of traditional systems in Bali suggested that farmers were likely to grow trees for fodder if agriculture was intensive; cattle were penned and fed by cut-and-carry; agroforestry was an integral part of local systems; shade-intolerant annual crops were not relied upon as the major agricultural output; and trees were superior to other sources in providing fodder in the dry season. Work with farmers at sites in Indonesia, Vietnam and the Philippines in which forages are being introduced and tested suggested the above and other factors of importance in the adoption of trees and other forages. Farmers perceived legume tree fodders positively in terms of animal health and weight gain; but were less happy about competition with crops, the (perceived) need to mix tree fodder with other sources, insect pests, and slow regrowth. The adoption of new trees also competed with the adoption or use of new grasses, natural grasses (almost universally viewed as healthy mixtures), and crop residues. Farmers did not appear to consider the difficulty of tree establishment as a constraint to adoption.

SMALLHOLDER farms in Asia vary widely in terms of their mixes of annual and perennial crops, trees, and livestock. Farmers with irrigated lowland rice may have few or no trees and a draft animal at most. Many migrant farmers who settle in forest lands and employ slash-and-burn agriculture to produce rice or maize initially plant few trees and have minimal numbers of livestock. In more intensive upland systems, some farmers produce high value crops and have no animals. Other systems feature mixes of crops and livestock.

Those farmers with livestock employ feeding strategies ranging from herding and tethering animals to exploit natural vegetation, to intensive systems characterised by penned animals, cut-and-carry feeding, and planted forages. In between these poles, other feeding systems combine cut-and-carry feeding of both planted and natural vegetation with animal herding or tethering. Crop residues may also form a significant portion of livestock feed. Planted forages include grasses and legumes, with the latter including trees.

The Forages for Smallholders Project (FSP) has worked with small farmers in various sites in Asia on the participatory testing of new forages and animal feeding systems. Farmers somewhat readily adopted some of the fast growing, high yielding grasses, but have been less quick to adopt legume fodder trees.

Fieldwork was conducted to examine under what conditions farmers have adopted and incorporated trees in their mixed systems. Three sites in Bali, Indonesia, were included to provide understanding of systems in which farmers have incorporated many trees and some grasses in their traditional intensive systems. Three FSP project sites, one each in Vietnam, Sumatra (Indonesia), and northern Mindanao (Philippines), were visited to examine the actual or potential adoption of introduced forages, including trees, in these more extensive land use systems.

Methods

Ethnographic and participatory evaluation procedures were used to understand mixed agricultural systems,

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farmers' animal feeding systems, and farmers' perceptions regarding the forages utilised.

A small team of researchers from the Faculty of Animal Husbandry at Udanaya University (Denpasar, Bali, Indonesia), the Environmental Bamboo Foundation, and CIAT visited Besakih and Petang in the uplands north of Denpasar and sites on the island of Nusa Penida to the south of Bali. These sites featured traditional mixed agroforestry and livestock systems ranging in intensity from fully penned animals in Besakih to cut-and-carry combined with tethering in Peteng and Nusah Penida. Farmers were asked about their wet and dry season fodder use and to evaluate the forages used according to their own criteria. Eighteen to 25 farmers were individually interviewed at each site. Field observations were recorded.

FSP sites were visited in central Vietnam (Xuan Loc, near Hue), northern Sumatra (Marenu), and northern Mindanao (Malitbog). At each site, a small group of researchers collaborating with the FSP project visited both forage adoptors and non-adoptors to discuss forage use and evaluations.

The proportion of fodders used by each interviewed group aggregated the individual forage uses across the sample. Most farmers at each site had similar numbers of livestock. Where a few informants had larger herds, care was taken to determine whether their forage use proportions were similar to those of their neighbours and to correct the aggregate use as necessary.

In terms of participatory forage evaluations, farmers evaluated forages using matrices presenting each respondent's species × each respondent's evaluation criteria and by farmers' assignment of relative values (using beans or maize as counters). Individuals differed in terms of both forages used and evaluation criteria. Data were aggregated in two ways: by presenting relative values for those planting a particular forage and employing a given evaluation criterion; and by presenting the percentage of total 'votes' received by a given species × evaluation criterion combination. The first method over-valued the less frequently encountered species × criteria combinations, that is, it ignored the negative 'votes' of informants not using a particular forage and evaluation criterion combination. The second method undervalued the species × evaluation combinations held by the minority. Data aggregated from farmers' individual evaluations were, therefore, presented to show both sets of values.

The matrix method also suffered in that values assigned to a cell could not be less than zero, eliminating relative degrees of negative evaluations. Farmers were then simply asked to name both positive or 'good' and negative or 'bad' characteristics associated with each forage source.

Findings

Traditional intensive crop/livestock/agroforestry in Bali

Nineteen farmers were interviewed in Besakih. The volcanic slopes used by the Besakih farmers extend from some 1000 to 1500 metres above sea level, providing a cool climate and relatively rich soils suited to agroforestry and root crops. Farm size was a mean 0.95 ha, skewed by three extended families. Mean farm size was 0.6 ha for the 16 families (range 0.2–1.0 ha); while the remaining three families had 2.0–4.0 ha. Coffee and sweet potato were the most important crops followed by cassava, citrus, banana, cloves, coconut, and some maize. *Albizia* sp. was grown for timber for the local wood-carving industry.

The modal number of cattle was two (range 2–6 for the 16 families, 7–20 for the three extended families). Cattle were penned and not grazed or tethered. All feed was provided by cut-and-carry. Farmers relied on-farm feed resources ranging from natural grasses or weeds to planted grasses (*Pennisetum purpureum* (Napier grass)), trees (*Calliandra calothyrsus* (calliandra), *Gliricidia sepium* (gliricidia), *Albizia saman*, and jackfriut), and crop residues (sweet potato vines, leaves, and tubers) (Table 1). [n.b., Farmers near a forested hilltop outside of the study area relied more on natural grasses from the common area and planted fewer trees.]

Farms were intensively cultivated, with small parcels separated by 'live fences' comprising a wide mix of trees and a few grasses. Fence row species included the trees gliricidia, calliandra, *A. saman*, *Erythrina orientalis*, jackfruit, avocado, *salak* (a local fruit), and grasses Napier grass and king grass (*P. purpureum* × *P. glaucum*). Farmers admitted that, as all their animals were penned, the apparent live 'fences' were not established as fences per se. It is more likely that these were 'linear fields' established for fodder (and some fruit and timber) and having the advantages of ease of harvest and, more importantly, the deflection of much of the above- and below-ground competition of the trees into adjacent pathways, roadsides, and terrace walls.

Individual farmers in Besakih evaluated the forages they each used, using criteria each saw as important. When data are aggregated to show entries reflecting the mean score for farmers planting a particular forage and using a given criterion (Table 2), calliandra, gliricidia, Napier grass and sweet potato were judged as somewhat equal and superior to *A. saman*, jackfruit, and local grasses. The most important criteria were yield, palatability, and weight gain. Calliandra scored high in terms of weight gain, yield, animal health, and fast growth. Although scoring high across most criteria, gliricidia was especially valued

Table 1. Farmers' fodder sources (%), wet and dry seasons, Bali.

	Besakih			Peteng			Nusa Penida		
	% Farmers	Weight season	Dry season	% Farmers	Weight season	Dry season	% Farmers	Weight season	Dry season
TREE FODDER		37	43		25	37		41	53
G. sepium	78	11	10	100	12	14	100	32	28
C. calohyrsus	100	20	19	28	2	3		–	–
A. saman	33	2	7	22	1	1		–	–
E. orientalis		–	–	50	4	6		–	–
Ficus sp.		–	–		–	–	89	5	23
Sesbania sp.		–	–		–	–	28	4	2
Jackfruit	61	4	7	83	6	13		–	–
PLANTED GRASSES									
P. purpureum	94	19	15	100	21	13		–	–
LOCAL GRASSES	89	11	8	94	24	11	94	25	8
CROP RESIDUES		13	13		24	30		28	33
Sweet potato (tuber, leaf)	89	13	13		–	–		–	–
Cassava		–	–	61	6	8	63	6	6
Banana stalk		–	–	100	14	15	83	12	16
Coconut fronds		–	–	56	4	7	56	1	10
Bean leaf		–	–		–	–	50	9	1
TOTAL		80	79		94	91		94	94

Table 2. Species evaluation*, Besakih, Bali.

	Evaluation criteria										
	% Plant	Yield	Palatability	Weight gain	Animal health	Dry season	Establishment	Fast growing	Planting material	Total	Rank
Use criteria (%)		78	78	72	50	22	22	17	5		
C. calothyrsus	100	5	4	6	5	3	3	5	2	33	1
G. sepium	78	5	4	4	4	3	4	4	4	32	1
A. saman	33	3	3	2	2	2	3	3	3	21	5
Jackfruit	61	3	3	3	2	2	2	2	3	20	5
P. purpureum	94	6	5	5	2	3	3	4	2	30	1
Local grasses	89	4	3	4	2	1	3	1	1	19	5
Sweet potato	89	4	7	7	4	2	1	6	2	33	1
TOTAL		30	29	31	21	16	19	25	17		
Relative importance		1	1	1	5	7	5	4	7		

*Nineteen farmers each planted different species and used different evaluation criteria. Entries are mean scores for those planting a given species and using a given criterion. Relative scores for species are present planting × total. Relative importance of criteria are percent using criterion × total.

for yield. Napier grass was valued for its high yield; and sweet potato (leaves and tubers) especially high for palatability, weight gain, and fast growth.

Only slightly different results emerged when the percentage of 'votes' gained by each species × evaluation criteria was considered (Table 3). The criteria of yield, palatability, and weight gain remained the most important; and the forages *Calliandra calothyrsus*, *Pennisetum purpureum* and sweet potato were still the highest rated. Gliricidia and local grasses followed in popularity. The 'less important' evaluation criteria for Besakih farmers were animal health, ease of establishment, fast growth, dry season productivity, and availability of planting material.

Moving downslope, 18 farmers were interviewed in Petang. Farm size was a mean 0.6 ha. Cassava was the most important crop, followed by citrus, coffee, banana, cacao, cloves, peanut, coconut, ginger, papaya, and maize. As in Besakih, farmers in Peteng relied on their linear fields for tree fodders (gliricidia throughout the year and *E. orientalis* and jackfriut in the dry season) and Napier grass, as well as local grasses and crop residues – banana stalk, cassava leaf, and coconut fronds (Table 1).

Eighteen farmers were interviewed in Sakti on the small island of Nusa Penida, off the southern coast of Bali. Mean farm size was 2.0 ha (range 0.3–7.0 ha, mode 1.5 ha). The island receives less rainfall, has a drier dry season, and has poorer (limestone) soils than the Balinese uplands. The main crops were cassava, maize, coconut, banana, and beans.

The mean number of cattle was three head per family (range 1–5, mode, 2 head). Cattle were fed by tethering (largely on each farmers' own lands, often under coconut) and by cut-and-carry. Farmers relied on tree fodders, including gliricidia throughout the year and Ficus sp. in the dry season. Local grasses were abundant in the wet season (accounting for 25% of cut-and-carry fodder), but were less abundant in the dry season. Banana stalk was an important feed source throughout the year (Table 1).

Although farmers in Sakti agreed that *Sesbania* sp. (sesbania) was superior to all other forages in terms of weight gain, palatability, and animal health, only one fourth of the farmers maintained the tree, which accounted for only 4% of feed in the wet season and 2% in the dry. Sesbania was not more widely adopted because of its short life span. On the other hand, although Ficus sp. was viewed as providing poor quality fodder, it served as an 'insurance' feed source in the dry season adopted by 50% of the farmers and providing 23% of dry season fodder.

Forages for Smallholders Project: Cooperators, non-cooperators, adoptors, and non-adoptors in Sumatra, Vietnam, and northern Mindanao

The FSP site in Marenu, Sumatra, is a recently settled transmigration site. Farmers, both FSP project

Table 3. Species evaluation*, Besakih, Bali.

		Evaluation criteria									
	% Plant	Yield	Palatability	Weight gain	Animal health	Dry season	Establishment	Fast growing	Planting material	Total	Rank
Use criteria (%)		78	78	72	50	22	22	17	5		
C. calothyrsus	100	5	5	5	3	1	1	1	<1	21	1
G. sepium	78	4	3	3	2	<1	1	1	<1	15	4
A. saman	33	1	1	<1	<1	<1	<1	<1	<1	3	7
Jackfruit	61	2	2	2	<1	<1	<1	<1	<1	7	6
P. purpureum	94	6	5	5	1	1	1	1	<1	20	1
Local grasses	89	4	3	3	2	<1	1	<1	<1	14	4
Sweet potato	89	4	6	6	3	<1	<1	1	<1	21	1
TOTAL		26	25	24	11	3	5	5	2	100	
Relative importance		1	1	1	4	7	5	5	8		

*Entries are percentage of all 'votes' for each species × evaluation combination. Species rank and relative importance of criteria reflect respective sums of rows or columns.

cooperators (n = 10) and non-cooperators (n = 8) reported having a mean of one ha; although some may have had more land and reported the 'official' land holding for settlers. Cooperators had a mean 34 head of sheep; while non-cooperators had 19. The main income sources for cooperators were sheep, upland crops, and off-farm labour. Cooperators additionally claimed lowland rice and oil palm as main income sources. Cooperators complained of wild pigs, drought/lack of water, lack of capital, lack of job opportunities, and sheep theft as problems. Non-cooperators saw pigs, lack of capital, and drought/lack of water as problems. It appeared that non-cooperators had fewer sheep than cooperators, but were more successful in terms of off-farm employment and in the establishment of lowland rice paddies and oil palm plantations.

Sheep were fed by combined grazing on commons and cut-and-carry for mornings and evenings, when animals were penned. Both cooperators and non-cooperators planted grasses and trees. Rates of adoption for several grasses were higher for cooperators, with non-cooperators relying more on king grass than cooperators. Half of the cooperators, but none of the non-cooperators, had sown *S. guianensis*; and more cooperators than non-cooperators had adopted and were using gliricidia and *L. leucocephala* (leucaena). Non-cooperators relied more upon local grasses than cooperators in the dry season (Table 4). Farmers' evaluations of fodder species were recorded in terms of positive and negative qualities of each (see below).

Ten FSP cooperators and 8 non-cooperators were interviewed in Xuan Loc, near Hue, in central Vietnam. Besides producing lowland rice and sugar cane, almost all farmers were tree planters. Most had fairly large numbers of fruit trees; a large proportion managed re-forestation areas under government contract; and a high proportion had family land similarly sown to plantation forests.

Comparing cooperators and non-cooperators, cooperators had more land (mean 2.4 ha vs 1.6 ha), but, for families having each enterprise, similar areas of lowland rice (0.2 ha), sugar cane (0.2 ha), areas under family forestry (1.3–1.4 ha) and numbers of cattle (4.0–4.4). Greater proportions of cooperators, however, had sugar cane, family forestry, and cattle (67% vs 50%). Although fewer non-cooperators had water buffalo, those having such animals had a higher number per family. More non-cooperators cared for government forest plots than cooperators, but they had smaller areas than cooperators having such contracts (7.5 ha, cf. 9.7 ha) (Table 5).

Farmers identified problems as lack of water for crops, lack of capital, low soil fertility, and lack of transport, followed by a lack of labour for grazing livestock and a lack of grazing land.

Cooperators were just becoming familiar with some of the grasses and a small number of trees through testing (on small plots) as a part of FSP activities. The main evaluation criteria used by farmers were palatability, 'quality', yield, weight gain, and animal health. If the evaluations of farmers using particular species and evaluation criteria are

Table 4. Forage use, FSP cooperators and non-cooperators, wet and dry seasons, Marenu, Sumatra.

	Cooperators			Non-cooperators		
	% Farmers	WS	DS	% Farmers	WS	DS
TREES		25	19		13	12
G. sepium	90	10	7	38	4	3
A. saman	50	6	5	50	4	4
L. leucocephala	90	9	7	50	5	5
LEGUMES						
S. guianensis	50	8	4	0	0	0
LOCAL GRASSES	80	12	17	63	19	32
PLANTED GRASSES		45+	50		61	45
P. atratum	90	15	15	100	20	15
P. guenoarum	100	16	12	75	11	8
B. humidicola	60	4	12	25	7	6
B. decumbens	60	7	6	50	9	6
S. sphacelata	20	3	3	13	1	1
King grass	10	<1	2	63	13	9
TOTAL		91	90		93	80

compared (without reference to the actual proportions of farmers actually using a given forage and/or evaluation criteria), native grasses were given highest marks due to high scores in terms of quality, palatability, and yield. *P. maximum* was also rated highly across criteria, and especially in terms of palatability (Table 6). The trees gliricidia and leucaena, although planted by 77% of the informants, scored low across criteria. Factoring in proportions of farmers planting a given forage and using particular evaluation criteria, native grasses, *P. maximum*, and *S. guianensis* (which all farmers were testing or using) were given highest ratings.

Ironically, farmers' tree planting practices appeared to work against the adoption of fodder trees. Most farmers planted a wide range of fruit trees in their home gardens and cared for forest plantations on both their own and on government lands. Introduced fodder trees had to compete with fruit trees in the home gardens and with commercial timber elsewhere. Because farmers perceived the potential for receiving high (and apparently low-risk) returns from forestry, the enterprise competed with livestock husbandry. Maturing forest plantations also resulted in less available natural fodder for either grazing or cut-and-carry. Some farmers had reduced

Table 5. Production assets, Xuan Loc, Vietnam.

	Participants (n = 10)			Non-participants (n = 8)		
	% Sample	Mean	Range	% Sample	Mean	Range
Farm size (ha)	100	2.4	0.3–8.0	100	1.6	0.3–3.4
Paddy area (ha)	83	0.2	0.1–0.3	88	0.2	0.1–0.2
Sugar cane (ha)	89	0.2	0.1–0.3	57	0.2	0.1–1.0
Family forestry (ha)	83	1.4	0.1–5.0	29	1.3	0.5–2.0
Contract forestry (ha)	27	9.7	6.0–20.0	50	7.5	6.0–10.0
Fruit trees (units)	100	104	23–290	86	140	29–280
Cattle (animals)	67	4.4	1–10	50	4.0	1–10
Buffalo (animals)	44	1.7	1–3	25	4.0	3–4

Table 6. Fodder assessment (n = 13), Xuan Loc.

		Criteria								
	% Farmers	Palatability	Quality	Yield	Weight gain	Animal health	Total	Rank	Corrected total	Corrected rank
Use criteria (%)	–	100	85	77	70	38				
S. guianensis	100	2	3	3	3	3	14	4	14	1
P. maximum	70	6	4	4	4	2	20	2	14	1
B. ruziziensis	31	3	7	3	2	2	17	3	5	6
Native grasses	46	7	8	7	4	3	29	1	13	1
G. sepium	77	2	2	2	2	1	9	5	7	5
L. leucocephala	77	2	2	2	1	3	10	5	8	4
TOTAL		22	26	21	16	14				
Relative importance		2	1	2	4	4				
Corrected total		22	22	16	11	5				
Relative importance		1	1	3	4	5				

*Entries are relative mean scores for those planting a given species and using a given criterion. Ranking of species and relative importance of criteria were calculated from sums of rows and columns, respectively. Corrected totals and ranking reflect proportion of those using the species and criterion.

their animal numbers; and the community as a whole may reduce cattle and buffalo numbers further to just the point where draft needs are met.

Future forage adoption will depend on the relative economic importance of lowland rice, sugar cane, forestry, and livestock. The importance of livestock will depend on needs for draft, the importance of farmyard manure, and the long-term investment advantages of cattle compared to forestry. A guess would be that cattle numbers would either stay the same or decrease. Livestock enterprises may, however, intensify in response to demand from Hue, possibly requiring higher quality feed produced on small on-farm areas.

A short period was spent in Malitbog in northern Mindanao, in the Philippines. Small farmers have one or two head of cattle fed by tethering and cut-and-carry. Main crops are bananas, maize, and coconut. Although FSP cooperators were testing a range of new forages, many appeared to be interested in the possibility of receiving cattle via government dispersal programs (which traditionally required adoption of new forages as a pre-requisite). The high availability of banana stalk and open grazing lands meant that fodder resources were available, a factor working against new forage adoption. One community had a large area of mature leucaena trees, which was not being used as a major fodder source. On the other hand, dry-season fodder shortages and increasing demand for meat in the city of Cagayan de Oro may eventually lead to an increase in the genuine adoption of new forages for cattle-fattening enterprises.

An evaluation of forage species across sites

Farmers across sites were asked to name positive and negative characteristics associated with their different forage options (Table 7). The results were aggregated because of the substantial consensus across sites in the three countries (albeit, farmers at each site had a different suite of forages and, therefore did not evaluate all species).

The legume trees, calliandra, gliricidia and leucaena were viewed positively in terms of yield, palatability, animal weight gain, and animal health. Negative characteristics included the need to mix leguminous tree fodder with other fodders, pests, and leaf fall in the dry season (gliricidia). *Sesbania* sp fodder was considered of especially high value in Nusa Penida, but was not more widely planted because of its short life span. Although viewed as producing fodder of low nutrient value, Ficus sp. and jackfruit were valued for their needed dry season productivity. Vietnamese farmers appeared to prefer to plant fruit rather than fodder trees in their home gardens. *Albizia* sp. and jackfruit were valued for their timber as well as fodder.

Although farmers agreed that *Stylosanthes* spp. were good in terms of animal health, nutrition, and weanlings, slow regrowth and itchiness (for farmers harvesting the fodder) were described as problems. Informants disagreed as to the palatability and drought tolerance of *Stylosanthes*.

Most of the planted grasses were found to be desirable in terms of fast growth, high yield, palatability, weight gain, and ease of harvest. Common complaints about the grasses included that old growth was not palatable and crop competition. Farmers sought grasses which were tolerant of cutting and drought, adapted to low soil fertility, and grew quickly after cutting.

Farmers across sites generally favoured their natural grass mixtures as being fast-growing, good for animal health and weight gain, palatable, and, of course, available. In some areas, low production in the dry season was mentioned as a problem.

Sweet potato tubers and leaves were used for cattle fattening and ‘finishing’ in some of the upland areas of Bali. Cassava leaf was commonly used as fodder in many areas, and was also viewed positively in terms of animal weight gain. Banana stalk was a significant fodder source at several of the sites. Among several positive characteristics was that it also provided water in the dry season.

Discussion and Conclusions

Recent studies concerning the adoption of trees on farm, especially for fodder, range from pessimistic to hesitantly optimistic. Case studies in Nepal and India have shown that, in spite of increased tree planting for fuelwood and shifts from open grazing to stall feeding, farmers have relied heavily on crop residues and forage grasses to meet needs for animal feed. Researchers concluded for these cases that ‘In contrast to the previous analysis of fuel, trees on farm do not appear to be a viable strategy for livestock feed’ (Warner et al. 1999). Another review of forage husbandry in the tropics concluded that, ‘A wide and diverse range of trees and shrubs are used as fodder, but few are planted. When they are planted, it is seldom primarily to provide forage. Rather, forage is a by-product of fruit trees, live fences, and erosion-control strips, and makes the planting of these trees more attractive to farmers’ (Bayer and Waters-Bayer 1998, p. 139).

On the other hand, farmers in the highlands of Nicaragua (in an area somewhat similar to the sites visited in Java) used *Leucaena* spp. and gliricidia as fodder sources. They also maintained naturally occurring *Guazuma ulmifolia* and *Acacia pennatula* trees because of their dry-season forage productivity (Nicola Maria Keilbach, personal communication, cited in Bayer and Waters-Bayer 1998). A collection of studies from South Asia and Eastern Africa indicated that, in general, the (albeit few) observed shifts to more intensive on-farm tree planting were occurring in regions undergoing agricultural intensification, and that this intensification has taken place in the more arable and productive areas with relatively higher rainfall (Arnold and Dewees 1997).

For the areas visited in this study, several factors would appear to affect decisions regarding forage and tree forage adoption by smallholder farmers with mixed crop and livestock systems. Tree adoption was encountered where a combination of relatively high populations over a fixed land area had led to agricultural intensification. In Bali, such intensification featured high to exclusive reliance upon cut-and-carry feeding for penned animals; and a high reliance upon forages planted on-farm. In these cases, off-farm commons or open access areas

Table 7. Farmers' evaluations of fodder species.

Species	Good attributes	Bad attributes
LEGUMES		
Albizia sp.	Commercial wood, weight gain, palatable, fast growing, drought tolerant	Difficult to harvest, diarrhoea, not palatable, slow regrowth, excess leads to hair loss
Calliandra calothyrsus	Weight gain, yield, palatable, animal health	Root competition, must mix w/other fodders, reduces animal fertility
Erythrina sp.	Weight gain, palatable, animal health	Low yield, diarrhoea
Gliricidia sepium	High yield, weight gain, animal health, milk production, palatable, prevents diarrhoea, easy to grow, easy to harvest, cutting tolerant, long life	Not palatable if fed too much , must mix, lowers cattle fertility, leaf fall in DS, slow regrowth, pests
Leucaena leucocephala	Palatable, high milk production, easy to harvest, drought tolerant, cutting tolerant, quick regrowth	Pests, must mix, excess causes ewes to bleed
Sesbania sp.	Animal health, weight gain	Short life
Stylosanthes guianensis	Nutrition, animal health, good for weanlings, palatable, drought tolerant	Old growth not palatable (OGNP), itchy, not drought tolerant, slow regrowth, not palatable
GRASSES		
Branchiaria humidicola	Drought tolerant, quick regrowth, cutting tolerant, palatable, easy to maintain	Less leaf production, OGNP, crop competition, cannot plant other crops on same land after
Paspalum atratum	Quick regrowth, cutting tolerant, drought tolerant, high leaf yield, easy to harvest, palatable, all parts consumed	Sharp edged, OGNP
P. guenoarum	Fast regrowth, cutting tolerant, yield, easy to harvest, palatable, weigh gain, produces in DS	Not drought tolerant, OGNP, rots if cut too low
Pennisetum purpureum	Weight gain, fast growing, perennial, yield, palatable, easy to harvest, available	OGNP, must mix, no contribution to animal health, needs fertiliser
Pennisetum hybrid (king grass)	Easy to establish, quick regrowth, palatable, easy to harvest, yield	OGNP, crop competition, not drought tolerant, difficult to maintain, itchy
Setaria sphacelata	Quick regrowth, palatable, drought tolerant	Short life
Local grasses	Natural mixtures for animal health, fast growing, weight gain, palatable, available	Low productivity in dry season
OTHERS		
Ficus sp.	Produces in DS, long life	Low nutritive value, low yield, one harvest per year, not for animal health, shade competition
Jackfruit	Available in dry season/drought resistant, timber, prevent diarrhoea	Low nutrient value, constipation
Sweet potato	Fattening and animal 'finishing'	Diarrhoea
Cassava leaf	Palatable, weight gain	Not palatable 3 days after harvest, bloat
Banana stalk	Animal health, provides water in DS, palatable, easy to harvest, increases milk production in DS	Diarrhoea if fed in excess

supplying grazing land or fodder for cut-and-carry were not available. Indeed, in Besakih every plant – trees, crops and weeds – was privately owned. Fodder tree adoption also appeared more likely where farmers were already agroforesters, growing a range of trees for a variety of purposes. Agroforestry itself also appeared more likely where systems were not largely reliant upon shade intolerant annual crops, such as upland rice or maize. Finally, fodder trees were likely to be adopted where a marked dry season significantly decreased the relative availability of fodder from plants other than trees, as compared to tree sources.

The presence of adequate fodder sources in the form of open grasslands, grasslands under coconut, crop residues (e.g, banana stalk in Indonesia and the Philippines), and the growing of field crops for animal feed (some of the sweet potato in Besakih) would tend to decrease adoption of fodder trees. Livestock serve as a 'bank account' for many small farm systems. Family forestry (in Vietnam) served the same purpose and was viewed as a better long-term investment, thus 'competing' with livestock as an enterprise.

Farmers in project areas may also genuinely adopt new forages as they shift from herding and grazing to increased stall feeding (e.g., goats in Marenu) or spuriously in the hope of receiving animals through cattle distribution programs (e.g., Malitbog). These factors are synthesised in a farmers' decision tree (Figure 1).

Implications for the Forages for Smallholders Project

The FSP is correct in offering farmers at selected sites menus of forage grasses, legumes, and trees; and in facilitating farmer-participatory research in the testing of the introduced materials. The fieldwork reported on in our survey gives rise to several other suggestions:

1. Selection of project sites needs to examine existing forage resources carefully and also the possibly changing relative profitability of livestock over other on- or off-farm enterprises. There may be little opportunity for intensification where livestock simply take advantage of available native forages or where other enterprises such as forestry would 'compete' with livestock.
2. Areas undergoing intensification – e.g. where land is becoming less available and penned animals are replacing grazing – would be likely for the adoption of new forages. 'Linear fields', such as those encountered in Bali, may be appropriate for mixes of trees and grasses where open fields are not available.
3. Farmers in areas with more available land and natural forage resources may still be interested in new grasses and possibly trees if there are clear advantages in terms of dry season productivity. Farmers were willing to plant or use fodder trees producing inferior feed as long as dry season production was assured when needed. The *el Niño* related drought appears to have generated interest in Kalimantan when the new forage species provided the only green to be seen (W.W. Stür, pers. comm. 1999).
4. Farmers expressed a range of perceptions regarding the suitability of legume forages. In general, although good for weight gain and animal health, farmers also thought that legumes needed to be mixed with other foods, that animals refused to eat more than small amounts, and that fertility-related problems could arise. If not already doing so, the project may need to work with farmers willing to experiment with feeding regimes to determine the soundness of such perceptions. Farmers at one FSP site are apparently now more interested in *G. sepium* after recently finding that their goats would, contrary to previous belief, consume lopped branches from the tree (W.W. Stür, pers. comm. 1999).
5. Further research is needed on the gender and age distribution of labour for cut-and-carry systems. Although male informants generally claimed to contribute equal shares of labour to that contributed by women, observations give the impression that women contribute more for cut-and-carry and that children provide more for grazing and tethering. Women may have less involvement in fodder or tree planting decisions; and the opportunity costs of children's labour may be low. Both factors could reduce adoption of new forages.
6. Crop residues were a major animal feed source in the areas visited. The FSP may want to integrate crop residues within any on-farm research.
7. Where natural forages are plentiful, the FSP may want to work with farmers to address the resource use/access issues associated with such forages in order that farmers may benefit from improved management of the resource. For example, communities may be able to work together on enriched natural pastures.
8. Finally, and to repeat several points above, farmers did not appear to be worried about the establishment costs in terms of time to productivity and care of seedlings associated with trees. Competition with crops, longevity, recuperation and regrowth after lopping, tree pests, and fodder suitability were main concerns.

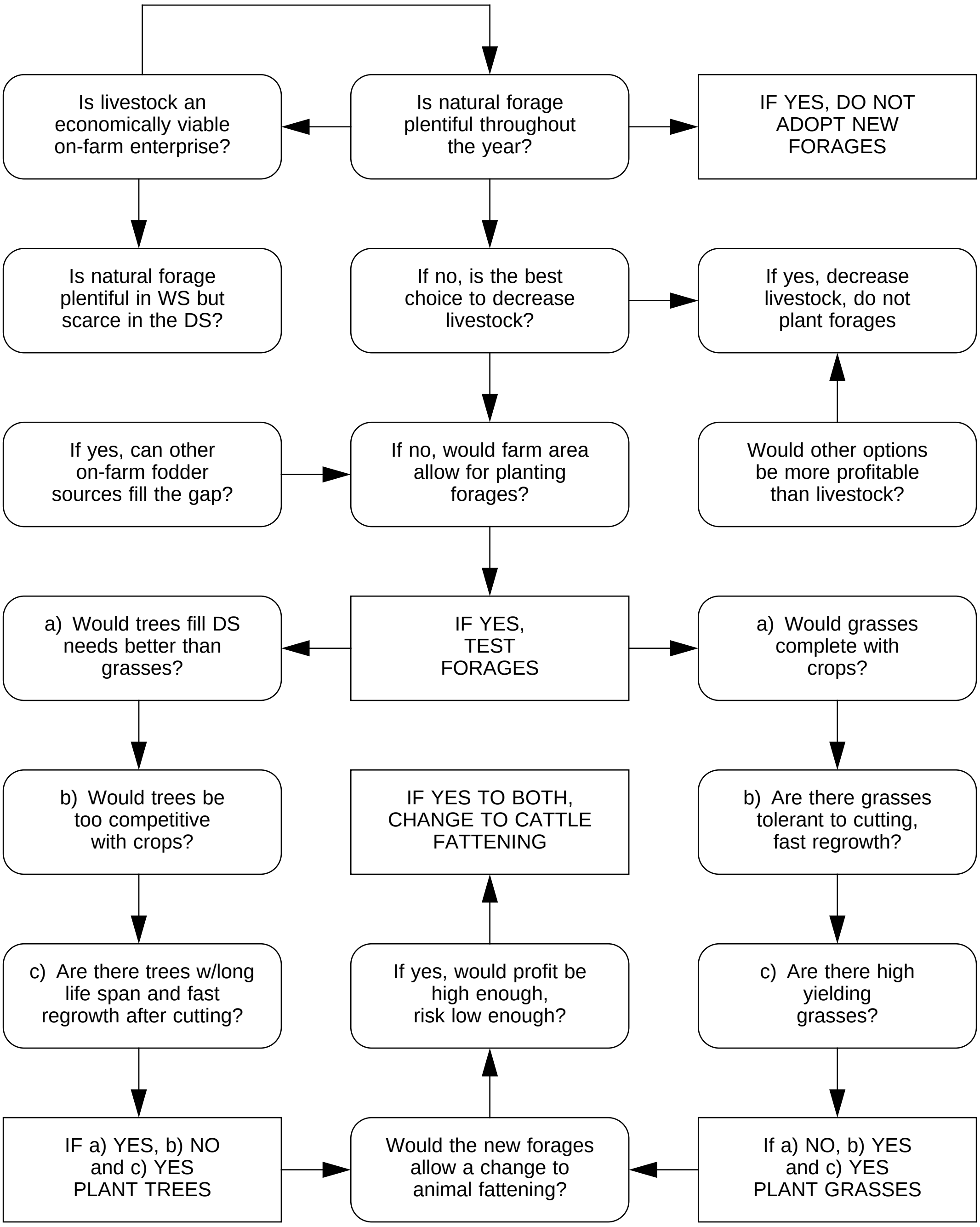

Figure 1. Farmer forage and tree adoption decision model.

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Participatory Methods in Research and Extension for Using Forages in Conservation Farming Systems: Managing the Trade-offs between Productivity and Resource Conservation

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Abstract

This paper reviews recent experiences related to the development and adoption of forages used for both ruminant nutrition and erosion control. It examines both technical and institutional innovations that were combined into successful adoption processes. It also highlights the interaction between the technical components and the institutional arrangements that have facilitated the dissemination of soil conserving practices through farmer-led organisations. Some forms of contour hedgerow systems combine erosion control on sloping land with the provision of added ruminant fodder for the farm enterprise. Others, for example, vetiver grass hedgerows, are employed basically to conserve soil, water and nutrients, while still others, such as alley cropping, are used with the objective of both erosion control and fertility improvement. The first section of the paper gives background on the current state of knowledge about the various practices, and the directions toward systems that are more attractive to farmers. The second section discusses the benefits and constraints of different systems. The third section presents results from researcher-managed and farmer participatory research (FPR) trials on the effectiveness of various contour hedgerow systems to control erosion in cassava-based cropping systems on sloping land. It describes the potential and constraints of the various species or systems used, and indicates under what circumstances they are most likely to be adopted by cassava farmers. The fourth section describes a participatory research process that led to the identification of natural vegetative strips as a farmer-preferred and widely adopted practice in the uplands of the southern Philippines. The final section discusses the evolution of a farmer-driven Landcare movement in the Philippines, and highlights the potential for this institutional innovation to spread knowledge about forage production systems, and provide a mechanism for involving large numbers of farmers in adaptive research to experiment with forage production systems.

DEVELOPMENT and diffusion of agricultural technologies for upland smallholder farming systems is a complex challenge. The environments and farming systems for which the practices must be designed are enormously diverse. Farmers who might use these technologies generally have little investment capital and by necessity have short investment horizons. Markets are often remote, transport is difficult and costly, and research and extension services are usually inadequate. Steep slopes and low inherent soil fertility provide a fragile resource base. In light of all these constraints, it is obvious that technology development has to be done in close collaboration with the farmers. And extension methods for the dissemination of new practices need to be more demand-driven.

In the countries of Southeast Asia, sloping uplands cover about 60% to 90% of the total land area (Garrity and Sajise 1991). In these hilly areas, the soils are generally highly weathered, infertile, and often of shallow depth. Many are strongly acidic (pH <5.5), and have a low to moderate organic matter (OM) content, low cation exchange capacity

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and base saturation, and low levels of available phosphorus (P). More than 40% of the arable land in the region consists of acidic upland soils classified as Ultisols and Oxisols (Craswell and Pushparajah 1990). It has been determined that soil erosion, as estimated by river sediment load per hectare of watershed, is much more serious in Southeast Asia than in any other region of the world (Milliman and Meade 1983).

Strategies to effectively control soil erosion by water either dissipate the kinetic energy of raindrops before they hit the soil surface, or reduce the velocity of run-off water and increase the water infiltration rate. Measures that employ these principles are classified as either engineering or vegetative techniques. Vegetative practices are generally less expensive and labour-demanding than are engineering practices. They maintain a living or dead vegetation cover to dissipate the force of falling raindrops or use vegetative barriers to reduce the velocity of water runoff.

The vegetative soil conservation technologies that have been used traditionally by farmers in the Philippines and Indonesia include the planting of hedgerows of *Leucaena leucocephala* or *Gliricidia sepium* and/or grasses such as napier grass (*Pennisetum purpureum*) (Kang et al. 1984; IIRR et al. 1992), or retaining natural vegetation in contour lines across the slope (Tung and Alcober 1991). Multi-storey agroforestry systems, commonly found in the Philippines and Indonesia, may also serve as a soil conservation measure. Farmers' local knowledge has proven to be a fruitful base for the development of improved technologies.

Soil conservation innovations, from mechanical methods such as terrace construction (PCARRD 1984) to biological erosion control using planted multi-purpose tree and grass hedgerows (IIRR et al. 1992), have been widely introduced to farmers cultivating sloping lands in the Philippines. Among the vegetative measures, the planting of contour hedgerow has been strongly promoted by government agencies and non-governmental organisations, and has become a major focus of research and extension (PCARRD 1997; Nelson et al. 1998a). The technology has become known in the Philippines and Vietnam as 'Sloping Agricultural Land Technology' or 'SALT' (Tacio 1991; Partap and Watson 1994). Government and non-governmental organisations have been promoting SALT as the basis for sustainable farming on sloping lands during the past two decades.

The following section of the paper gives more background on the current state of knowledge about the various practices, and the directions toward systems that are more attractive to farmers.

The second section discusses the benefits and constraints of the different systems.

The third section presents results from researcher-managed and farmer participatory research (FPR) trials on the effectiveness of various contour hedgerow systems to control erosion in cassava-based cropping systems on sloping land. It describes the potential and constraints of the various species or systems used, and indicates under what circumstances they are most likely to be adopted by cassava farmers.

The fourth section describes a participatory research process that led to the identification of natural vegetative strips as a farmer-preferred and widely adopted practice in the uplands of the southern Philippines.

The final section discusses the evolution of a farmer-driven Landcare movement in the Philippines, and highlights the potential for this institutional innovation to spread knowledge about forage production systems, and provide a mechanism for involving large numbers of farmers in adaptive research to experiment with forage production systems. The paper concludes with some suggestions for needed research.

Contour Hedgerow Systems to Control Erosion

SALT and alley cropping systems

In these hedgerow systems, leguminous trees are commonly planted in double rows along the contour line on cultivated slopes, with field crops being grown in the alleys between them (Kang and Wilson 1987). Periodic pruning of the hedgerows reduces shading and provides either green manure to maintain soil fertility (Kang and Wilson 1987; Nair 1993) or supplies high-quality fodder for livestock. The leguminous trees may contribute nitrogen (N) to the system through N fixation, and recycle phosphorus (P) and potassium (K) by absorbing these nutrients from lower soil layers and depositing them on the soil surface in fallen leaves or prunings.

Tree hedgerows tend to reduce soil loss by 50% to 95% under a wide variety of soil and slope conditions (Garrity 1995). They also, in many cases, have the potential to contribute to the maintenance of acceptable soil fertility levels (Kang et al. 1984; Young 1989; Partap and Watson 1994). Modelling work to predict the long-term changes in soil erosion and crop yield in the Philippines suggests that contour hedgerow systems can slow down crop yield decline, but might not halt or reverse the degradation process (Rusastra et al. 1997; Nelson et al. 1998b). Kang (1993) and Kang et al. (1996) note that the tree hedgerow technology generally has limitations in dry areas and on acidic and poor soils. Phosphorus is often a critical nutrient in systems on strongly acidic soils with low external inputs. The quantities of biomass produced by the hedgerows may be sufficient to supply nitrogen (N) to a maize crop with moderate grain yield of 4 tonnes/ha, but they cannot supply an adequate quantity of P to sustain this yield level (Garrity 1993; Palm 1995). Thus, in continuous production systems, the tree-crop system cannot recycle sufficient amounts of P to meet crop growth needs and replace the amounts removed with the crop harvest. The strategic use of manures or fertilisers is essential to sustain yields in this situation.

The adoption of tree hedgerows by upland farmers in the Philippines has been slow (Nelson 1994; Gerrits et al. 1996). There have been significant constraints to adoption of these systems. These include high establishment and management costs, substantial labour requirements, reduction of the area available for field crops (Smyle and Margrath 1990; Garrity et al. 1993), competition between the tree and crop components, negative allelopathic effects (Nair 1993), the unavailability of adequate amounts of planting material of suitable species, and insecurity of land and tree tenure (Tung and Alcober 1991; Garrity et al. 1993; Carter 1996). Contour hedgerow intercropping has often been disseminated through standard extension packages, notwithstanding the above mentioned constraints and location-specific conditions that require different solutions for different situations (Garrity 1996).

Contour grass strips for cut-and-carry animal fodder

The use of narrow grass strips planted along the contour as a source of animal fodder is another contour hedgerow technology (Lal 1990) commonly applied by farmers who own cattle. A disadvantage of this practice, however, is that when the biomass is removed as cut-and-carry fodder, there is a continuous nutrient drain from the system, if animal manure is not returned to the field. Garrity and Mercado (1994) observed that grass strips of napier grass reduced maize yields by 86% within two years in an on-farm trial in Claveria, Mindanao. This indicates that the competitiveness of the grass was very strong, and that an unsustainable draw down of nutrients and water was occurring.

Vetiver grass hedgerows for soil and water conservation

An alternative approach, initially promoted mainly by the World Bank (World Bank 1990) and now widely promoted by government organisations in Thailand (Office of the Royal Development Projects Board, 1998) and elsewhere, is the planting of contour hedgerows of vetiver grass (*Vetiveria zizanioides*). The main objective is to reduce soil erosion and losses of water and nutrients in runoff. The prunings of vetiver hedgerows are useful as in situ mulch to recycle nutrients, cover the soil, and reduce rainfall impact and erosion. The cuttings may also provide additional income as a roofing material or as a medium for growing mushrooms. However, they produce a very low quality fodder, and are not very suitable for ruminant feeding. Many farmers prefer their hedgerows to be composed of a species that provides a more useful economic product.

Natural vegetative strips (NVS)

The constraints observed with both trees and forage grasses have stimulated interest in an alternative concept, the use of non-competitive species as hedgerow plants (Garrity 1993). Recently, research has recognised natural vegetative filter strips as a low-cost and more readily adoptable technique to reduce soil erosion (Garrity et al. 1993; Fujisaka et al. 1994). NVS are installed by leaving a narrow contour strip unploughed during land preparation. This band, usually about 50 cm wide, fills in naturally with local grass and broadleaf weed species. Over time, the vegetation community shifts toward perennial grasses. In northern Mindanao, the major species in natural vegetative strips include *Paspalum conjugatum* and *Imperata cylindrica*. Another method of establishing natural vegetative strips is to pile crop residues along the contour lines. The natural vegetation establishes in this organic mulch as it decays.

The natural vegetative strip technology is not a new practice. The use of NVS and grass strips is a traditional soil conservation practice in some parts of the world (Reij 1988; Mwaniki 1991; Tung and Alcober 1991; National Research Council 1993). In the Philippines, examples of the traditional use of natural grass strips for soil conservation have been documented (Tung and Alcober 1991) on shallow limestone soils in Matalom, southern Leyte. However, natural vegetative strips also seem to be more recently applied or rediscovered as a low-cost method to reduce runoff and erosion on sloping land (Kemper et al. 1992). As well as reducing soil erosion, natural vegetative strips have also been used as a basis for incorporating perennials into contour farming, such as fruit and timber trees for cash, and for creating more complex agroforestry systems (Garrity 1993).

In the late 1980s, about 180 farmers in Claveria, Northern Mindanao, were trained through farmer-to-farmer extension in installing leguminous tree hedgerows to deal with soil erosion. They were strongly aware of erosion as a major constraint to the permanent cultivation of sloping fields in the area. Farmers started retaining natural vegetation (largely grasses and non-woody perennials) as hedgerow species instead of investing time on planting trees or fodder grasses. These activities were independent from the formal research being conducted on hedgerow intercropping with leguminous trees and fodder grasses (Fujisaka 1993). Several hundred farmers in Claveria installed natural vegetative strips on their sloping fields without outside extension efforts. NVS became popular as the preferred soil conservation technology in the area (Garrity et al. 1998). The major reason for the rejection of the introduced contour hedgerow technology was the high establishment and management costs associated with planted hedgerow species. Secondary reasons included: competition between vigorous hedgerow species and crops, unavailability of planting material and insecurity of land tenure (Garrity et al. 1993). Initial research on natural vegetative strips indicates that they compete less with adjacent field crops than do tree hedgerows and fodder grasses (Ramiara-manana 1993). NVS have also been shown to be at least as effective in reducing soil erosion as tree hedgerows, and are usually more effective (Garrity et al. 1993).

The width of alleys between adjacent hedgerows may vary to accommodate farmers' desired cropping and cultivation practices. It has been recommended that contour hedgerows be spaced at one to two metres vertical interval, to ensure effective soil erosion control (CFSCDD 1986; Prinz 1986; World Bank 1990). This translates into a 3.5 to 7-metre alley width (i.e. distance between hedgerows) on hillsides with 25% slope. The vegetative strip is commonly 0.5 to 1 metre in width. In such a case about 10% to 25% of the crop area is occupied by the hedgerows. Most farmers, however, prefer wider hedgerow spacing to minimise the crop area lost. Experiments conducted at ICRAF's research site in the Philippines have been investigating the effects of different vertical elevation intervals between hedge-rows on the amount of sediment loss and yield reduction. Results showed that as the spacing between hedgerows increased, soil loss declined, but at a decreasing rate. The study concluded that the establishment of hedgerows at a 2 to 4 metre eleva-tion drop is most practical (Mercado et al. 1997). Similar results were obtained by Inthaphan et al. (1998) for the spacing of vetiver grass hedgerows.

Aside from using natural vegetative strips, some farmers in Claveria maintain their tree hedgerows, but leave the hedgerow system fallow, commonly for one to three years. The system has been termed a 'fallow-rotational hedgerow system' (Garrity 1994). This system has also been observed in some other locations in the Philippines, for example in Matalom, southern Leyte (Fujisaka and Cenas 1993). The reason for choosing this kind of contour hedgerow management is explained by the limited availability of labour, and the lack of alternative ways to main-tain soil fertility (Suson et al. 1997).

Garrity (1994) emphasised that research on sus-taining annual crop production on sloping lands needs to follow two pathways: (1) when external nutrient inputs are not available, continuous farming depends on strategies based on fallowing, but (2) when external nutrients can be applied, low-maintenance contour hedgerows are a preferred system to reduce soil erosion and to provide a basis for more pro-ductive agriculture or agroforestry systems.

Benefits and Problems of Contour Hedgerow Systems

Narrow grass strips derive their effectiveness in con-trolling water erosion by shortening the slope length and slowing down runoff water flowing through the close-growing grass strips, and from the increased infiltration rate of water in soil under sod cover, which in turn reduces total runoff. Mature dense grass slows down runoff water, and diffuses and spreads concentrated water flow so that it trickles through the grass barriers with little or no further erosion. As the flow rate of the water is slowed down, and the amount of runoff water is reduced, sediment from the cropped field is deposited within or directly above the grass strip (FAO 1965). The deposition of sediment is accelerated by the adsorp-tion of negatively charged clay particles to positively charged dead plant parts (Wilson 1967). Over time, the deposition of the sediment load results in filling up of rills, ephemeral gullies and related depressions and facilitates the formation of terraces, creating a series of stable bench terraces on the cultivated slope. Even though vegetative contour bunds are usually very stable, rodents may damage grass barriers, which can reduce the effectiveness of the barriers or in some cases cause them to fail (Kemper et al. 1992).

The deposition of sediments above contour hedge-rows through water erosion contributes to the forma-tion of terraces. However, in most cases tillage operations on the contour between the hedgerows greatly accelerate the terrace formation process (Egger and Rottach 1986; Anecksamphant and Sajjapongse 1994; Garrity 1996). This process is particularly prominent where intensive ploughing is carried out by draft animals (Garrity 1996). Basri et al. (1990) reported a 60 cm drop in soil level between the alleys after 2.5 years on a field with 25% slope. Comparable rates of terrace development on farmers' fields were also observed by Fujisaka et al. (1995). The levelling effect of terrace formation is one of the major benefits of vegetative contour strips, because it improves water retention in the field, reduces the loss of applied nutrients, and makes land preparation easier. In high rainfall climates, however, nutrient leaching on flat terraces due to greater vertical infiltration may partly negate the benefits of erosion control.

Natural terracing results in the depletion of soil fertility in the upper parts of each terrace, and the increase in soil fertility downslope, because soil and nutrients from the upper part of the developing terrace are eroded or moved downhill by tillage practices, and accumulate on the lower part. Initial research confirmed that soil OM, N, Bray-II extractable P, and exchangeable calcium (Ca) contents increase from the upper to lower alley zones in a linear pattern, while exchangeable aluminium (Al) decreases (Turkelboom et al. 1993; Agus 1993; Samzussaman 1994). This scouring-deposition effect creates a more favourable crop growth environment immediately above the grass strip or tree hedgerow than immediately below it (ICRAF 1993; Turkelboom et al. 1993; Garrity 1996). A soil fertility gradient is visible in crop growth response across the alley. Anecksamphant and Sajjapongse (1994) report from research conducted in Thailand and the Philippines that maize and rice yields were drastically lower on the upper alley zones in contour hedgerow and grass strip trials. A similar study recorded reductions in rice yield of more than 50% in the upper alley zones compared with middle and lower zones on 21–35% slope in Thailand (Turkelboom et al. 1993). Comparable yield reductions of upland rice between hedgerows of either *Gliricidia sepium* or *Senna spectabilis*, combined with *Pennisetum purpureum* (napier grass) were observed by Solera (1993) on a 20% slope in the Philippines. At a nearby location, upper alley yield depression was also recorded in maize associated with *Gliricidia sepium* hedgerows (Agus 1993).

In the light of high initial soil losses from the upper parts of developing terraces, and of the absence of immediate benefits in terms of overall increased crop yields, serious concerns have been raised regarding the sustainability of the contour hedgerow system (Turkelboom et al. 1995; Garrity 1996). A major reason why farmers in Matalom, Philippines, did not continue to maintain previously installed natural vegetative strips in their sloping fields was the unhalted decline of soil fertility in the alleys, as fertilisation was not practised (Fujisaka and Cenas 1993). The biomass produced by natural vegetative strips provides substantially lesser amounts of mulch material than do tree hedgerows (Nelson et al. 1998a), and its contribution to soil fertility maintenance in the alleys is thus minimal.

With time, the scouring effect will dissipate as the terrace surface stabilises (i.e. levels off) and more organic matter can be retained in the surface soil in the upper zones of the alley. However, it is not known how long this process takes at different sites and under different management regimes. On deep soils with moderate to high soil organic matter levels, the scoured areas may recover in a few years, but the process will take longer if the terraces are wider (Garrity 1996). Strongly acidic Ultisols, Oxisols and Inceptisols are physically quite deep, but they are often chemically shallow because of excessive subsoil acidity due to soluble Al. With the loss of topsoil on upper terrace zones, rooting depth is restricted. The effects of soil scouring can be more drastic on calcareous soils with a shallow topsoil over limestone parent material, since the entire topsoil may be removed (Garrity 1996).

The decline in soil fertility of upper terraces can be compensated by appropriate soil management, such as minimum tillage to reduce soil movement on the terraces, and/or through the application of nutrient inputs (crop residues, mineral fertiliser, green manure) biased towards upper terrace zones (Garrity 1996). Experiments have been conducted at ICRAF's research site in Claveria, Northern Mindanao, to reduce the effects of soil fertility scouring on crop yield. Ridge tillage, a minimum tillage technology, proved to minimise scouring effects on crop yield, but slowed down terrace development significantly (Thapa et al. 1996). The application of more hedgerow cuttings and crop residues towards degraded upper terrace zones in tree hedgerow systems did not provide a significant positive effect on crop yield (Mercado et al. 1996). Even though upper terrace soil scouring occurs irrespective of hedgerow species, the effect is best studied in hedgerow systems using less competitive natural vegetation.

In spite of the documented negative effects of soil fertility scouring on crop yield, farmers' interest in the NVS technology in Mindanao is expanding, and the number of adopters has rapidly increased in recent years. There is a need for further study of farmers' experiences with soil fertility scouring in NVS systems, and to assess local strategies to overcome poor crop performance on the upper parts of developing terraces. A thorough understanding of locally-validated practices will allow more confident extrapolation of the NVS technology to other regions where soils and farming systems differ.

Table 1. Effect of contour hedgerow systems on the yields of cassava and intercropped peanut, on gross and net income, as well as on soil loss by erosion in an FPR erosion control trial conducted on a 40% slope by farmers in Kieu Tung village, Thanh Ba district, Phu Tho province of Vietnam. Data are average values for 1996, 1997 and 1998.

Treatments[1]	Yield (t/ha)		Gross income	Production costs	Net income	Dry soil (t/ha)	Farmers' ranking
	cassava	peanut		(mil. dong/ha)			
1. C+P, no hedgerows	18.05	1.05	13.68	5.70	7.98	35.6	4
2. C+P, *Tephrosia candida* hedgerows	17.12	0.76	11.72	6.05	5.67	24.0	3
3. C+P, pineapple hedgerows	20.43	0.91	14.62	5.90	8.72	20.0	2
4. C+P, vetiver grass hedgerows	24.08	0.80	15.19	6.05	9.14	20.1	1

[1]All plots received 10 t/ha of pig manure and 60 kg N, 40 P_2O and 120 K_2O/ha as chemical fertilisers

Participatory Approaches to the Use of Contour Hedgerows for Erosion Control in Cassava-based Farming Systems

Contour hedgerow systems differ in their effectiveness in controlling erosion, improving soil fertility, conserving soil moisture, and in their competitive effects on nearby crop plants. Also, some systems are better adapted to the local soil and climatic conditions, or fit better in the local production systems than others. There are often trade-offs to be made between total productivity of the system, effectiveness in controlling erosion, and the inputs (labour, capital) required for establishing or maintaining the hedgerows (or other conservation practices). Only farmers themselves can make these decisions and select the most suitable practices for their own conditions. It is, therefore, imperative to involve farmers directly in the development and dissemination of soil conserving technologies.

Farmer Participatory Research (FPR) in cassava-based cropping systems, conducted in China, Indonesia, Thailand and Vietnam, and supported by the Nippon Foundation in Japan, has led to the development and adoption of quite different soil conserving technologies in different locations. Table 1 shows the average results of hedgerow treatments in FPR trials conducted for three consecutive years by farmers on 40% slope in Phu Tho province of Vietnam. Vetiver grass hedgerows produced the highest cassava yields, gross and net income, and was the most effective, together with pineapple hedgerows, in controlling erosion; this was the treatment most preferred by farmers. Similar results were obtained in demonstration plots conducted for three consecutive years on a 21% slope at the Agroforestry College of Thai Nguyen Univ. in Thai Nguyen, Vietnam (Table 2). Vetiver grass hedgerows were again most effective in controlling erosion, followed by those of *Flemingia congesta* and *Tephrosia candida.* Vetiver hedgerows also resulted in the highest cassava yields, increasing yields on average 22% over those in the check plot without hedgerows. Although vetiver grass occupied about 10% of the total land area, productivity in the total area was increased, probably due to improved moisture retention and efficiency of fertiliser use. Erosion was reduced by 67%.

Table 2. Effect of various contour hedgerow systems on cassava yield and soil erosion, as observed in FPR demonstration plots established on a 21% slope at Agro-forestry College of Thai Nguyen University, Thai Nguyen, Vietnam. Data are average values for 1994, 1995 and 1996.

Treatments[1]	Cassava yield (t/ha)	Dry soil loss (t/ha)
1. No hedgerows	16.67	19.73
2. *Tephrosia candida* hedgerows	17.61	11.89
3. *Flemingia congesta* hedgerows	17.21	8.44
4. Vetiver grass hedgerows	20.39	6.46

[1]All plots received 60 kg N, 40 P_2O_5 and 120 K_2O/ha.

In spite of being very effective in controlling erosion, the lack of sufficient planting material and the high cost of establishment will greatly limit adoption of vetiver grass hedgerows in Vietnam. Farmers in some areas of North Vietnam have traditionally used *Tephrosia candida* hedgerows as a green manure to improve soil fertility. Although generally less effective than vetiver grass in controlling erosion, the ease and low cost of establishment (from seed) of *Tephrosia* hedgerows has made this a preferred hedgerow species (Table 3) in northern Vietnam. This technology is now being adopted in some of the FPR pilot sites. In Dong Rang village of Hoa Binh province, the planting of *Tephrosia* contour hedgerows, which often revert to natural weedy strips when the *Tephrosi*a dies after 3-4 years, has resulted in the formation of natural terraces with terrace risers up to 1 metre high. In Kieu Tung village, Phu Tho province, farmers are planting both *Tephrosia candida* and vetiver grass contour hedgerows to control erosion in their fields.

Conditions for Thai cassava farmers are quite different from those in northern Vietnam. The climate is tropical rather than subtropical, the topography is rolling rather than mountainous, cassava fields are generally 5–10 times larger, and land preparation (and sometimes harvesting) is mechanised. Although slopes are quite gentle (0-10%) they are also long, resulting in large amounts of water rushing down the slope in natural drainage ways. This can result in serious soil losses of 50–100 tonnes/ha/year, but mostly localised in a fraction of the total field. Many soil erosion control experiments have been conducted to identify those practices that are most effective in reducing erosion, produce high cassava yields and are easy to establish and maintain. Table 4 shows some recent results from experiments conducted in Khaw Hin Sorn, Thailand. Contour hedgerows of all species tested reduced erosion, but also reduced cassava yields. Vetiver grass hedgerows were most effective in reducing erosion and caused less reduction in cassava yields than those of most other species.

Table 4. Effect of various contour hedgerows on cassava yield and erosion when cassava, cv Kasetsart 50, was grown on a 5% slope in Khaw Hin Sorn Research Station, Chachoengsao, Thailand. Data are average values for 1995/96 and 1996/97.

Treatments[1]	Cassava yield (t/ha)	Dry soil loss (t/ha)
1. No contour hedgerows	30.36	8.09
2. Vetiver grass (local variety) hedgerows	24.17	3.65
3. Vetiver grass (Sri Lanka) hedgerows	21.85	2.72
4. Pigeon pea hedgerows	23.06	7.44
5. *Crotalaria juncea* hedgerows	23.02	7.02
6. *Leucaena leucocephala* hedgerows	20.15	4.91
7. *Gliricidia sepium* hedgerows	19.89	4.12

[1]Pigeon pea and *Crotalaria* hedgerows were established in May 1995; other treatments in Oct 1993. Cassava received 94 kg each of N, P_2O_5 and K_2O/ha

Farmers in Soeng Saang and Wang Nam Yen districts conducting FPR erosion control trials chose to experiment with contour hedgerows of vetiver

Table 3. Effect of various contour hedgerow systems on the yields of cassava and intercropped peanut, on gross and net income and on erosion in FPR demonstration plots established on 9% slope at Agro-forestry College of Thai Nguyen University, Thai Nguyen, Vietnam, in 1998[1].

Treatments[1]	Yield (t/ha)		Gross income	Production costs	Net income	Dry soil (t/ha)	Farmers' preference (%)
	cassava	peanut	(mil. dong/ha)				
1. C+P, no hedgerows	15.42	0.73	11.36	5.06	6.30	21.91	71
2. C+P, natural grass strips	14.83	0.60	10.42	6.06	4.36	20.63	57
3. C+P, *Tephrosia candida* hedgerows	17.75	0.71	12.43	7.08	5.35	11.20	74
4. C+P, vetiver grass hedgerows	15.83	0.63	11.07	7.42	3.65	11.08	34
5. C+P, pineapple+*Tephrosia* hedgerows	16.50	0.65	11.50	7.70	3.80	16.57	34
6. C+P, vetiver+*Tephrosia* hedgerows	16.83	0.77	12.27	7.48	4.79	10.03	51

[1]1998 was first year of establishment of hedgerows
[2]All plots received 60 kg N, 40 P_2O_5 and 120 K_2O/ha

Table 5. Effect of contour hedgerows of vetiver and/or sugarcane on cassava yield and gross income when planted in production fields of 1600 m2 of five farmers in Soeng Saang and Wang Nam Yen districts in Thailand in 1997–1998.

Farmer	Hedgerows	Cassava yield (t/ha)		Gross income ('000B/ha)[1]	
		With hedgerows	Without hedgerows	With hedgerows	Without hedgerows
Mrs. Naakaew[2]	Vetiver	25.72	31.31	38.58	46.96
Mrs. Champaa[2]	Sugarcane and vetiver	9.26	12.45	18.71	18.67
Mr. Sawing[3]	Vetiver	15.99	19.05	23.98	28.57
Mr. Somkhit[3]	Vetiver	16.39	21.66	24.58	32.49
Mr. Phuem[3]	Vetiver	21.81	26.25	35.71	39.37
Average		**18.23**	**22.14**	**28.31**	**33.21**

[1]Prices: cassava: B 1.50/kg fresh roots sugarcane: 3.0/stalk (for chewing)
[2]In Soeng Saang district of Nakorn Ratchasima province
[3]In Wang Nam Yen district of Sra Kaew province

grass, sugarcane and mulberry bushes, as well as with various intercropping systems, and mulching with dry grass. After 2–3 years of testing in small plots on their own fields, they were convinced that vetiver grass hedgerows were the most effective in reducing erosion, but that sugarcane hedgerows or intercropping with peanut, sweet corn or pumpkin produced more income. Farmers have also tried some of these systems on larger areas (1600 m^2) of their fields. Measurements of cassava yields with and without hedgerows revealed that yields were reduced on average 18% (Table 5) by the presence of hedgerows of vetiver grass or sugarcane. The value of the sugarcane (for chewing) more or less compensated for the lower cassava productivity of the system. These data indicate that farmers are often faced with difficult decisions concerning trade-offs between short-term productivity and long-term resource conservation. It also points to the need to make adaptations to make the system more acceptable; in this case the distance between hedgerows must be increased from 1 metre vertical distance to 3–4 metre vertical distance to reduce the negative effect on total crop yield and to facilitate mechanical land preparation.

Eventually most farmers abandoned the intercropping systems and sugarcane because of lack of labour, and frequent intercrop failures during periods of drought. But many expanded the areas with vetiver grass hedgerows, especially since planting material in Thailand is provided free of charge by the government. After having seen the effectiveness of vetiver grass hedgerows in FPR trials in a neighbouring village, farmers in Noon Samraan village of Nakorn Ratchasima province organised a 'Soil Conservation Group'. The group has collected money and the members are now working together to plant 320 ha of sloping cassava land near the village with vetiver grass contour barriers. The combination of a useful technology, developed with farmer participation in a nearby village, government incentives in the form of free planting material, and an active local extensionist working with farmers who are convinced of the need to control erosion on their land, is facilitating the widespread (but still very localised) adoption of vetiver grass barriers for erosion control in cassava fields in Thailand. Even so, adoption will be rather slow due to the enormous task of transporting and planting millions of bagged plants in the field.

As mentioned above, large-scale adoption of vetiver grass barriers, even in Thailand where conditions are most favourable, will remain problematic because of the high cost of producing, transporting and planting of vegetative planting material. While seed sterility in most vetiver grass varieties is considered useful to prevent the grass from ever becoming a weed, it does make large-scale plantings time-consuming and costly. Moreover, in countries like Indonesia where farms tend to be very small and most farmers raise cattle or goats, the use of vetiver grass hedgerows is generally rejected in favour of grasses or leguminous species that produce useful forage for farm animals, especially in the dry season. Various ecotypes of napier grass, dwarf napier, and king grass (*Pennisetum purpureum* × *P. glaucum*), are the preferred hedgerows species, even though they compete strongly with neighbouring crop plants.

To identify grass species that produce useful forage, that can be planted from seed, that do not become noxious weeds, and that do not compete too strongly with neighbouring cassava plants, an experiment comparing 16 grass species/ecotypes was planted in Khaw Hin Sorn research station in Chachoengsao province, Thailand. Contour hedgerows of each grass were planted three metres apart and three rows of cassava were planted in the alleys, as shown in Figure 1.

Cassava yields were determined in each row separately in order to determine the competition effect of the grass barriers on the adjacent and centre rows of cassava. Table 6 shows the cassava yields during all three years of testing, while Figure 1 shows the cassava yields in each row during the third year after grass establishment. During the first and second year after establishment, hedgerows of *Paspalum atratum, Setaria sphacelata* and lemon grass (*Cymbopogon citratus*) resulted in the highest cassava yields, indicating that these grasses were the least competitive. The three vetiver grass varieties were intermediately competitive. During the third year of testing (Figure 1), however, when most hedgerows had become somewhat wider due to lateral tillering, all grasses competed strongly (mainly for soil moisture) with the adjacent rows of cassava. The highly competitive grasses, like napier, king grass and *Panicum maximum*, even competed with cassava in the centre row 1.5 metres from the hedgerow. Least competitive with cassava were lemon grass, vetiver grass (Songkla 3) and *Setaria spacelata*. *Brachiaria ruziziensis* became less competitive (and less productive) during the third year as it had depleted the nutrients in the soil.

Although no definite conclusions can be drawn from this preliminary trial, it appears that *Setaria sphacelata*, *Paspalum atratum* and *Brachiaria brizantha* could become useful hedgerow species. They produce good forage for ruminants, can be planted from seed (without becoming weedy), and they are less competitive than the more traditional cut-and-carry grass species like napier and king grass. More research is needed to determine the optimum management of these species to further reduce their competitive effects. Some of these promising species should be tested in FPR trials in farmers' fields, in comparison with vetiver grass, natural vegetative strips, and possibly other farmer-selected hedgerow species. If farmers find these new species effective in erosion control, useful as an animal feed or mulch, and convenient in establishment and maintenance, their adoption for soil conservation could be greatly accelerated.

Table 7 summarises the locations where, and the conditions under which, particular soil conserving practices are most likely to be adopted, according to the experience of the Nippon Foundation project. Contour hedgerows are likely to feature as an important soil conservation practice in all locations. However, the most suitable species will vary according to the local conditions and farmers' needs, as indicated in Table 7. Moreover, contour hedgerows should be combined with other agronomic practices, such as intercropping, manure and fertiliser application, minimum tillage, closer plant spacing, productive germplasm etc, in order to maximize the effectiveness of erosion control and fertility maintenance, while at the same time increasing yields and/or the farmers' income.

Building on Indigenous Innovations and Farmer-led Technology Dissemination: Participatory Research on Forages and Soil Conservation on Acid Upland Soils

In Claveria, Northern Mindanao Region, research was conducted by the International Rice Research Institute (IRRI) and the Department of Agriculture on contour hedgerow intercropping from 1984 to 1992. The goal of the work was to improve upland-rice-based farming systems in degraded acidic soil environments. Initial rural appraisals revealed that farmers cultivating sloping lands in Claveria commonly experienced soil erosion and soil fertility decline, and associated crop yield reduction. Farmers were interested in learning new techniques to halt the soil degradation process. Since most farmers faced cash and labour constraints, agroforestry-based technologies, such as contour hedgerow intercropping, were tested for their efficacy in controlling soil erosion and maintain soil fertility levels (Fujisaka and Garrity 1989).

Studies were conducted over a period of 7 years (1993–1999) to determine the effects of different forage legumes and grasses as contour hedgerows on productivity of an upland rice — maize crop sequence, their biomass production and their relative

Table 6. Effect of contour hedgerows of various grasses on the yield of three adjacent rows[1] of cassava grown during three consecutive years on a 5% slope in Khaw Hin Sorn Research Station, Chachoengsao, Thailand, from 1996 to 1999.

Contour hedgerow treatments[2]	Cassava yield (t/ha)			
	1st year	2nd year	3rd year	Average
Check without hedgerows	19.62	21.46	29.83	23.64
Vetiver grass-Nakorn Sawan variety	15.68	6.80	9.72	10.73
Vetiver grass-Sri Lanka variety	16.95	8.19	12.04	12.39
Vetiver grass-Songkla 3 variety	19.60	6.46	15.46	13.84
Lemon grass	12.89	12.09	18.18	14.39
Citronella grass	13.68	8.79	13.28	11.92
Setaria sphacelata	22.11	7.81	14.61	14.84
Paspalum atratum	33.05	14.77	10.13	19.32
Panicum maximum TD 58	13.35	7.07	3.50	7.97
Panicum maximum CIAT 6299	9.59	5.50	3.33	6.14
Brachiaria brizantha	16.36	7.50	7.55	10.47
Brachiaria ruziziensis	9.03	5.94	19.52	11.50
Dwarf napier grass	5.14	4.63	5.65	5.14
Normal napier grass	2.38	0.24	0.96	1.19
King grass	10.70	1.39	1.83	4.64
Sugarcane	12.46	5.83	—	—

[1]Two cassava rows planted at 0.5 m and one row at 1.5 m from the center of the hedgerows
[2]Hedgerows established in June 1996

competitiveness on acid sloping uplands in Claveria. *Flemingia congesta* (shrub), *Stylosanthes scabra* (erect fodder legume), *Panicum maximum* (fodder grass), *Vetiveria zizanioides* (grass, no value as fodder), and a control (no hedgerow in contour ploughing and planting) were evaluated. The hedgerows were spaced 6–8 metres apart.

Hedgerows of *Flemingia congesta, Vetiveria zizanioides, Stylosanthes scabra, and Panicum maximum* were all effective in reducing off-field soil losses (Table 8). The two grass species controlled erosion most effectively (about 95% reduction compared with the open-field control). However, the tree legume and the forage legume also reduced soil losses dramatically (greater than 65% reduction). Thus, it is evident that the use of any of these species as the contour hedgerow component will dramatically alleviate soil degradation on sloping terrain (18% to 24% in this case.) The fodder species tested could support 2–4 steers weighing 200 kg per ha through a 360-day feeding period, assuming that feeding rate is 2.5% of the animal's body weight.

Table 7. Location and conditions where particular soil conserving practices have been (or are most likely to be) adopted for cassava-based cropping systems on sloping land in Asia.

Location	Conditions	Soil conserving practices
Java, Indonesia	limestone derived soils (Alfisols); steep slopes; small farms; cattle and goat raising; land constraint	Terracing, hillside ditches; agroforestry; Contour hedgerows of *Leucaena, Gliricidia,* napier, *Paspalum atratum;* Intercropping with maize, rice, grain legumes; Fertiliser+manure application
Java, Indonesia	acid Inceptisols, Entisols; steep slopes; small farms; cattle and goat raising; land constraint	Terracing, hillside ditches; Contour hedgerows of *Gliricidia,* napier, *Paspalum atratum;* Intercropping with maize, rice and grain legumes; Fertiliser+manure application
North Vietnam	acid Ultisols, Oxisols; steep slopes; small farms; pig raising; land constraint	Intercropping with peanut, cowpea; Contour hedgerows of *Tephrosia candida,* pineapple, vetiver, natural grass, *Paspalum atratum;* Manure+fertiliser application
Hainan, China	acid Ultisols, steep slopes; rather large farms; labour constraint	Contour hedgerows of vetiver grass and sugarcane; Manure+fertiliser application
Northeast Thailand	acid Ultisols; gentle but long slopes; large farms; mechanisation; labour constraint	Contour hedgerows of vetiver grass, sugarcane, *Paspalum atratum;* Fertiliser application; Closer plant spacing

Table 8. Average grain and total dry matter yield of an upland rice-maize crop sequence, soil loss, pruning biomass and carrying capacity as influenced by different hedgerow species and different pruning and crop residues managements in an acid upland soil, Claveria, Misamis Oriental, Philippines. (mean of 3 years).

Species	Upland Rice cv IR30716-B-1-B-1-2		Maize Pioneer # 3274		Soil loss (t/ha)	Pruning Biomass (t/ha)	Carrying capacity*
	Grain yield (t/ha)	TDMY (t/ha)	Grain yield (t/ha)	TDMY (t/ha)			
Control	2.46	6.37	4.27	8.99	34.18	—	
Panicum maximum	2.35	5.23	4.04	8.29	1.65	3.04	2
Flemingia congesta	2.26	4.85	4.72	9.73	4.60	5.83	3
Stylosanthes scabra	2.47	6.38	4.61	9.47	7.15	1.63	1
Vetiveria zizanioides	2.23	6.01	4.52	9.62	1.69	4.16	2
Mean	1.27	3.04	4.43	9.22	2.43	3.67	2
CV (%)	4.79	7.47	23.22	20.35	47.93	45.98	

*number of 200 kg steers per ha per year

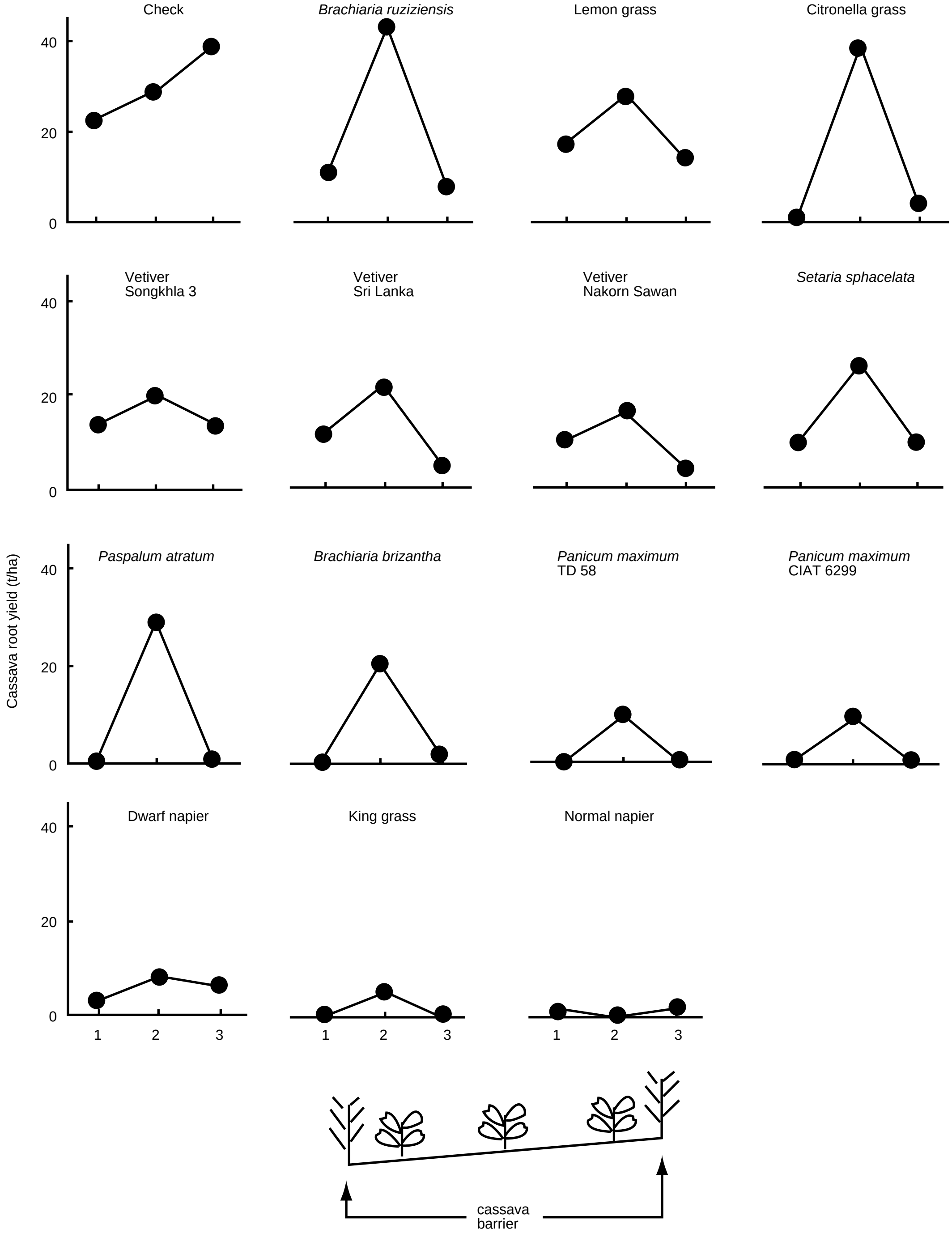


Figure 1. The effect of different grass species as contour barriers on the fresh root yield of cassava, cv. KU 50, grown in three rows between barriers in Khaw Hin Sorn, Chachoengsao, Thailand in 1998/99 (3d year).
Note: row 1 is cassava row just above and 0.5 m from hedgerow; row 2 is centre row and 1.5 m from each hedgerow, and row 3 is just below and 0.5 m from the next hedgerow.

Crop yields (calculated on a whole field area basis) did not differ among the hedgerow treatments and the open-field control. Thus, the soil fertility enhancement provided by the prunings was negated by the additional non-cropped area occupied by the hedgerows. The ranking of hedgerow species from least to greatest in relative competitiveness was stylo, vetiver, flemingia, and guinea grass (*Panicum maximum*). Guinea grass, exhibited severe competitive effects on the associated annual crops and reduced crop yields. This species may not be appropriate as a hedgerow component unless carefully managed to avoid competition. The legume species were not distinctly superior to vetiver in stimulating yields or in exhibiting reduced competition, as might have been expected. On the other hand, vetiver exhibited crop competition, contrary to some claims that it tends to be vertically rooted and is non-competitive.

Napier (*Pennisetum purpureum*) was also extensively used in many of our contour hedgerow experiments. We found that napier can produce from 5.0 to 6.5 tonnes of dry herbage annually in different hedgerow combinations; this can support 3–4 200 kg steers for a 360-day feeding period (Table 2). Monthly harvesting of napier hedgerows for a period of 2 years showed a seasonal range in dry matter production ranging from 50 to 550 kilograms per hectare (Figure 2). The herbage production fluctuated in response to the amount of rainfall during the growing period. Thus, farmers may experience an over supply of fodder during the rainy season and an under supply in the dry season.

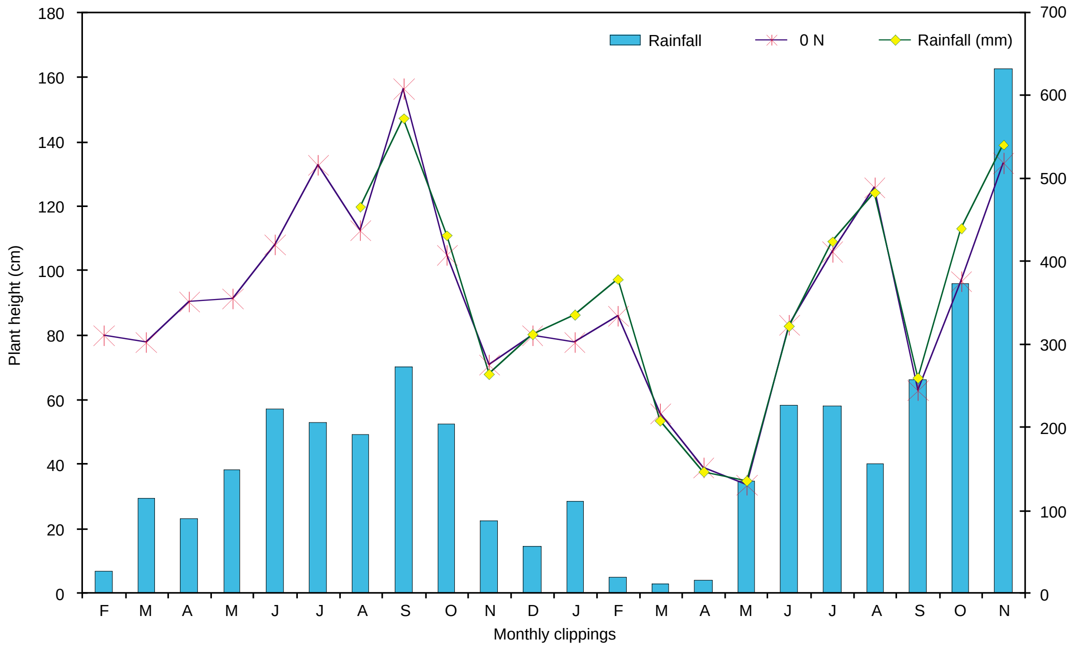
The International Rice Research Institute (IRRI), in collaboration with CIAT, conducted extensive evaluations of forage legumes and grasses as alternative species. Among the species evaluated, *Setaria sphacelata* var. *splendida* was selected by farmers and is now widely adopted because of its being less competitive with companion annual crops, and is palatable and nutritious to ruminants. Vetiver was also introduced to farmers but was not accepted, in spite of being very effective in controlling soil erosion. Farmers were looking for multi-purpose species as contour hedgerows.

Currently, there are more than 1500 farmers in Claveria who have adopted contour hedgerow systems using different hedgerow species, but almost all of them (over 95%) started by using the natural vegetative strips (NVS). They then progressed to planting a range of plants, including fodder grasses, timber and fruit trees, and pineapple. The most popular fodder grasses are *Setaria sphacelata* var. *splendida*, *Panicum maximum* and *Pennisetum purpureum*. A major reason for greater adoption of these particular species was the greater availability of planting materials. Most farmers are concerned about excessive competition by napier and its shading effect when not cut back regularly.

In 1987, six interested farmers from Claveria and two IRRI technicians went to a non-governmental project (initiated by 'World Neighbors', a USA-based NGO) in the neighbouring island Cebu, to learn from farmers how to establish contour lines with the A-frame and how to plant hedgerows. In the original technology, hedgerows were planted on contour bunds, comprised one or two rows of *Gliricidia sepium* (Madre de Cacao), and one or two rows of *Pennisetum purpureum*. Eroded sediment, which was collected in a ditch below the rows of trees and grasses, was regularly returned to the alley above (Fujisaka et al. 1994). The following year, the Cebuano farmers paid a return visit to observe contour hedgerows established in Claveria, discuss the adaptations made by Claveria farmers, and share ideas on how the system might be further developed (Fujisaka 1989). From 1987 to 1989, trained farmers and later adopters in Claveria extended their knowledge to 182 interested farmers, using the same farmer-to-farmer approach which they had learned from World Neighbors in Cebu. Of these trained farmers, 64 had adopted some form of contour hedgerow system by late 1990, and a further seven farmers were identified which had spontaneously adopted the technology after they had observed neighbours' farms (Fujisaka et al. 1995).

Simultaneously to the study of farmers' adoption of the contour hedgerow technology, and its adaptation to local conditions and needs, IRRI conducted formal on-farm research in collaboration with the local DA. Technology adaptation trials managed by the researchers focused on improving upland rice and hedgerow germplasm and farming systems, and emphasised farmer participation in the concurrent technology validation (and adaptation) and extension process (Fujisaka et al. 1994).

Continuous documentation of farmer adoption and modification of the introduced contour hedgerow technology revealed that many farmers in Claveria adopted some form of soil conservation practices, but modified them to minimise labour inputs and reduce competition from vigorous grass and tree species. First, they abandoned the creation of contour bunds before the hedgerows were planted, and discontinued the use of ditches below the hedgerows to capture sediment. They observed that both of these labour-intensive practices were unnecessary. They tended to plant either trees (usually *Gliricidia sepium*) or fodder grasses (predominantly napier), instead of a combination of both. By 1992, the majority of farmers simply left the marked contour lines unploughed during land preparation without planting any trees or grasses (Fujisaka et al. 1994).



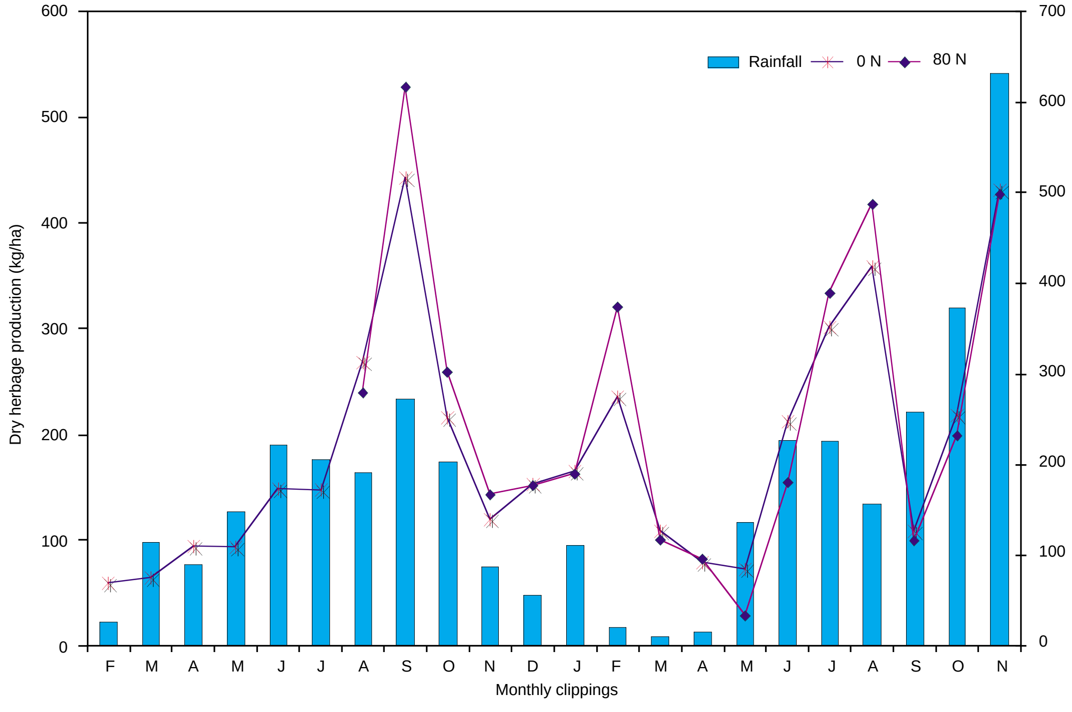


Figure 2. Dry herbage of Napier (*Pennisetum purpureum*) in a contour hedgerow system as influenced by nitrogen applied on the associated alley crops and rainfall. Slopping acid upland soil, Claveria, Misamis Oriental. February 1989 to November 1990.

A study conducted by Cenas and Pandey (1995) showed that among the 64 initial adopters of contour hedgerows of leguminous trees (largely trained by IRRI), 63% eventually abandoned or fallowed their contoured fields, mainly due to labour constraints. However, it was estimated that by 1994 more than 250 farmers in the area had adopted modified forms of hedgerow intercropping, mostly in a spontaneous adoption process, whereby natural vegetative strips and fodder grass strips were preferred to pruned tree hedgerows (Garrity et al. 1998).

Farmer participation in the research process in testing, evaluating and adapting the introduced hedgerow technology under farm conditions, led researchers to re-evaluate the rationale for using leguminous tree species in hedgerows (Fujisaka, 1993). Natural vegetative strips were recognised as a useful intermediate step towards the adoption of more complex agroforestry systems (Garrity et al. 1993). Many farmers in Claveria have shown initiative in establishing fruit and timber trees for cash income on previously installed NVS to make productive use of the space occupied by the vegetative strips (Garrity et al. 1998). The prices for timber have been steadily rising in the Philippines, and so has farmers' interest in planting trees. Contributing to this development are dwindling natural forest resources and the enforcement of a total logging ban in several regions of the country.

The use of leguminous crops as a soil cover, or as intercrops with major food crops, has been recommended as an alternative or complementary option to maintain soil fertility and provide a supply of higher quality fodder for cattle (Garrity et al. 1993). However, farmers' interest in leguminous cover crops has not been enthusiastic, because most species do not perform well on strongly acidic soils, or are prone to destruction from dry season fires. Cover crops also cannot grow undisturbed in areas where fallow land is considered public grazing area (Garrity 1994), as is the case in Claveria. Often, seed supply is a significant problem. Another constraint to the use of leguminous inter- and relay-crops has been their limited potential in systems using animal-power for land preparation and weeding, due to incompatibility of reduced tillage systems with the farmers' traditional tillage methods.

Since 1993, after IRRI had completed its work, the International Centre for Research in Agroforestry (ICRAF) continued research on contour hedgerow technologies in Claveria. The participatory learning approach was reinforced by strengthening researcher and farmer interactions, and by focusing on the identification and validation of local practices. The assessment of minimum tillage as an alternative or complementary measure to reduce soil degradation on sloping lands was continued. Research is allied with the institutional strengthening and capacity building of farmer groups, and is encouraging greater interaction between the groups, local government, and institutions from outside the location. Throughout the whole research process, from identifying research topics to disseminating the findings, farmers' initiative has been a driving force. The stronger redirection of the project towards participatory technology development and dissemination has raised a whole new set of research questions.

The Farmer-Driven Landcare Movement: An Institutional Innovation with Implications for Extension and Research

Smallholders can engage in farming and management of natural resources in both a productive and resource-conserving manner. Awareness of this has focused attention on evolving demand-driven, community-based approaches to natural resource management. A look at current prescriptions for more sustainable farming systems in the uplands reveals an enormous variability in conditions, and consequently a high degree of technical uncertainty about the effectiveness of the solutions proposed. The problems are not solved by simple recipes. Often, the issues need to be tackled cooperatively at the community level, at a scale bigger than the individual household.

In Asia, much attention has been given to the role of local organisations in the management of forests and other common natural resources. This is exemplified by the progress in Joint Forest Management in India, Forest Users' Groups in Nepal, and Community-Based Forest Management in the Philippines (Poffenberger and McGean 1996). But local organisations may also be a means to mobilise knowledge to solve problems in agriculture through improved land husbandry. Particularly in countries where decentralisation of power and fiscal responsibility is occurring, and democracy is becoming institutionalised down to the village level, leadership skills in the farming population are maturing. These skills provide a basis for the evolution of organisations led by farmers that address practical ways of overcoming their problems in creating a more sustainable agriculture.

Among the organisational models for enhancing local initiative in attacking land degradation, one of particular interest is called 'Landcare'. Through this approach, local communities organise themselves to tackle their agricultural problems in partnership with public sector institutions. The distinguishing characteristics of Landcare groups are that they are voluntary, self-governing, and focus on problem-solving resources within the community. Experience in the Philippines (300 groups) and Australia (4500 groups) suggests that such an approach may provide a means to share and generate technical information more effectively, spread the adoption of new practices, enhance research, and foster farm and watershed planning processes. These groups exhibit some similar characteristics to the farmer field schools made popular in integrated pest management. Landcare groups, however, are more formalised and aim at a broader range of land degradation and sustainability issues. Some distinguishing features of Landcare groups are:

- They develop their own agendas and tackle the range of sustainability issues considered important to the group.
- They tend to be based on neighbourhoods or small sub-watersheds.
- The impetus for formation comes from the community, although explicit support from outside may be obtained.
- The momentum and ownership of the group's program is with the community.

Farmer-driven approaches show promise of being more effective and less expensive than current transfer-of-technology approaches. In the southern Philippines, farmer organisations became the basis for a successful grassroots approach to finding new land care solutions, forming partnerships with local government, pulling in outside technical and financial resources, and diffusing new information throughout the community (Garrity in press).

The Landcare movement in the Philippines began in Claveria, Mindanao, in 1996. There are now some 300 village-based Landcare groups in Claveria and in other municipalities in northern, central, southern and eastern Mindanao, with a membership of several thousand households. They have established conservation practices on more than 1500 farms. More than 200 community and household nurseries have been developed, that produced hundreds of thousands of fruit and timber trees seedlings, all done entirely with local resources.

Local governments at the village, municipal, and provincial levels have been notably interested and supportive of this movement. The provincial governments of Bukidnon and Misamis Oriental are launching province-wide Landcare movements. The movement has also attracted the attention of the national government. The national watershed management strategy has now been based on Landcare as a foundation upon which to build an effective community-based approach to sustainable agriculture and natural resources. This has provided the opportunity to scale-up Landcare principles and experiences to other parts of the Philippines. The experience suggests that there is potential for promoting this grassroots approach elsewhere in Southeast Asia.

There are signs that institutions like this could help transform extension systems. Extension agents move from role of teacher of individual farmers one-on-one, to that of being a facilitator to whole farmer groups (Campbell 1994). Conservation farming based on contour buffer strips was one practice that was popularised through Landcare in the Philippines. Another has been nurseries for growing new species of fruit and timber trees to diversify the farm enterprise. But since the agendas of the groups are determined by their own members, we observe a wide range of issues taken up by different groups, including dairy and beef farming, cut flower production, and problems in vegetable crop farming, among others. Landcare groups have also gained significant influence at the local political level. Local governments are actively and enthusiastically assisting the movement with budgetary allocations and solid political support. At the community level, Landcare has proven to be a powerful force for evolving initiatives that protect the whole watershed. The collaborative structure of Landcare is fostered through mutually supportive relationships among the farmers' organisations, local government, and technical support agencies in research and extension (Figure 3). The approach of farmer field schools for conservation farming is currently being experimented with as a method through which community groups may be initiated.

We are only beginning to exploit the opportunities that Landcare provides for enabling major innovations in the way on-farm participatory research is done. We see the prospect for research to be carried out through, and managed by, Landcare groups. This would multiply the amount of work, and the diversity of trials, that can be accomplished, ensuring a more robust understanding of the performance and recommendation domain of technical innovations. Currently, we are conducting surveys through the Landcare groups to get a grassroots feedback on the priorities for research, from the farmers' perspective. In Australia, public sector research institutions such as CSIRO are adjusting to the new reality that through Landcare, farmers sit on, and may even dominate, the boards that decide on research project funding. This is having a galvanising effect on focusing researchers on problems that farmers are concerned about.

We may summarise by listing four hypothetical functions of farmer-led knowledge-sharing landcare organisations:

- Enhanced efficiency of extension or diffusion of improved practices (more cost-effective than 'conventional' extension functions).
- Community-scale searching process for new solutions or adaptations, suited to the diverse and complex environments of smallholder farming (a unique aspect of landcare).
- Enhanced research through engagement by large numbers of smallholders in formal and informal tests of new practices.
- Mobilisation process at the community level to understand and address landscape-level environmental problems related to water quality, forest and biodiversity protection, soil conservation, and others.

There are three significant concerns about the sustainability of the Landcare movement. One is that the Landcare concept is sufficiently popular that there is a definite risk of 'projectising' the movement, i.e. attracting support projects that do not understand the concept, and provide funds in a top-down, target-driven mode that defeats the whole basis of a farmer-led movement. The second is the issue of sustaining such movements in the long run. Networking, and the stimulation from outside contacts, is widely considered to be crucial in the long-term success of such institutions. This can be provided through Landcare Federations, as has evolved locally in Claveria, and through provincial and national federations, which is currently being explored in the Philippines. Third, group leadership is a time-consuming and exhausting task, particularly when it is done on a voluntary basis. Landcare is still very young in both the Philippines and Australia, but increasingly leadership 'burn-out' is discussed as a concern.

Our analysis indicates that the following needs to be done to further release the power of the Landcare concept. The public sector and non-government sector can assist in facilitating group formation and networking among groups, enabling them to grow, developing their managerial capabilities, and enhancing their ability to capture new information from the outside world. They can also provide leadership training to farmer leaders, helping ensure the sustainability of the organisations. Cost-sharing external assistance can also be provided. For this, the use of trust funds should be emphasised, where farmer groups can compete for small grants to implement their own local landcare projects. This has been remarkably successful in the Australian Landcare movement. We envisage that the Landcare approach may be suited to other locations in the Philippines and elsewhere, providing a national focus for the sustained management of resources by farmers with (minimal) local government support.

These farmer-led organisations can be an excellent venue for spreading knowledge about forage production systems for sloping lands. The groups also provide an excellent potential mechanism for involving large numbers of farmers in adaptive research that would experiment with new species and cultivars of forages with superior production and compatibility with soil and water conservation.

Conclusions

Forage production is and will be an important component of many conservation farming systems on small farms in Southeast Asia. The erosion control

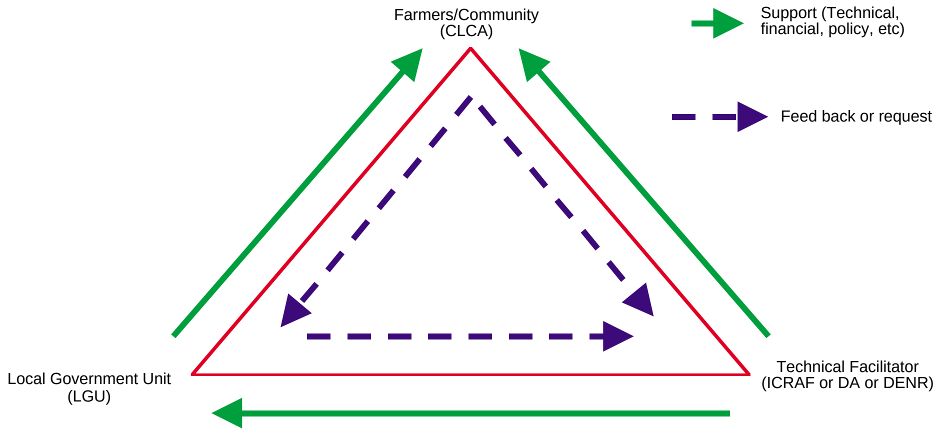


Figure 3. The triangle of Landcare approach: grass organisation (CLCA), local government unit (LGU), and technical facilitator (ICRAF/DA). The success of Landcare as an approach is dependent on how these 3 groups interact and work together. (Mercado et al. 2000).

benefits of forage production in contour hedgerows are well demonstrated. There are, however, a number of significant trade-offs between high, sustained forage production and long-term resource conservation. These trade-offs need to be carefully managed. One of the most serious of these is minimising the competition between the fodder species in the hedgerow and the associated crops in the alleyways, and maximising overall benefits from both enterprises to farm household.

The choice of an appropriate hedgerow species is dependent upon adequate understanding of the trade-off between fodder production, crop yield, and soil and water conservation. Research with farmers in a number of environments has amply demonstrated that this trade-off is very dynamic across locations and enterprise types. Thus, choice of the appropriate system will be a decision that very much depends on each farmer's circumstances and goals. Participatory research is needed to build a much better information base to enable farmers to make informed forage species and cultivar choices. The balance also necessitates careful attention to the nutrient off-take from the field by both the fodder and annual crop. The biomass of the fodder crop must also be carefully managed so as not to cause excessive shading of the annual crop. Currently, there is little research information available to guide soil fertility and pruning management in such fodder-annual crop systems.

More research is needed to identify and analyse the array of intensively-managed and extensively-managed fodder systems for hedgerows for the wide range of smallholder circumstances found in South-east Asia. Better ways of engaging farmers in this research will be needed so as to do it in an efficient and cost-effective manner. Farmer-led organisations are an excellent means of spreading knowledge about forage production systems for sloping lands. They also could provide an excellent mechanism for involving large numbers of farmers in adaptive research to experiment with new species and cultivars of forages with superior production and compatibility with soil and water conservation. The Landcare movement is one promising manifestation of farmer-led organisations that is growing rapidly. It could become a potent force for accelerating the improvement of smallholder fodder systems that optimise the productivity-conservation trade-offs to suit the diverse needs of upland farmers in many parts of the region.

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How Do Forages Fit into Smallholder Farms in Mixed Upland Cropping Systems?

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THE Forages for Smallholders Project (FSP) is working at several sites in Southeast Asia which are mixed crop-livestock upland systems with cropping being the main source of income. Figure 1 shows an example of this type of upland farming system. This poster presents the development of forage technologies at five of these sites. The sites are shown in Figure 2.

Figure 1. An example of a mixed crop-livestock system in Southeast Asian uplands.

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Figure 2. Project areas featured in this paper.

All 5 sites are in humid or sub-humid areas (mean annual rainfall 1700–2300 mm) with dry seasons ranging from 2–4 months (Table 1). Soil fertility at all sites is moderately fertile with moderate soil pH (H_2O). The sites vary in the intensity of land use from very intensive in Guba to moderately extensive in Matalom (Table 1).

At Guba, all agricultural land is used throughout the year and much of the cropping area is contoured. At Matalom, up to 50% of the agricultural land may be left fallow. All sites are hilly or mountainous with only limited areas of flat land for agriculture.

The common feature of all these mixed upland cropping sites is great diversity in the range of crops grown and animals raised. Major crops are maize, fruits and vegetables. At all sites, farmers raise animals and these are either kept in a shed (Guba), tethered in fields and vacant areas (Pagalungan) or grazed in areas away from the village (Xuan Loc). They play an important role in utilising natural vegetation and crop residues from the cropping activities and provide manure for the crops. Manure is recognised as an important by-product of raising animals, particularly at the more intensively-cropped sites.

Table 1. Site characteristics.

	Pagalungan, Cagayan de Oro	Malitbog, Bukidnon	Xuan Loc, Thua Thien Hue	Guba, Cebu	Matalom, Leyte
a) Physical					
Annual rainfall (mm)	1500	1880	2300	1670	2210
Dry months (<50mm)	3.1[1] (2–5)[2]	1.9 (0–4)	3–4	3.1 (1–6)	1.6 (0–2)
Soil fertility			moderately fertile		
Soil pH (H_2O)	5.8–6.5	5.8	5.0–5.5	4.9–6.5	5.0
b) Agricultural system (n=15 per site)					
Farm size (ha)	2.7 (0.75–6)	2.2 (0.1–5)	1.2 (0.2–2.6)[3]	1.5 (0.25–4.5)	2.6 (0.5–3.5)
Land use intensity (1 – 10, where 10 = high intensity)	4	5	7	10	3
Access to other grazing land	✔✔	✔✔	✔✔✔		✔
Main crops	fruits, maize, vegetables	maize, fruits, vegetables	rice, cassava, sweet potatoes	vegetables, fruits, maize, flowers	maize, coconuts, rice, fruits
Cattle and buffalo per family (Head/family)	3.5 (1–9)	1.7 (0–3)	3.9 (1–13)	2.7 (1–5)	1.8 (1–3)
Sheep or goats per family (Head/family)	0.4 (0–5)	1.9 (0–6)	0	1.4 (0–15)	1.5 (1–9)
Income from animals (% of family income)	6%	16%	<20%[4]	4%	8%

[1]Mean
[2]Range
[3]Most farmers also have access to forest areas for grazing
[4]Estimated only, no data available

Animal densities are relatively high in these systems but they contribute only a small portion of the family income.

Problem Diagnosis

Farmers identified lack of feed at specific times of the year (such as dry periods or during planting seasons) and labour requirements for finding enough feed for animals as major issues in raising animals.

Some farmers also mentioned poor animal production, and, at the more extensive sites, weed encroachment (e.g. *Chromolaena odorata*) into cropping areas was seen as a major problem which could be addressed with forages.

Which forage options are emerging?

Most farmers started to evaluate forages with a range of species in small areas near their houses. This gave them the opportunity to observe the performance of the different varieties and feed them to their animals to check palatability. If they decided that forages could benefit them in some way, farmers looked for ways of integrating those varieties they liked best into their farm. As farmers experimented with different ways of growing and using forages, some farmers concentrated on one or two varieties while others grew a wide range of forage varieties. Different systems evolve with time and the information presented here is only a glimpse in time. The results

Table 2. Forage varieties adopted by farmers.

	Pagalunngan	Malitbog	Xuan Loc	Cuba	Matalom
Arachis pintoi 'Itacambira' and CIAT 17844	•[1]	•		•	
Brachiaria brizantha 'Marandu'	•		••		•
Brachiaria humidicola 'Tully' and 'Yanero'		•			
Brachiaria ruziziensis 'Ruzi'		•	•		
Calliandra calothyrsus 'Besakih'			••		
Centrosema pubescens 'Barinas'	•				•
Desmanthus virgatus 'Chaland'				•	
Desmodium cinerea 'Las Delicias'	•	•			
Gliricidia sepium 'Retalhuleu'	•	•			
Leucaena leucocephala 'K636'	•	•	•		
Panicum maximum 'Simuang' and 'Tobiata'	••	•••	•••		
Paspalum atratum 'Terenos'	••	••	•	•	
Pennisetum purpureum and *Pennisetum* hybrids	•••	•••		•••	•••
Setaria sphacelata 'Lampung' and 'Golden Timothy'	•	••		•••	•
Stylosanthes guianensis 'Stylo 184'	•		•		•

[1]• = few farmers, ••• = many farmers

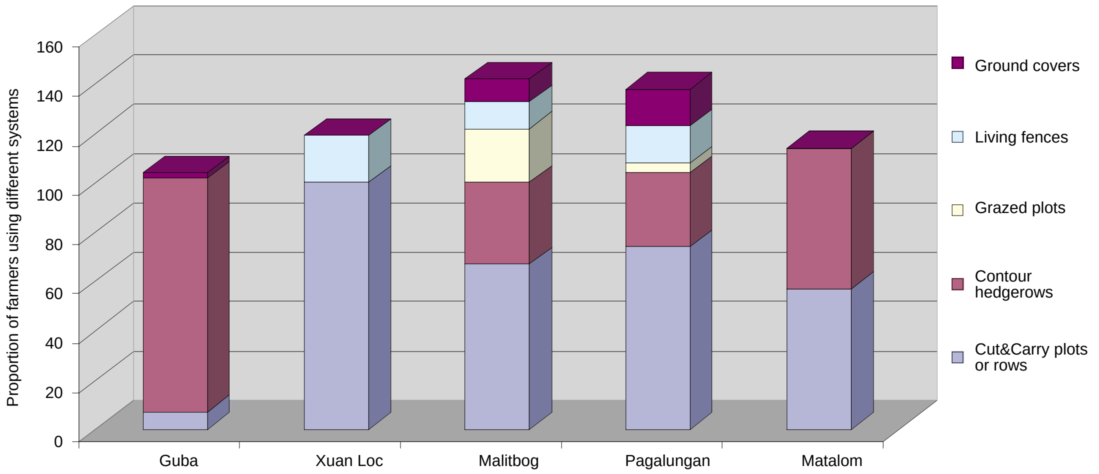

Figure 3. Percentage of farmers integrating forages in different ways (column totals exceed 100% where farmers plant forages in more than one system).

are based on a survey conducted in mid to late 1999. More and different systems will emerge with time as farmers gain more experience with growing and using forages.

Contour hedgerows and intensive cut-and-carry plots have emerged as the main ways farmers integrate forages into their agricultural system (Figure 3). Other ways of integrating forages (living fences, ground covers and small grazed plots) are starting to emerge at some sites. It seemed to be the moderately intensive upland farming systems where farmers planted forages in many different systems (Figure 3) while farmers at the most intensive site (Guba) adopted mainly contour hedgerows and farmers at the most extensive site (Matalom) adopted cut-and-carry and hedgerows systems.

What type of forage species are farmers selecting?

The most frequently used forage varieties are grasses which lend themselves to contour hedgerows and intensive cutting (Table 2). However, a large range of forage varieties are used by some farmers and other ways of integrating forages are being evaluated by farmers. These include *Arachis pintoi* as a ground cover (e.g. Malitbog) and under grapes (Guba), tree legumes along contours and small grazed plots.

Initially, farmers tended to integrate grasses rather than legumes into their farm. There are many reasons for the preference for grasses such their higher yield, cattle and buffalo tend to prefer to eat grasses, and their growth habit, which makes them suitable for growing in rows which seems to be a preferred way of planting forages. However, some farmers have already recognised the high quality of legumes and their ability to increase animal production. For example, many farmers comment on the positive effect of *Arachis pintoi* on egg production of chickens and young animals. We expect that farmers will integrate more legumes to use as a supplement to other feed resources as they gain experience.

The way farmers are growing forages and the species they are using is changing as farmers are gaining experience with forages. For example, the use of *Panicum maximum* 'Tobiata' is declining in hedgerows while the use of *Paspalum atratum* 'Terenos' is increasing. This process is expected to continue for several years.

Conclusions

Farmers in mixed crop-livestock systems in South-east Asian uplands regard animals as an important part of their agricultural system and are interested in growing forages, mainly in contour hedgerows and intensive cut-and-carry rows between crops. Forages are integrated into the cropping system, utilising whatever areas are available. They are not replacing crops but are used in areas which are not usable for crop production. It is likely that more complex forage technologies will emerge as farmers gain experience with growing and using forages.

Forage Technologies for Smallholders in Grassland Areas

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THE grasslands of Southeast Asia occur mostly in areas with long dry seasons, such as eastern Indonesia or southern Laos, or in areas where forests have been cleared and a cycle of cropping and fire has led to dominance of *Imperata cylindrica* and native grasses, such as central Vietnam and eastern Kalimantan. Often grassland areas are utilised for extensive grazing of cattle by smallholder farmers living in these areas (see, for example, Figure 1). Many unsuccessful attempts have been made to convert these grasslands into improved pastures for extensive, commercial livestock production.

The Forages for Smallholders Project (FSP) has taken the approach of working with smallholder farmers in these grassland areas to develop forage technologies to improve their livestock production system. The Project selected two sites; these were Sepaku, East Kalimantan Province, Indonesia and M'Drak, Daklak Province, Vietnam (Figure 2).

Figure 1. Cattle return to village after grazing in Sepaku, Indonesia.

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Figure 2. Location of featured project sites.

Different Countries, Similar Problems

The two locations have similar farming systems but M'Drak is considerably drier than Sepaku (Table 1). Soil fertility in Sepaku is very poor and soil acidity is severe. Soil fertility is moderate in M'Drak.

Both sites have been progressively settled by transmigrants over the past 25 years, following forest clearing (in the case of M'Drak, following chemical defoliation during the Vietnam war) (Figure 3a). Farmers established small home gardens and rice paddies in the few suitable areas. Large areas of upland crops were established in Sepaku but not M'Drak because of limited land tenure (Figure 3b). Regular fires in the fallows led to the development of large grassland areas. In Sepaku, fire and wild pigs destroyed all attempts at upland cropping. (Figure 3c). By 1999, increasing populations at both sites have allowed the slow expansion of lowland cropping and home gardens (Figure 3d).

Cattle are an essential part of both farming systems. In Sepaku, farmers generally keep from 2–10 head of cattle. In M'Drak, there is a larger variation in herd size, ranging generally from 2–50 head per family, depending mainly on how much land they have been allocated.

Farmers at both sites identified similar problems:

- grasslands provide very poor quality feed for animal production;
- at particular times of year there is not enough feed for animals nearby and farmers have to go long distances to find sufficient feed;
- it takes too long to find and cut native grasses to feed sick animals.

Similar Problems, Similar Solutions

The FSP has been working with farmers at Sepaku for four years and M'Drak for three years to develop forage technologies that have potential to solve these particular problems. The pattern of forage development has been similar at both sites:

Initially, farmers evaluated a range of species in small plots near their houses. Later, most farmers planted forages in cut-and-carry plots or rows (Table 2). Very few planted forages in grazed plots. In Sepaku, some farmers planted forages in contour hedgerows which they managed as cut-and-carry feed.

Table 2. Proportion of farmers planting forages in different systems (based on a survey in 1999).

Forage systems	M'Drak (n = 31)	Sepaku (n = 78)
	(% of farmers[1])	
Cut-and-carry plots or rows	100	85
Grazed plots	3	8
Contour hedgerows	3	27
Living fences	0	10

[1]Some farmers used more than one forage system, thus column totals exceed 100%.

Table 1. Site characteristics.

Sites	Annual rainfall (mm)	Likelihood of dry months (%)[1]	Soil characteristics	Farming system
Sepaku	2750	10	pH (H_2O): 4.5–5.0, infertile	Small areas of home gardens and lowland rice with extensive areas of native grasslands on surrounding low hills. Slowly expanding areas of upland crops and fruit trees near houses and villages.
M'Drak	1890	80	pH (H_2O): 5.0–5.5, moderately infertile	

[1] = percent of years with 4 months of <50mm rainfall (average from 10 years)

The forage varieties preferred by farmers depended on their individual needs, but there were some common varieties used by many farmers (Table 3). Initially, most farmers were interested in forage grasses rather than legumes. This preference is likely to be related to the need for more feed, grasses having a much higher yields than legumes. It is anticipated that farmers will become interested in forage legumes as they experience the large positive effect of supplementing the low-quality basal diet with legumes containing high protein contents (Lanting et al. 2000).

New forage options are starting to emerge. These include forage for feeding fish in M'Drak, establishing intensively-managed plots for short-term grazing of animals in the evening before being penned, and the use of 'Stylo 184' as a cover crop to suppress *Imperata cylindrica*, and the use of 'Stylo 184' as a protein supplement.

The FSP is now working directly with 250 farmers at Sepaku and 95 at M'Drak. Many of these are planting from 500–5000m^2 of forage; some up to 10 000 m^2.

Table 3. Forage varieties adopted by many farmers in M'Drak and Sepaku.

Forage varieties	M'Drak	Sepaku
Andropogon gayanus 'Gamba'		✔
Brachiaria brizantha 'Marandu'	✔	✔
Brachiaria decumbens 'Basilisk'		✔
Brachiaria humidicola 'Tully' and 'Yanero'		✔
Brachiaria ruziziensis 'Ruzi'	✔	
Panicum maximum 'Simuang'	✔	
Paspalum atratum 'Terenos'		✔
Pennisetum purpureum and *Pennisetum* hybrids		✔
Setaria sphacelata 'Solander' and 'Lampung'	✔	✔
Stylosanthes guianensis 'Stylo 184'	✔	✔

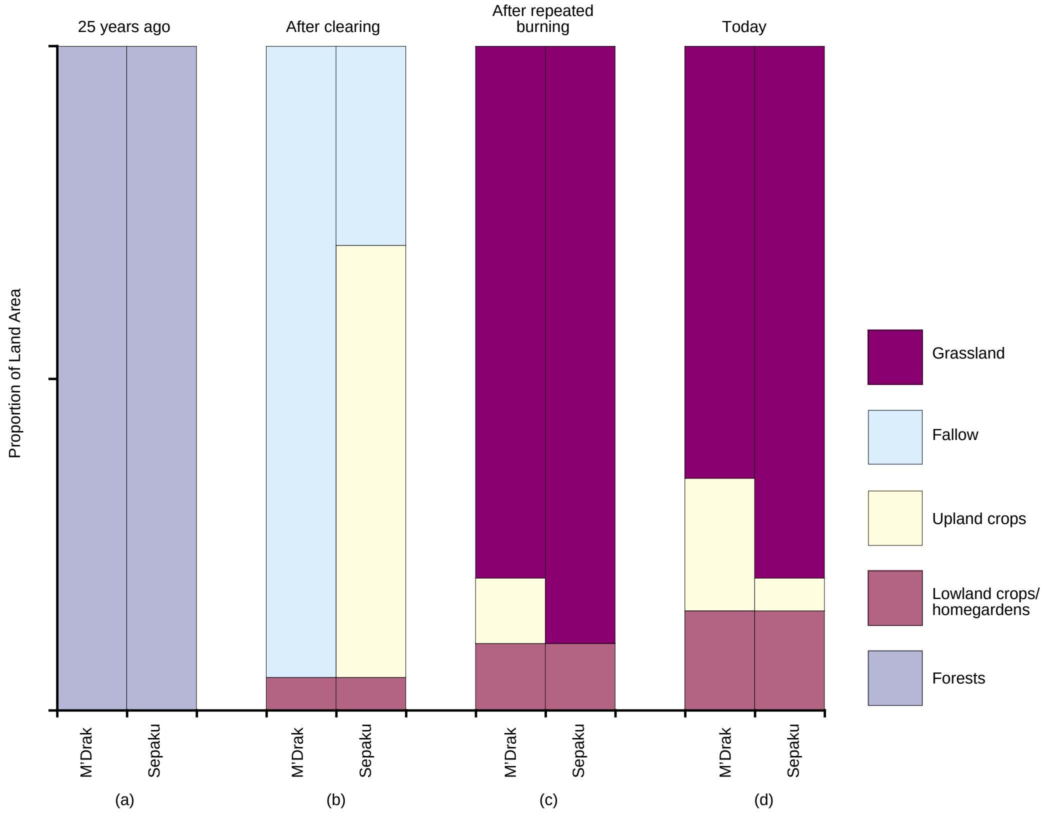

Figure 3. Changes in land use.

Lessons Learned

Through working with farmers, we have learned that:

- **Managed-forages are being used to supplement native grasslands rather than to replace them.** Initially, some farmers imagined they could use forages to replace or improve the native grassland. As they became familiar with the species and the ways of utilising them, they invariably opted for forage systems that provide supplementary feed to animals grazing on the native grassland.
- **Minimising the labour required to look after animals is a major issue in the grassland areas.** At both sites, farmers frequently commented that a significant benefit of having planted forages is the time it saves them cutting native grass for their penned animals.

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