and the extent of suppression depended on the amount of multipurpose tree included (Fig. 2). The reverse was true for leucaena. These effects were further demonstrated in vivo when animals were fed A. angustissima or Tephrosia. The effect of anti-nutrition factors on dry matter intake could be quite drastic. Anti-nutrition factors depressed dry matter intake in sheep fed A. angustissima to such an extent that many of the animals died; sheep fed Tephrosia had massive rumen stasis.

Use of Multipurpose Trees in Agroforestry Systems

The nutritional and anti-nutritional qualities of multipurpose trees will not benefit smallholders unless attractive practical systems of integrating them into farm systems are available. In this regard, alley farming (an agroforestry system) contributes to fallow management, crop production, soil nutrient replenishment, soil conservation, and animal feed supply. It is particularly important to note the negative role of social institutions, e.g. land tenure rules, on the adoption of alley farming in certain parts of south-central Nigeria (Sumberg and Atta-Krah 1988; Kang et al. 1990).

Multipurpose trees have been grown in association with food crops or forage crops. In trials undertaken in support of smallholder milk production by ILCA in the subhumid coast of Kenya, both Leucaena leucocephala and Gliricidia sepium were intercropped with maize/cassava or Napier (Pennisetum purpureum) grass. Table 2 summarises four years data on leucaena intercropped with maize. Total dry matter yields were increased from 16.4 t/ha when Napier grass was grown alone to 29 t/ha for Napier plus leucaena plus manure slurry. The effects of nitrogen source (fertilizer or Clitoria ternatea) were also demonstrated. It is important to note the contribution of slurry, a potential water pollutant. Similarly, results from intercropping maize/cassava with gliricidia showed the benefits of the multipurpose trees. When crossbred dairy cows were supplemented with some of the leucaena produced from the intercropping trials, supplementation significantly improved (p<0.01) dry matter intake and milk yield and reduced body weight loss. Further gains were made (p<0.01) by feeding the leucaena along with 1 kg of maize bran. Improved milk production has a lot of social benefits for smallholders and their families.

Conclusion

Multipurpose trees contribute in many ways to soil management and conservation, and provide very valuable nutrients to animals. However, some multipurpose trees contain anti-nutritional factors which can be detrimental to animal production or could be harnessed to nutritional advantage. Research is needed on the use of multipurpose trees as livestock feed and in agroforestry systems. This work should aim at identifying rapid methods of evaluation, the role of anti-nutritional factors, particularly their effects on pure and mixed cultures of rumen microbes, and implications of plant toxins and their degradation products for the environment. Furthermore, methodologies for rapid assessment of multipurpose trees from the agronomic to the animal utilisation stages are needed.
Table 2. The effect of intercropping leucaena with maize on maize grain (and stover) dry matter yields (DM t/ha) (ILCA, Mombasa 1994).

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<td>L</td>
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<td>L</td>
<td>S</td>
<td>L</td>
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<tr>
<td>Hedge</td>
<td>Mulch</td>
<td>Slurry</td>
<td>L</td>
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<td></td>
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<td>2.7</td>
<td>1.0</td>
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<td>+</td>
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<td>3.3</td>
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<td>0.9</td>
<td>1.1</td>
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<tr>
<td>75 kg N,</td>
<td></td>
<td></td>
<td>4.2</td>
<td>1.0</td>
<td>2.1</td>
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<td>20 kg P</td>
<td></td>
<td></td>
<td>3.7</td>
<td>2.0</td>
<td>3.3</td>
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<tr>
<td>Mulch N</td>
<td></td>
<td></td>
<td>7.0</td>
<td>3.8</td>
<td>6.3</td>
</tr>
<tr>
<td>yield (kg</td>
<td></td>
<td></td>
<td>99</td>
<td>72</td>
<td>109</td>
</tr>
<tr>
<td>/ha)</td>
<td></td>
<td></td>
<td>26</td>
<td>26</td>
<td>63</td>
</tr>
</tbody>
</table>

L = long rains.
S = short rains.

Acknowledgments

This paper was based on the multidisciplinary work of several ILCA scientists and graduate associates. In particular I would like to thank the following Dr W. Thorpe, Prof. N.N. Umunna, Dr I. Nsahlai, Dr J. Hanson, Dr H. Khalili, Dr O. Kurdi, and Mr El Hassan, Mr M. Bonsi, Mr Abule Ebro and Mr J. Johns.

References


Tanner, J.C., Reed, J.D. and Owen, E. 1990. The nutritive value of fruits (pods with seeds) from four Acacia spp. compared with extracted noug (Guizotia abyssinica) meal as supplements to maize stover for Ethiopian highland sheep. Animal Production, 51, 127–133.


Agroforestry Plantation Systems: Sustainable Forage and Animal Production in Rubber and Oil Palm Plantations

P.M. Horne*, T. Ismail† and Chong Dai Thai‡

Abstract

Integration of animal production with conventionally-spaced oil palm and rubber plantations is restricted by low light levels which result in low forage yields, stocking rates and liveweight gains. While these may be acceptable in some plantation systems, especially with feed supplementation, expansion of integrated animal-plantation production systems will depend on improving the forage resource. Shade-tolerant forages show promise for the moderate shading in young plantations, but are not likely to improve forage quality and availability in mature plantations. Sustainable forage and animal production in conventionally-spaced plantations will depend on staggered replanting to ensure continuity of adequate forage supply in young plantations.

An alternative to this is to eliminate the problem by changing the planting pattern of the trees to allow some areas of the plantation to be permanently set aside for production of forages under little shade. One promising scheme, double hedgerows, is discussed.

The rapidly growing economies of Southeast Asia have created substantial increases in demand for animal products, especially meat. In recent years, domestic demand for bovine meat in Southeast Asia has consistently outstripped domestic supply. Despite increases in animal numbers (Table 1) imports of bovine fresh meat into Indonesia, Malaysia and Thailand in 1990 totalled 42,000 million t compared with only 1300 million t of exports. Given existing animal management practices, Remenyi and McWilliam (1986) estimated that the demand for forage resources in Southeast Asia will double (from 1985 figures) by the year 2000 and meat self-sufficiency will fall from 95% to 62%.

Given the limited land area available for monoculture animal production, plantations (specifically rubber, oil palm and coconut) are the largest areas available for expansion of animal production (especially small ruminants) in Southeast Asia (Shelton et al. 1987; Iniguez and Sanchez 1991; Shelton and Stür 1991; Sivaraj et al. 1993). This paper discusses the prospects of sustainable forage and animal production in rubber and oil palm agroforestry plantation systems (the prospects for coconut plantations are dealt with by Stür, these proceedings).

For the purposes of this paper, agroforestry plantation systems are defined as landuse systems in which plantation crops are grown in association with pastures and animals in a spatial arrangement, a rotation or both, and in which there are both ecological and economic interactions between the tree and pasture/animal components of the system (after Young 1989). The viability of plantation-animal integration in the future will depend on the long-term sustainability of integration, which can be best summarised as incorporating:

- little or no negative effects on growth and yields of plantation crops;
- levels of forage production that can maintain both long-term and economically acceptable levels of animal production; and
- substantial economic benefits of the agroforestry plantation system over the plantation monoculture.

The potential negative effects of animals on growth and yields of plantation crops come from the brows-
...ng of fronds/leaves, interference with latex-collection cups, and soil compaction. However, it has been generally found that these negative effects can be eliminated by simple management of stocking rates, age of plantations grazed and the type of grazing animal. Sheep, for example, are the best choice of animal for rubber plantations because of ease of management and minimal damage to rubber trees greater than 2 years old. Goats and cattle have been successfully integrated with both young and mature oil palm plantations. There are also some significant positive effects of sound animal management in plantations, including substantial reductions in weeding costs and use of herbicides, more efficient recycling of nutrients and the conversion of otherwise useless plantation forages into meat and other animal products (Devendra 1993). In general, simple management of grazing animals, the net effect of grazing on plantation yields is neutral or even beneficial. Chen et al. (1979) and Chen et al. (1991), for example, found no negative effects of cattle grazing in young oil palm plantations up to 5 years old on fresh fruit bunch yield, so long as stocking rates were kept at or below 2 beasts/ha. At higher stocking rates significant damage to fronds of young trees reduced fresh fruit yields. In later research, Chen (1992) reported 10% higher yields in the first 5 years of palm harvesting when weeds were suppressed by grazing cattle as compared with ungrazed plantations. Jusoff (1988) found significant positive effects of sheep on nutrient cycling and tree girth in a 3-year-old rubber plantation after only 1 year of grazing.

The land areas available for integration of animals with rubber and oil palm plantations are substantial (Table 2). Little information is available on the extent of livestock integration into existing plantations but it is clearly very low. In Malaysia, while a large proportion (44%) of the national sheep population is in rubber and oil palm plantations, this is equal to only 74000 head (1989 figures) (Tajuddin et al. 1991). In Indonesia sheep are not normally found in the plantation areas outside Java (only 7% of the national sheep flock is located in Sumatra which has 54% of the plantation area of Indonesia) (Biro Pusat Statistik 1992). In Thailand, only 18% of the sheep population is found in the southern areas, which account for 61% of the plantation area (mostly rubber) (Vijchulata 1991). The biological potential for animal production in these under-utilised plantation areas is determined largely by the forage production potential, which is in turn dependent on the management characteristics of the existing plantation systems.

**Forage Production Potential of Existing Plantation Systems**

The productivity of native forages and the changes in botanical composition over time in conventional rubber and oil palm plantations (those with regular planting patterns) are summarised in Table 3. The main problems associated with the forage resource as an oil palm or rubber plantation ages are a rapid and severe decline in productivity and a reduction in the proportion of palatable species. The legume cover-crops in rubber and oil palm plantations (*Pueraria javanica, Centrosema pubescens* and *Calopogonium spp.*) are not very shade tolerant and are rapidly replaced by shade-tolerant native grasses and broad-leaved species, especially under grazing. The resulting low forage yields and quality (especially lower digestibility and energy content and higher stem:leaf ratios) in mature plantations generally lead to lower voluntary forage intake, and hence lower energy and protein intake, limiting animal production per head and per hectare (Horne et al. 1993). In conventional rubber plantations, the productivity of native forages will decline from 5-7 t DM/ha/year in 1-2 year old plantations to 1-5 t DM/ha/year in 2-5 year old plantations and <1 tDM/ha/year thereafter.

Despite these problems, most large estates and many smallholdings in Thailand, Malaysia and Indonesia have potential for profitable integrated animal production. Smallholder plantations account for the majority of the area of rubber and oil palm production in Southeast Asia (Table 2) and most of these, being conventional plantations, have adequate forage

<table>
<thead>
<tr>
<th></th>
<th>Indonesia (million head)</th>
<th>Malaysia (million head)</th>
<th>Thailand (million head)</th>
<th>Total Southeast Asia (million head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>10.4 (3.5)</td>
<td>0.7 (1.9)</td>
<td>6.0 (2.6)</td>
<td>34.3 (3.7)</td>
</tr>
<tr>
<td>Sheep</td>
<td>5.8 (3.8)</td>
<td>0.2 (15.7)</td>
<td>0.2 (25.6)</td>
<td>6.4 (3.6)</td>
</tr>
<tr>
<td>Goats</td>
<td>11.3 (4.0)</td>
<td>0.3 (-0.8)</td>
<td>0.1 (11.7)</td>
<td>15.5 (3.6)</td>
</tr>
</tbody>
</table>

*Figures in brackets are average annual growth rates since 1981.

resources (as described in Table 3) to support integrated animal production. These include:

- nucleus and plasma estates in Indonesia (approximately 550,000 ha, representing 21% of all smallholder farms) consisting of smallholder estates (oil palm and rubber) developed by government and private estate companies using high-yielding, even-aged trees, regular planting intervals and intensive management (Dereindra et al. 1991). These estates consist of 2 ha of plantation and 0.25–0.5 ha of cropland per smallholder.

- state-sponsored smallholder schemes in Malaysia (FELDA, RISDA, FELCRA) which have resulted in the development of over 250,000 ha of smallholder rubber plantations and over 450,000 ha of oil palm plantations (Yew et al. 1986).

- state-sponsored smallholder schemes in Thailand, where the majority of smallholders use management practices recommended by the larger estates.

- most smallholder oil palm plantations, which are generally indistinguishable from the larger estates in the management practices that will affect animal production.

However, in Indonesia, most of the smallholder rubber area (>2 million ha) is unconventional or 'jungle rubber', consisting of a dense mix of irregularly-spaced and uneven-aged rubber, timber and fruit trees resembling a rainforest, with little existing potential for livestock integration (Gouyon et al. 1993).

Animal Production Potential of Existing Plantation Systems

The animal production potential of existing conventional plantation systems will vary substantially with plantation management practice, age and location (Table 4). Even though low forage yields result in low stocking rates, it can be seen that acceptable levels of production are possible, especially in Indonesia and Thailand where labour costs are relatively low. However, even in Malaysia, where labour costs are high (US$6.00/day for a rubber tapper compared with US$1.20/day in Indonesia), animal integration with plantations can be beneficial simply as a cheaper and safer form of weed control. Animal productivity, especially on the forages of mature plantations, can be improved through supplementation with plantation by-products and waste products, such as palm kernel cake, palm oil mill effluent, ex-decanter palm oil solid waste, rubber seed meal and agro-industrial by-products such as molasses, rice bran, cassava meal and fish meal. Energy supplementation of sheep grazing forages in mature rubber plantations appears to be especially beneficial, but may only be economic for weaned lambs and ewes immediately pre-and post-partum (Sanchez and Pond 1991). Supplementation will be essential for improved breeds (such as the hair sheep breeds in Indonesia and Malin × Dorset in

<table>
<thead>
<tr>
<th>Natural rubber</th>
<th>Thailand</th>
<th>Malaysia</th>
<th>Indonesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total plantation area, 1992 ('000 ha)</td>
<td>1844</td>
<td>1837</td>
<td>3155</td>
</tr>
<tr>
<td>Change in area since 1989 (%)</td>
<td>5.6</td>
<td>-1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Smallholder producers (% of total area)</td>
<td>95</td>
<td>81</td>
<td>83</td>
</tr>
<tr>
<td>Latex production, 1992 (% world total)</td>
<td>26.8</td>
<td>21.9</td>
<td>24.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil palm</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total plantation area, 1992 ('000 ha)</td>
<td>109</td>
<td>2167</td>
<td>1181</td>
</tr>
<tr>
<td>Change in area since 1989 (%)</td>
<td>-</td>
<td>21.5</td>
<td>48.8</td>
</tr>
<tr>
<td>Smallholder producers (% of total area)</td>
<td>-</td>
<td>54</td>
<td>31</td>
</tr>
<tr>
<td>Palm oil production, 1992 (% world total)</td>
<td>2</td>
<td>53</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 2. Rubber and oil palm plantation areas and production statistics, Thailand, Indonesia and Malaysia.

a Smallholders defined as holdings less than 40 ha.

Sources: Vichtulata (1991); IRSG (1993); Ministry of Primary Industries, Malaysia (1993); Biro Pusat Statistik (1992).
Table 3. Forage production potential of existing plantations sown with cover crops.

<table>
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<th>1–3</th>
<th>3–5</th>
<th>5–10</th>
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<tbody>
<tr>
<td><strong>Oil palm</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PAR (%)a</td>
<td>95–85</td>
<td>85–40</td>
<td>&lt;40</td>
</tr>
<tr>
<td>Standing dry matter (t/ha)</td>
<td>3.0</td>
<td>2.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Botanical composition (%)b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legume</td>
<td>28</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Grass</td>
<td>40</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td>Other palatable species</td>
<td>22</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>Unpalatable species</td>
<td>10</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>Stocking rate (cattle/ha)</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Rubber</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAR (%)</td>
<td>95–65</td>
<td>65–20</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Standing dry matter (t/ha)</td>
<td>1.9</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Botanical Composition (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legume</td>
<td>79</td>
<td>37</td>
<td>10</td>
</tr>
<tr>
<td>Grass</td>
<td>14</td>
<td>31</td>
<td>37</td>
</tr>
<tr>
<td>Other palatable species</td>
<td>2</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>Unpalatable species</td>
<td>0</td>
<td>3</td>
<td>44</td>
</tr>
<tr>
<td>Stocking rate (lamb/ha)</td>
<td>17–14</td>
<td>14–4</td>
<td>4–2</td>
</tr>
</tbody>
</table>

a Photosynthetically active radiation.
b Will vary according to site and season.

Sources: Sivaraj et al. (1993b); Chen and Chee (1993); Wilson and Ludlow (1991); Chong et al. (1991a, b); Chen et al. (1979); Chen (1992).

Improving the Forage Resource in Existing Plantation Systems

Existing oil palm and rubber plantation systems have some inherent management problems for animal production. The reduction of forage yields as a plantation matures and the consequent necessity to reduce stocking rates means that flocks/herds must either be constantly moved to new areas of immature plantation or supplemented with cut-grass and concentrates in the barn. In some systems, such as the nucleus rubber estates of Indonesia, this is feasible. However, for commercial-scale enterprises, the labour costs involved and slow returns on investment make integration of animal production with plantations less attractive to investors. These problems can be partly overcome by improving the forage resource.
Table 4.  Animal production potential from native pastures in rubber and oil palm plantations.

<table>
<thead>
<tr>
<th>Mature rubber</th>
<th>Feeding regime</th>
<th>Performance variable</th>
</tr>
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<tbody>
<tr>
<td>Ram lamb growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STT and SC × STT</td>
<td>Free grazing, no supplementation</td>
<td>ADG 45–68 g/hd/day</td>
</tr>
<tr>
<td>SC × STT</td>
<td>6–12 animals/ha ± supplement</td>
<td>ADG 80–117 g/hd/day</td>
</tr>
<tr>
<td>SC × STT</td>
<td>6–12 animals/ha ± supplement</td>
<td>LWG 175–490 kg/ha/year</td>
</tr>
<tr>
<td>SC × STT</td>
<td>Cut forage + concentrate supplement</td>
<td>ADG 78–166 g/hd/day</td>
</tr>
<tr>
<td>M × D</td>
<td>Free grazing, no supplementation</td>
<td>ADG 43–95 g/hd/day</td>
</tr>
<tr>
<td>M × D</td>
<td>Free grazing + concentrate supplement</td>
<td>ADG 63–106 g/hd/day</td>
</tr>
<tr>
<td>Ewe reproductive performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STT</td>
<td>Free grazing, no supplementation</td>
<td>0.68–0.92&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>STT</td>
<td>Free grazing, supplementation at up to 1.4% BW</td>
<td>0.76–1.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>M × D</td>
<td>Free grazing + PKC supplement 200 g/hd/day</td>
<td>16.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>M</td>
<td>Free grazing + PKC supplement 200 g/hd/day</td>
<td>7.7–14.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Young oil palm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ram lamb growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Free grazing, no supplementation</td>
<td>ADG 61 g/hd/day</td>
</tr>
<tr>
<td>M × D</td>
<td>Free grazing, no supplementation</td>
<td>ADG 95–100 g/hd/day</td>
</tr>
<tr>
<td>M × D</td>
<td>10 lambs/ha</td>
<td>LWG 250–350 kg/ha/yr</td>
</tr>
<tr>
<td>Cattle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KK</td>
<td>Free grazing of native pasture + grass/legumes</td>
<td>ADG 260–379 g/hd/day</td>
</tr>
<tr>
<td>KK</td>
<td>1–3 hd/ha on native pasture + grass/legumes</td>
<td>LWG 117–284 kg/ha/year</td>
</tr>
<tr>
<td>KK</td>
<td>2 hd KK cattle/ha</td>
<td>ADG 234–390 g/day</td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaysian local</td>
<td>Free grazing + cut forage</td>
<td>ADG 50 g/hd/day</td>
</tr>
</tbody>
</table>

<sup>a</sup>kg lamb weaned/kg ewe/year.

<sup>b</sup>kg lamb weaned/ewe/year.

STT = Sumatra thin tail; SC × STT = St Correct × STT F<sub>1</sub> crossbreed; M = Malin; M × D = Malin × Dorset Horn crossbreed; KK = Kedah Kelantan breed.

ADG = average daily gain; LWG = liveweight gain; BW = body weight; PKC = palm kernel cake.

Sources: Ranges in the table were compiled from Sanchez (1988); Sanchez (1991); Sanchez and Pond (1991); Chong et al. (1987); Chen et al. (1979); Chen et al. (1991).
Wong et al. (1985a, b), Shelton and Stür (1991) and Sanchez and Ibrahim (1991). The ideal species should have the following properties (Horne et al. 1993):

- persistent and productive under moderate shading and grazing/cutting;
- able to grow well on acid soils;
- rapid establishment to control weeds, especially Imperata;
- negligible competition with the plantation crop for water or nutrients;
- only moderate fertilisation needed to provide the nutrients required for plant growth and animal production;
- establishment costs no greater than conventional cover crops; and
- higher yield potential of better quality forage than from the conventional cover crops.

Some species that meet most of these criteria have been sown in experiments to investigate agronomic and animal production potential in large rubber estates (Chong et al. 1994; Horne et al. 1994). These include the grasses Brachiaria humidicola, Brachiaria brizantha, Paspalum notatum and Panicum maximum and the legumes Stylosanthes guianensis and Arachis pintoi. It is expected that by using mixtures of these species, forage production in 2-year-old plantations can be increased to around 15 t DM/ha/year with stocking rates of 20-35 DSE/ha. However, it is not expected that any of the improved species will persist under grazing in mature rubber plantations. For this reason, the value of these improved forages for smallholders is limited, except on the large cooperative smallholder schemes such as RISDA in Malaysia. Smallholders have less ability to adjust animal numbers to match forage resources or move flocks around to ensure grazing in young plantations.

Establishment of these improved forages in conventional plantations can be problematic, not only because of the requirements for weed control during establishment, but also because of the inability to graze the forages when the plantation trees are too young. Without grazing, competition from the forages can depress tree growth. One way of overcoming this in rubber plantations is through the use of core-stump or high-budded-stump planting material (Leong et al. 1986). These are grafted seedlings that, instead of being transplanted directly into the field, are raised in nurseries for two years before transplanting. The advantage is that grazing can commence as soon as the forages are ready with no risk of damage to the trees. However, the disadvantages are that the canopy of core-stump plantations closes earlier than that of plantations established with grafted seedlings, and core-stumps entail a greater cost and possible higher risk of failure due to wind damage and poor transplanting success. A possible alternative is to establish conventional cover crops at the time of tree transplanting, followed by spraying of 2 m wide strips after 20 months, which are then established with the improved forages and grazed after 4 months (Tajuddin et al. 1991). This method has yet to be evaluated for efficiency and cost. Given the spatially uneven and rapidly changing light environment in a young plantation, it is also likely that a mixture of species adapted to high and low light conditions will be more successful than a single species pasture.

Persistence and feeding value of improved forages in the moderate shade of young conventional plantations may be better under light but frequent grazing than under heavy or continuous grazing, since regrowth of shaded forages is likely to be more dependent on residual leaf area after grazing than on mobilisation of root carbohydrate reserves. A rapid rotational grazing system would give the best control over this kind of pasture utilisation, but it would require investment in fencing and continual monitoring, which is possibly not justified by the short-term benefits to animal production before the canopy closes. Shepherded grazing, which is common in rubber and oil palm plantations in Indonesia, can be managed to imitate rotational grazing. However, there is a conflict of recommendations between the frequency of grazing for optimising pasture quality and production (3-4 weeks in young plantations and 6-8 weeks in mature plantations) and the frequency of grazing required to adequately control gastrointestinal parasite larvae in the field (3 months or more). The grazing system used will have to be simple and will depend largely on the relative costs and benefits of pasture establishment and maintenance, fencing and sheep parasite control (Horne et al. 1993). Since forage yields from each area of immature plantation decrease rapidly with increasing shade, replanting would ideally be staggered so that there are always areas of better forage within easy walking distance of the flocks/herds.

Alternative plantation management

The inherent problems of forage production in conventional plantations has led to a re-examination of alternative rubber plantation management systems, that allow more light into some areas of the plantation to support sustainable forage production. Similar approaches may also be appropriate for oil palm plantations. The system that has attracted most interest is known as hedgerow plantings. In conventional rubber plantations regular tree spacings result in an even distribution of 400-450 trees/ha with canopy closure after 4-5 years. In hedgerow plantings, the distribution of trees is uneven with rows of trees and wide intervening alleys for permanent crop or forage pro-
### Table 5. Comparison of some features of conventional and hedgerow plantation systems.

<table>
<thead>
<tr>
<th></th>
<th>Conventional rubber, native forages</th>
<th>Conventional rubber, improved forages</th>
<th>Double hedgerow, improved forages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial tree density (per ha)</td>
<td>416–462</td>
<td>416–462</td>
<td>400–420</td>
</tr>
<tr>
<td>Forage DM yield (young rubber)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5–7 t/ha/year</td>
<td>12–15 t/ha/year</td>
<td>12–15 t/ha/year</td>
</tr>
<tr>
<td>Forage DM yield (mature rubber)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt;1 t/ha/year</td>
<td>&lt;1 t/ha/year</td>
<td>8–10 t/ha/year</td>
</tr>
<tr>
<td>Regrowth interval (mature rubber)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&gt;6 weeks</td>
<td>&gt;6 weeks</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Stocking rate DSE (1–3 years)</td>
<td>14</td>
<td>35–20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40–30&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stocking rate DSE (3–5 years)</td>
<td>14–4</td>
<td>20–4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40–30&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stocking rate DSE (5–10 years)</td>
<td>2–4</td>
<td>2–4</td>
<td>30–20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stocking rate DSE (&gt;10 years)</td>
<td>2–4</td>
<td>2–4</td>
<td>20–15&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LWG (kg/ha/year)</td>
<td>500–50</td>
<td>700–50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1000–900</td>
</tr>
<tr>
<td>Savings on weeding costs</td>
<td>15–25%</td>
<td>15–25%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&gt;50%</td>
</tr>
<tr>
<td>Estimated net return of sheep ($ million)</td>
<td>62</td>
<td>138–147&lt;sup&gt;b&lt;/sup&gt;</td>
<td>114–245&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Estimate.

<sup>b</sup> First figure is for grass/legume mix followed by N-fertilised grass mix. Note that these figures are relative indicators only as they are subject to significant variation as latex prices and costs of production change. The figure for double hedgerows includes an estimated 10% reduction in latex yields.

Sources: Wan Mohammed (1977); Tajuddin and Chong (1994a, b); Stür (1991).

Production. Hedgerows were initially investigated in Indonesia in the 1930s for the incorporation of coffee and cacao into rubber plantations and then in Malaysia in the 1950s mainly to try to reduce rubber tapping costs. In Malaysia, research was abandoned because of low yields of latex per hectare resulting from low tree populations but in Indonesia, it was reported that latex yields were equal to, or higher than, those from conventional plantations; an effect attributed to selective thinning of the densely planted trees in the hedgerows.

The main attraction of hedgerow plantation systems for improved forage production is that they create a permanent agroforestry plantation system with potential benefits for both plantation management and sustainable sheep production at reasonable levels of productivity per hectare. The Rubber Research Institute of Malaysia (RRIM) is currently investigating a double hedgerow system that consists of hedges of two rows of trees (planted with a spacing of 2 × 3 m) with a 22 m wide alley between the adjacent hedges (Fig. 1). The potential advantages of this system, as summarised in Table 5, consist mainly of relatively high and sustainable forage and animal production from the predominantly unshaded forages in the alleys, and possibly only minor reductions in latex yield resulting mostly from increased competition between the closely planted trees. The estimated net returns from incorporation of sheep into the different plantation systems compare with net returns from conventional monoculture rubber plantations of $M 490–874/ha, at the time of the analysis (Stür 1991).

Double-hedgerow rubber plantation systems could be applied to both large estates and organised smallholders, and RRIM has a total of more than 200 ha of experimental area. Many of the figures in Table 5 are estimates and will remain speculative until the experiments are more advanced. Double hedgerows are an innovative potential solution to the problems of low and variable animal and forage production in rubber plantations. It is hoped that the system will live up to the expectations alluded to in Table 5 and be optimised (better tree spacings and better management) not only for rubber but also for other plantation crops to give a sustainable agroforestry plantation system incorporating benefits for the tree, forage and animal production components.
Fig. 1. Comparison of a conventional and a double-hedgerow planting system for rubber plantations.
References


sia, 9–14 September 1990. SR–CRSP, University of California.


Agroforestry as a Feed Base for Livestock in Semi-arid Regions of Asia

Panjab Singh*

Abstract

Livestock, especially the large and small ruminants, are a valuable resource in the semi-arid Asian region. But their productivity is quite low in most situations. Lack of adequate amounts of quality feed is one of the principal reasons for this.

Incorporation of a leguminous component has potential to improve the quality of existing grasslands. Among such legumes, trees and shrubs assume special importance because of their ability to provide fodder during lean periods, the multiple uses to which they can be put, the ease of their establishment and maintenance, and the possibility of growing them as a component in two-and three-tier systems. Potential species may be incorporated in the farm through various agroforestry options: live fences, alley cropping, plantations on uncropped areas, and agrosilvopasture/silvopastures.

The paper identifies some promising tree/shrub legumes for different agroforestry systems in the region, and discusses management aspects with a view to developing agroforestry as feed for livestock.

Ruminants such as buffaloes, cattle, goats and sheep are an extremely important resource in the semi-arid regions of Asia. They contribute meat, milk, fibre and draught power. This in turn is significant to the productivity, stability and sustainability of many developing country farming systems.

Although these livestock are of value to farms, their performance and productivity are generally poor because of limited farm areas, low inputs and low quality and quantity of animal feed. Increasing animal populations and availability of grasslands have created a situation of marked imbalance. Shrubs and trees having fodder value are becoming increasingly important as feeds because of harsh environmental conditions in the region. Also, there exists large areas of marginal lands that cannot support good crop and pasture growth.

Although throughout the developing countries of the region, shrubs and tree fodders are widely available and traditionally used by farmers, these resources are underused in livestock feeding systems. There exists enormous potential to include such resources in conventional farming systems. Such agroforestry systems may be managed for obtaining fodder supplies at regular intervals, especially during lean periods. Thus agroforestry may very well serve as an important feed base for livestock in this region.

In the present paper, an effort is made to explore the possibilities of including shrub and tree legumes in farming systems/grasslands of the region. It also presents an account of management aspects for obtaining regular yields and their effects on livestock productivity.

Livestock Population vs Feed Availability

Livestock has been an essential component of the farming systems of many countries in the region. The region contains the majority of the world’s buffaloes and goats. India has the largest bovine population in the world with 191 million cattle and 69 million buffaloes, of which 80–85% are nondescript. The number of milch animals include 50.7 million cattle and 28.3 million buffaloes (Badve 1991). Pakistan has 30.6 million large ruminants (buffaloes and cattle) and 58.5 million small ruminants (sheep and
goats). By the year 2000, there will be 19.2 million cattle, 24.8 million buffaloes, 36.6 million sheep and 56.8 million goats (Akram et al. 1990).

In Bangladesh, cattle account for about 90% of the country’s animal units. Sri Lanka has 1.8 million cattle, 0.97 million buffaloes, 0.53 million goats and 0.29 million sheep (MIRD 1985). Philippines has 1.6 million cattle, 2.9 million buffaloes and 2.06 million goats (BAI 1988). Between 1975 and 1985 the buffalo population in the region remained almost static. Cattle population showed an annual growth rate of 1.2%. Goat and sheep numbers grew by 1.5% and 1.4% respectively.

Buffaloes and cattle are widely used for draught power. Draughting duties range from a wide variety of ploughing operations to transportation. As the use of tractors involves considerable capital expenditure, the importance of draught animals and their contribution to agriculture is likely to increase in future. Most of the milk and meat supplies come from buffaloes. Goat meat accounts for approximately 63% of the total volume of meat produced in the world. Dairy farming is becoming an important means of promoting social and economic change as well as the pace of rural development.

However, average livestock productivity is low in the region, mainly because of limited farm areas, low input levels, low quality and quantity of feed and low genetic potential of livestock. Contribution towards secondary products, especially milk, due to genetic factors of livestock, is about 25%. According to Remenyi and McWilliam (1986) the low quality and seasonal nature of forage supply, together with low intake by animals and poor digestibility of the forage are the major factors contributing to low productivity of ruminants in the region, especially the arid and semi-arid parts. In such parts the situation becomes quite serious during dry seasons.

The gap between feed requirements and supplies is large. For example, in India, there is a huge annual shortage of concentrates (44%), green fodder (36%) and dry roughage (36%) (Raghvan 1990). In Pakistan, the annual shortage of DCP and TDN is estimated to be around 1.6 and 12.5 million respectively (Akram et al. 1990).

Most of the countries experience a long drought period during which CP content of natural grasses goes below 3%, thus affecting livestock productivity (Evans 1968). The growing period of grasses in the semi-arid regions is short compared to that in the temperate regions. The grasslands are mostly located in marginal and submarginal areas having low fertility. These are invaded by nonpalatable species which dominate with increasing grazing pressure. Thus, there exists a marked imbalance between total ruminant livestock units and available permanent pastures in the region, as compared to other regions of the world.

The Role of Legumes in Improving Feed Quality

Most of the grasses, either native or improved, have comparatively low metabolisable energy values (7.0-11.0 MJ/kg DM) when cut between 2-8 weeks. The digestibility of such grasses lies between 50-60%, which is lower than temperate grasses. The decline in digestibility with age is more rapid in such grasses compared to legumes—a decrease of 0.1-0.2 digestibility units/day.

The legumes have higher metabolising energy values. Their CP and CF is superior to grasses. They retain relatively high digestibility at maturity. Thus, incorporation of legumes in grasslands is particularly valuable for animals in dry seasons. Results from grazing pangola-legume pasture have indicated that liveweight gain of beef cattle was linearly related to legume component in the pasture (Aminah and Chen 1991).

Incorporation of legumes in pasture production systems is better than relying on nitrogenous fertilizers: soil condition improves due to N build up in soil from the accumulation of organic matter, N-fixation through Rhizobium synthesis occurs; and increased animal production occurs due to the higher nutritive values of legumes and the shorter digestive passage time in the gut that enhances voluntary uptake.

Higher milk production per cow has been reported in grass-legume mix pastures as compared to nitrogen fertilised grass pasture (Moog 1991).

However, legume viability and persistence are always problematic, especially on acidic soils. There could be several factors that affect the legume component in a pasture. The more important controllable factors are defoliation, grazing management and fertilizers (Aminah and Chen 1991). Presently, little is known about optimum levels of legume components in the grasslands of the region.

Shrub/Tree Legumes

Amongst legumes, shrubs and trees have high potential in this region:

• They have deep root systems and can withstand drought — often serving as the main source of forage during dry seasons.
• Some tree legumes are multipurpose plants and yield fuelwood, timber, pole and even food in addition to fodder.
• These, once established, are easier to maintain in association with grasses as compared to conventional creeping legumes and they can be grown as a component of two or three tier production systems.

Many such legumes are known as a potential source of fodder in the region: genera like Albizia, Gliricidia, Mimosa, Leucaena, Samanca, Acacia,
Agroforestry as a Feed Base

Potential trees and shrubs may be incorporated into the farm through various forms of agroforestry. In this region such incorporation may be achieved in the following four principal ways.

Live fences

Creation of live fences around household and farms may provide not only additional fodder but also fuelwood and food. These may also act as windbreaks and protection against wildlife in specific situations.

Species choice is important. It should have fodder value and should be easily propagated, initially fast-growing, able to withstand frequent lopping and strong winds. Suitable species for the region include *Leucaena leucocephala*, *Pithecellobium dulce*, *Gliricidia sepium*, *Sesbania grandiflora* and *Prosopis juliflora*.

Plantation on uncropped areas

There are opportunities on farmlands and other areas to incorporate trees and shrubs. These include farm boundaries, paddy bunds, forest margins etc. Such plantations may provide not only additional fodder but also fuelwood, vegetables, fruit, and medicines, depending on the species. These also provide shelter for livestock during summer.

Many farmers in the region believe that trees compete with crops for water, light, nutrients and space. Therefore, they are not motivated to plant trees (Sapkota 1988). However, with promotion of trees having multiple benefits including fodder, several fast growing species are being adopted by farmers. Characteristics such as vigorous tap root development, dry season leaf retention, and high digestibility of foliage are preferred. Species like *Acacia xeneura*, *A. nilotica*, *Cajanus cajan*, *Albizia lebbeck*, *A. procera*, *Bauhinia spp.*, *Dichrostachys cinera*, *Sesbania spp.*, *L. leucocephala*, *Gliricidia spp.*, *Erythina spp.*, *Prosopis spp.* and *Pithecellobium dulce* may be introduced in the region.

Tree Management

Not much information is available with regard to management aspects of trees and shrubs in agroforestry systems. Of several traditional forestry management practices; pollarding, pruning and lopping are of importance in fodder production.

Pollarding management

In this system branches are removed at a height of about 1–3 m above ground level at periodic intervals. This system can be used for managing live fences. Species like *Azadirachta indica*, *G. sepium*, *Cassia siamea*, *Erythina spp.*, *L. leucocephala* and *Cajanus cajan* have good pollarding ability.

At Jhansi (India) it was found that a 1-m cutting height in *L. leucocephala* around crop fields (dryland situation) in single hedgerows provided the highest annual forage yield (1.8 t DM/ha) (Pathak and Patil 1982).

In Malaysia *G. sepium* provided a dry matter yield of 2 t/ha/year through pollarding at 1–1.5 m cutting height. In irrigated conditions *L. leucocephala* provided a dry matter yield of 13–22 t/ha/year at 0.5–1.0 m cutting height. *C. cajan* yielded dry matter in the range of 3.7–9.8 t/ha/year with 6–8 week cutting frequencies (Chee 1990).

Pruning management

In this system, small branches and twigs are removed at periodic intervals. It is often required for maintenance of trees, especially in alley cropping and live-fence systems. These clippings may constitute a substantial source of fodder. In *L. leucocephala* and *G. sepium*, such clippings may be taken at 6–12 week intervals in alley cropping systems – providing...
annual average dry matter yields of 7.9–10.7 t/ha respectively. Under irrigation, dry matter yields of up to 20 t/ha/year has been reported from S. sesban in 5–6 cuts/year (Topark-Ngaram 1990).

Lopping management

In this system, major branches are removed to obtain fodder, especially during lean periods. The fodder yield is influenced by species, age, moisture level, fertility status of soil, season of lopping, severity of lopping and severity of weather.

In Nepal, Panday (1982) reported fresh fodder yields of 20–400 kg/tree/year in different trees. High yielding trees were Ficus glaberrima (400 kg/tree/year) and F. lacor (150 kg/tree/year) from a 10-year-old plantation. Trees and shrubs fed to ruminants, and their chemical compositions, have been detailed by Joshi and Singh (1990).

In Jhansi (India), Roy (1989) reported fresh fodder yields of 1–31 kg/tree/year in different leguminous trees. High yielding trees were Albizia procera (31 kg/tree/year) and A. amara (25 kg/tree/year) from a 6–9-year-old plantation having 440 trees/ha.

In arid zones of India, Prosopis cinerarea has been found to produce more fresh fodder (6.3–10.5 kg/tree/year) from annual loppings as compared to loppings done once in four years 95.2–6.9 kg/tree/year. Such trees have remarkable capacity to recover — complete loppings on an annual basis provided more fodder than partial or infrequent loppings (Robinson 1985).

In lopping studies conducted on L. leucocephala and Acacia tortilis in silvopastoral systems in Jhansi (India) the former gave a peak fodder yield of 1.77 t/ha/year while the latter could provide only 0.62 t/ha/year (Fig. 1) (Singh et al. 1990).

Tree/Shrub Legumes and Livestock Productivity

Generally the CP content (at about 25%) of tree/shrub legumes is higher than that of grasses at similar ages and stages of growth. The fluctuations are less as compared to grasses during the growing process. Apart from N content, these maintain higher S (0.07–0.21%) and Ca (1.3–1.93%) as compared to grasses (0.09–0.15% and 0.17–0.41% respectively). Similarly, values of P in legumes are higher than in grasses. Also, these legumes increase the mineral content of pasture and this has an additive effect on animal nutrition and production.

In the Philippines leucaena is the most popular tree legume. Farmers with small dairies feed their animals on 5–19 kg fresh leaves in combination with fresh grass fodder and obtain 4–7 kg milk/cow/day. The psyllid attack in 1985 badly affected the farmers and forced them to reduce their animal holdings. This suggests that a search for alternative fodder trees for different situations is warranted (Moog 1991).

In Sri Lanka, Liyange and Jayasundera (1988) reported that Gliricidia may be used as an animal feed. Gliricidia loppings mixed with Bracharia miliformis in a 50:50 ratio and fed to crossbred heifers resulted in an average liveweight gain of 700 g/head/day. These leaves are succulent but not very palatable to animals when first introduced. However, livestock freely eat them when they become accustomed to them. Similarly, Premaratne (1993) reported that field supplements of G. sepium, Tithonia diversifolia and L. leucocephala have a significant effect on voluntary intake and digestibility of rice straw, which in turn resulted in weight gain of sheep (Table 1). Studies in India indicate a significant effect of leucaena supplementation on liveweight gain of calves and goats (Table 2).

In a silvopastoral grazing trial at Jhansi (India) where top feed from L. leucocephala and A. tortilis was introduced in the diet of animals, growing heifers gained on average 55 g/head/day. Growing lambs gained 44.2 g/head/day (Fig. 2). Breedable Barbari goats gave birth to 19 kids. Performance of lambs and

![Fig. 1. Lopped fodder yields in different silvopastoral systems at Jhansi: (a) A. tortilis; and (b) L. leucocephala. Treatments: 1 = spacing 4 × 3, lopping 25%; 2 = spacing 4 × 4, lopping 25%; 3 = spacing 4 × 6, lopping 25%; 4 = spacing 4 × 3, lopping 50%; 5 = spacing 4 × 4, lopping 50%; 6 = spacing 4 × 6, lopping 50%.

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kids under different agroforestry systems showed significant liveweight gains (Table 3). The kids gained from 38 to 46 g/head/day during 9 months. Breedable sheep provided two wool clippings in a year. The average wool production was in the range of 726 g/head/year (Singh et al. 1990).

Future of Agroforestry as a Feed Base in the Region

Milk and meat production in most of the semi-arid Asia region is low. Countries like Korea rapidly expanded milk and meat products, largely based on imported feeds. Although the country has a sizeable trade surplus, it is now paying greater attention to the development of domestic feed resources through agroforestry. In China, the original target of producing 30 million t milk by 2000 had to be revised, mainly because of short feed supplies. Unlike China, Thailand, Indonesia and India have given priority to smallholder dairy farmers in their rural development policies. In India, ‘Operation Flood’ — the World’s largest dairy development project — is based largely on local feeds and indigenous cattle and buffaloes. It is therefore clear that in future agroforestry has enormous potential as a feed base for livestock in this region.

Table 1. Effect of fodder supplementation on the DM intake and in vivo digestibility and weight gain in sheep.

<table>
<thead>
<tr>
<th>Item</th>
<th>Straw</th>
<th>Straw + G. sepium</th>
<th>Straw + T. diversifolia</th>
<th>Straw + L. leucocephala</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake (g/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total DM</td>
<td>439.8</td>
<td>603.7</td>
<td>633.2</td>
<td>670.0</td>
</tr>
<tr>
<td>Straw DM</td>
<td>382.0</td>
<td>380.2</td>
<td>417.6</td>
<td>445.9</td>
</tr>
<tr>
<td>DM digestibility (%)</td>
<td>41.7</td>
<td>49.1</td>
<td>51.7</td>
<td>48.2</td>
</tr>
<tr>
<td>Weight gain (g/day)</td>
<td>-18.0</td>
<td>268.0</td>
<td>208.0</td>
<td>250.0</td>
</tr>
</tbody>
</table>


Table 2. Effect of leucaena supplementation on liveweight gains.

<table>
<thead>
<tr>
<th>Item</th>
<th>Dry matter intake (gw&lt;sup&gt;0.75&lt;/sup&gt;kg)</th>
<th>Dry matter digestibility (%)</th>
<th>Weight gain/loss (g/HD/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chaffed mixed with dry grass</td>
<td>114</td>
<td>44</td>
<td>-240</td>
</tr>
<tr>
<td>Chaffed mixed with dry grass + 4 kg leucaena leaf/HD/day</td>
<td>114</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Chaffed mixed with dry grass + 2 kg concentrate</td>
<td>140</td>
<td>48</td>
<td>285</td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry grass</td>
<td>33</td>
<td>36</td>
<td>-117</td>
</tr>
<tr>
<td>Dry grass + 50% leucaena</td>
<td>57</td>
<td>50</td>
<td>13</td>
</tr>
<tr>
<td>Dry grass + 75% leucaena</td>
<td>60</td>
<td>47</td>
<td>45</td>
</tr>
</tbody>
</table>

Fig. 2. Patterns of liveweight gain in growing heifers and lambs when fed on silvopastures at Jhansi (India).
Table 3. Comparative performance of lambs and kids under silvopasture and natural grassland.

<table>
<thead>
<tr>
<th>Animal species</th>
<th>Silvopasture system</th>
<th>Natural grassland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial weight (kg/hd)</td>
<td>Final weight (kg/hd)</td>
</tr>
<tr>
<td>Kids (4–6 months old)</td>
<td>11.8</td>
<td>21.3</td>
</tr>
<tr>
<td>Lamb (4–5 months old)</td>
<td>13.4</td>
<td>27.0</td>
</tr>
</tbody>
</table>

Future Research Areas

To ensure adequate quality feed supplies in the region, appropriate site-specific fodder-based agroforestry practices are recommended. The following research areas need strengthening:

- An inventory of existing agroforestry practices and their effects on the farmer household economy should be carried out. This research should determine opportunities for, and constraints for, improvement.
- Identification of species that yield high quality fodder in substantial quantity for alley cropping systems.
- Standardisation of various tree management practices in different agroforestry systems in respect of each potential species.
- Investigation of quality aspects of fodder trees and shrubs. The promising species should be ranked in relation to their potential as animal feed and suitability for different agroclimatic zones.

Conclusion

Tree and shrub legumes are valuable components of livestock feeding systems in the region. Increasing population trends indicate that more of the grasslands will be diverted towards crop production and most of the fodder supplies will have to come from marginal areas where crop production is uneconomical. Also, smallholder livestock producers will increase.

In such a situation, tree and shrub legumes will play an even greater role. Livestock research and development programs should focus on using tree and shrub legumes in existing farming systems in a more scientific way. There is also a need for more research on the efficient cultivation, management, and use of, fodder trees and shrubs for livestock production.

References


Cattle Production under Coconuts

W.W. Stür*, S.G. Reynolds† and D.C. Macfarlane§

Abstract

Coconut plantations offer an excellent opportunity for integration of cattle with coconuts. This has become increasingly attractive over the years because of the long-term structural decline in copra prices, while, at the same time, the price for meat has increased.

It is demonstrated that the level of cattle production under coconuts is comparable to that obtained in the open, provided that adapted forages are planted to ensure a sustainable, high quality feed resource.

Worldwide, coconuts occupy between 10 and 11 million ha of agricultural land (Taufikkurahman 1991). The Asia-Pacific region accounts for approximately 90% of the world’s area under coconut (Reynolds 1988) with Indonesia and the Philippines being the largest producers of copra and coconut oil in the region.

Successful integration of cattle production with coconut enterprises is based on the premises that cattle are beneficial to the management of coconuts and that the combined income of the two enterprises is greater than that of coconuts alone. In the past, coconut was the main agricultural activity and cattle management was directed towards reducing plantation weeding costs and increasing copra production (largely from a higher recovery of fallen nuts). In recent years the marked fluctuation in copra prices, both monthly and from year to year, and the structural decline in copra prices since 1950 (Fig. 1), has encouraged farmers to diversify and to find a reliable secondary source of income.

Reynolds (1988) demonstrated the importance of a secondary source of income in a case study in Western Samoa (Table 1). The local copra price dropped sharply from US$0.30/kg in early 1975 to US$0.09/kg later in 1975. Based on data for liveweight gain and copra production, the contribution of beef to gross farm income increased from 21 to 41% for a farm with cattle on natural pasture, and from 42 to 71% for a farm with cattle on improved pastures. The farm without cattle suffered a reduction in gross farm income of 70%. Clearly, cattle provided a stabilising influence on farm income, possibly enabling farmers to stockpile coconuts until copra prices recovered.

Iniguez and Sanchez (1991) estimated the percentage contribution of the cattle component in a coconut-cattle system in Bali, Indonesia to be 75%. In the Philippines typhoons can completely defoliate coconut trees and cause loss of yield for several years (Deocareza and Diesta 1991).

Cattle production is one avenue for diversification. It is beneficial to coconut production and is increasingly economically attractive both through consistent price increases and price stability. In the Philippines, retail prices for beef have nearly tripled between 1985 and 1992 (Fig. 2). Although increases in actual farmgate prices may have been lower, cattle production compares very favourably with other intercropping options. Similarly, Levine and Soedjana (1991) concluded that the gap between domestic supply and demand for meat is increasing in Indonesia, and this has led to considerable price increases.

Constraints and Benefits

Incompatibility of cattle and coconuts is likely to be caused by unacceptable damage to trees or interference in the management of coconuts.
Table 1. Effect of fluctuations in copra price on farm gross return (US$/ha/year) in Western Samoa (adapted from Reynolds 1988).

<table>
<thead>
<tr>
<th>Gross return (copra) when</th>
<th>Gross return (beef)</th>
<th>Contribution of beef to gross return when</th>
</tr>
</thead>
<tbody>
<tr>
<td>copra price was</td>
<td></td>
<td>copra price was</td>
</tr>
<tr>
<td>High&lt;sup&gt;a&lt;/sup&gt; (US$)</td>
<td>Low (US$)</td>
<td>High (%)</td>
</tr>
<tr>
<td>High (US$)</td>
<td>Low (US$)</td>
<td>Low (%)</td>
</tr>
<tr>
<td>Coconuts only&lt;sup&gt;b&lt;/sup&gt;</td>
<td>407</td>
<td>Coconuts only&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Low 122</td>
<td>0</td>
<td>Coconuts + cattle on natural pastures</td>
</tr>
<tr>
<td>Coconuts + cattle on improved pastures</td>
<td>346&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Coconuts + cattle on improved pastures</td>
</tr>
<tr>
<td></td>
<td>104</td>
<td>249</td>
</tr>
</tbody>
</table>

<sup>a</sup> High copra price = US$0.30/kg; Low copra price = US$0.09/kg.
<sup>b</sup> Assuming copra production is similar to farm with cattle on natural pasture. In practice it is likely to be lower.
<sup>c</sup> Copra production was initially depressed when improved pasture was established because no fertilizer was applied.

Damage to fronds of young coconuts could be caused by grazing animals and it is usual practice to keep cattle away from young coconuts until fronds are out of reach of the grazing animals. The time required for coconuts to grow beyond the reach of cattle varies, but periods of 3–8 years have been mentioned in the literature (Plucknett 1979). Small ruminants such as sheep have been successfully grazed in 2-year-old coconuts (Simonnet 1990). Damage to stems of coconut is minimal although there are concerns over possible soil compaction (Chen et al. 1978) and increased erosion that may occur when the understorey vegetation is overgrazed.

On the positive side, cattle are important for weed control and this has been the traditional use of cattle in coconut plantations. Light transmission in the commonly used tall coconut varieties decreases from >90% in recently planted coconuts to a minimum of around 40% at an age of 5–10 years, and then increases again with time until the coconuts are due for replanting at age 50–70 years (Fig. 3). Light transmission obviously varies depending on variety (with dwarf or hybrid varieties intercepting more light than the tall varieties), tree spacing and management (Litscher and Whiteman 1982). Much of the area of existing coconut plantations is of tall varieties and often more than 30 years old, therefore light levels are high enough to support an understorey vegetation. Unless it is controlled, this understorey vegetation competes with the trees for water and nutrients.

Grazing can reduce competition from the understorey vegetation by recycling nutrients 'locked up' in the standing biomass. A near doubling of coconut yield was reported by several researchers (Childs and Groom 1964; Ovasuru 1988; Moog and Faylon 1991) when previously ungrazed coconuts were grazed. This was probably only partly related to increased nutrient cycling; the main effect of grazing being related to a higher recovery rate of nuts in short, grazed vegetation. Studies comparing the effect of grazed improved forages with grazed naturally occurring vegetation on coconut yield vary but often the effect is neutral or slightly positive (Reynolds 1988). Moog and Faylon (1991) found that nut yield in

![Fig. 1](image1.png) Copra prices (US$/t, 1990 prices) in Vanuatu, 1950–1992 (Department of Agriculture and Horticulture, Vanuatu 1993).

![Fig. 2](image2.png) Retail price index (1985 = 100) for beef, Manila, Philippines 1985–1992 (CRC, various years).
grazed improved pastures (80–100 nuts/tree/year) was higher than for grazed natural pastures (30–50 nuts/tree/year). Negative effects of any understorey vegetation on coconut yield must be expected if rainfall or soil fertility is marginal for coconut growth, although the latter can be ameliorated by sufficient fertilisation. Reynolds (1993) concluded that competition for moisture is likely to occur where annual rainfall is below 1750 mm, particularly if rainfall is not evenly distributed.

As far as animal production is concerned the provision of shade and thus lower heat loads on animals is likely to have a positive effect on animal productivity. The nutritive quality of forages grown in partially shaded environments such as older coconuts is comparable to those grown in full sun (Norton et al. 1991; Kaligis and Mamonto 1991).

Production Systems

Cattle have been used traditionally as ‘sweepers’ for brush/weed control to assist in the collection of coconuts on larger coconut plantations. However, over the last few decades, with rising demand for animal protein (and rising prices for meat) and falling copra prices, commercial interest in improving ruminant productivity under coconuts has increased in both Asia and the Pacific.

In Asia, smallholder farmers often have one or two cattle which are grazed on whatever feed resources are available in their area. This varies considerably, depending on the available resources and farming system. In many situations cattle are grazed on fallow cropping areas before and after rice or other food crops, and are shifted to plantation areas during the cropping period when there is little available land for cattle. Also smallholders have to maximise use of their limited land resources, and coconuts are usually intercropped with food and other perennial crops such as banana, cloves, pepper and vanilla, particularly in areas with high population density. Despite this intensive land use, there are often small areas under coconuts available for grazing or the growing of forage crops. Cattle are generally tethered in such intensive farming systems and shortfalls in feed are overcome by cutting naturally occurring grasses from communal areas such as roadides. In these circumstances tree legumes can play a significant role in increasing protein content of the fed material, and thereby animal production. The use of tree legumes grown along field boundaries is particularly widely used in Bali.

In the Pacific, a large proportion of cattle are grazed under coconuts. For example, approximately 85 000 cattle of the national herd of 135 000 head are grazed under coconuts in Vanuatu (Skea et al. 1993). In Fiji, Papua New Guinea (PNG), Western Samoa and Vanuatu, cattle have been used traditionally to control weeds and thus reduce upkeep costs, and to provide an additional income from extra copra and meat. In PNG, Ovasuru (1988) mentions a 70% reduction in upkeep costs and Carrad (1977) refers to substantially reduced labour costs on plantations in the Solomon Islands.

The distinction between ‘smallholding’ and ‘commercial plantation’ is blurred with the size of smallholder cattle enterprises varying enormously. For Western Samoa, Tonga, Fiji, Vanuatu and Solomon Islands the average smallholding keeps 10–30 cattle, frequently with up to three households contributing cattle.

In Vanuatu, a survey of 800 smallholdings (Eberhard and Robinson 1993) indicated that 86% of ni-Vanuatu rural households produced coconuts and 47% of rural households kept cattle. The average smallholding with cattle has 2.6 ha open pasture, 7 ha under coconuts and 4.2 ha bush grazing. Tethering of cattle was practiced to some extent by 31% of smallholders, mainly in subsistence rather than in more commercially orientated farms. In areas of high population pressure, cattle under coconuts are rare and intercropping with cocoa, kava and traditional food crops is more common. Macfarlane (1993) reported that for smallholders, gardening is the principal daily activity with commercial cash cropping and livestock production being a secondary activity. The division of responsibilities for activities varies enormously throughout the Pacific between men and women. In Vanuatu, in smallholder enterprises with cattle, there is significant sharing of workloads by men and women, with women participating in cattle/pasture activities in 75% of cases and men spending almost as much time as women in gardening. In other Pacific Melanesian and Polynesian societies, with the excep-
tion of dairying in Fiji, women appear to be less involved with large ruminants.

In Vanuatu, coconuts in the commercial plantation sector are largely 60–70 years old but, due to the low copra prices, only 500 ha have been replanted during the last five years. This contrasts with the smallholder sector where approximately 1200 ha were planted annually.

Both cattle breeding and fattening operations are feasible under older coconuts and these may be based on grazing of pastures or cut-and-carry feeding systems.

Cut-and-carry systems extract a considerable amount of nutrients from the forage production area and this is moved to where the animals are fed; particular care is required to return nutrients to the forage area. Neglect to do so may result in loss of coconut yield and cause a sharp decline in forage yield. This is illustrated in Figure 4, where productivity of three grasses, grown under coconuts, was compared at a 2-monthly cutting interval (Rika, pers. comm.). Yield of the tall grass *Panicum maximum* was very high initially but quickly decreased to the level of *Brachiaria decumbens*, a grass of intermediate height, and within 1 year yield declined to a level similar to the yield of the local, prostrate grass *Axonopus compressus*.

Grazing systems are generally found in more extensive coconut plantation areas such as in North Sulawesi, Indonesia, parts of the Philippines and also in many South Pacific countries. Some tethering is used to control animals but the majority of cattle is herded or animals are allowed to graze freely.

A key factor hampering the development of more commercially oriented cattle production systems under coconuts is the lack of marketing facilities in the more remote coconut plantation areas. The importance of market access for the successful development of a viable cattle industry in the South Pacific was clearly demonstrated by Shelton (1991a).

### Animal Production

#### Grazing systems

The level of animal production reported in grazing trials varies greatly (Table 2). Average daily gains (ADG) vary from 0.12 kg/ha/day to 0.51 kg/ha/day and liveweight gain per hectare varied from 44 kg/ha/year to 744 kg/ha/year. Stocking rates (SR) also varied widely from 1 to 4 cattle/ha (varying sizes) and stocking rate was related negatively to ADG.

The variation in animal production was clearly related to the feed resource available. Liveweight gains were lower on natural vegetation than on improved forages except in the experiments in Solomon Islands where the natural pasture consisted of a very high proportion of legumes. In other cases (Reynolds 1981; Manidool 1984), substantial improvement in LWG was obtained by planting improved pasture. The importance of legumes was clearly indicated in many experiments (Smith and Whiteman 1985; Deocareza and Diesta 1991). Other factors affecting forage growth and therefore animal production were soil fertility and/or fertilizer strategy, and light transmission. In general terms, yield of forages is linearly related to the amount of light available, provided that other factors affecting growth are not limiting (Stür 1991). This means that in a coconut plantation with a light transmission of 50%, the yield of a highly productive grass such as *Panicum maximum* will be approximately 50% of the yield achievable in full sunlight. Animal production is likely to be affected similarly by light transmission. In practice, forages seldom reach their full yield potential because other growth factors such as water and nutrients limit productivity, and light to moderate shading as occurs in older coconut plantations (i.e. >70% light transmission), is unlikely to affect productivity to any great extent. Nevertheless, coconuts take up physical space and this may reduce the available area by as much as 20%. In more shaded situations, animal production will be affected by reduced forage productivity.

This has been shown for Vanuatu (>2500 mm/year rainfall, fertile soils) where stocking rate recommendations for different coconut plantations were almost linearly related to light transmission (Fig. 5).

Shelton (1991b), analysing liveweight data of four long-term stocking rate grazing trials under coconuts (Rika et al. 1981; Watson and Whiteman 1981; Smith and Whiteman 1985; Manidool 1984) by using the stocking rate model of Jones and Sandland (1974), related animal production to pastures. He noted that in three of the four grazing trials persistence of the sown grasses was poor and that the sown grasses tended to be replaced by more grazing-tolerant albeit less productive grasses such as *Axonopus compressus*. Legumes (e.g. *Centrosema pubescens*) were initially more persistent than grasses but eventually also declined while the proportion of weeds such as *Mimosa pudica* and unpalatable weeds increased. He concluded that long-term sustainability of improved pastures under coconuts will depend on the use of grasses tolerant to regular grazing and sufficiently aggressive to keep pastures relatively free of weeds. The challenge then is to find legumes which are compatible with such grasses.

In Vanuatu, the stoloniferous grass *Stenotaphrum secundatum* has proven its ability to suppress weeds better than *Axonopus compressus* or *Paspalum conjugatum* at the same stocking rate (Macfarlane 1993). *Stenotaphrum secundatum* pastures are able to produce high liveweight gains if grown in association with legumes.
Table 2. Cattle production from grazing experiments under coconut.

<table>
<thead>
<tr>
<th>Country (rainfall)</th>
<th>Pasture</th>
<th>Light transmission (%)</th>
<th>Liveweight gain (kg/ha/year)</th>
<th>Average daily gain (kg/ha/day)</th>
<th>Stocking rate (cattle/ha)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia (1700 mm/year)</td>
<td>Improved</td>
<td>79</td>
<td>288-505</td>
<td>0.22-0.29</td>
<td>2.7-6.3</td>
<td>Rika et al. 1981</td>
</tr>
<tr>
<td>Philippines (&gt;2000 mm/year)</td>
<td>Improved</td>
<td>n.a.</td>
<td>170-315</td>
<td>0.43-0.47</td>
<td>1-2</td>
<td>Moog et al. 1993</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>n.a.</td>
<td>130-158</td>
<td>0.14-0.36</td>
<td>1-3</td>
<td>Deocareza and Diesta 1993</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>n.a.</td>
<td>137-306</td>
<td>0.20-0.37</td>
<td>1-3</td>
<td>Deocareza and Diesta 1991</td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>n.a.</td>
<td>51</td>
<td>0.14</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>n.a.</td>
<td>91-146</td>
<td>0.20-0.25</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Solomon Islands (2900 mm/year)</td>
<td>Natural</td>
<td>60</td>
<td>235-345</td>
<td>0.27-0.40</td>
<td>1.5-3.5</td>
<td>Watson and Whiteman 1981</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>60</td>
<td>227-348</td>
<td>0.27-0.40</td>
<td>1.5-3.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>62</td>
<td>219-332</td>
<td>0.26-0.40</td>
<td>1.5-3.5</td>
<td>Smith and Whiteman 1985</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>62</td>
<td>206-309</td>
<td>0.23-0.35</td>
<td>1.5-3.5</td>
<td></td>
</tr>
<tr>
<td>Thailand (1600 mm/year)</td>
<td>Natural</td>
<td>n.a.</td>
<td>44</td>
<td>0.12</td>
<td>1.0</td>
<td>Manidool 1984</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>n.a.</td>
<td>94-142</td>
<td>0.16-0.26</td>
<td>1.0-2.5</td>
<td></td>
</tr>
<tr>
<td>Vanuatu (&gt;1500 mm/year)</td>
<td>Improved</td>
<td>n.a.</td>
<td>175</td>
<td>0.32</td>
<td>1.5</td>
<td>Macfarlane and Shelton 1986</td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>n.a.</td>
<td>250-285</td>
<td>0.26</td>
<td>2.6-3.0</td>
<td>Evans et al. 1992</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>n.a.</td>
<td>550</td>
<td>0.50</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Western Samoa (2900 mm/year)</td>
<td>Natural</td>
<td>50</td>
<td>148</td>
<td>0.22</td>
<td>1.8</td>
<td>Reynolds 1981</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>50</td>
<td>225-306</td>
<td>0.33-0.47</td>
<td>1.8-2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>70-84</td>
<td>127</td>
<td>0.14</td>
<td>2.5</td>
<td>Robinson 1981</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>70-84</td>
<td>273-396</td>
<td>0.30-0.43</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>70-84</td>
<td>401-466</td>
<td>0.27-0.32</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>70-84</td>
<td>421-744</td>
<td>0.29-0.51</td>
<td>4.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Shelton (1991) and references cited.

Fig. 4. Yield (g/m²/day) of grasses grown under coconuts without fertilisation and harvested every 2 months in Bali (I.K. Rika, pers. com.).
Macfarlane et al. (1994) reported animal production of steers (300 kg liveweight) grazing a S. secundatum pasture containing 20% Desmodium heterophyllum and Vigna hosei under coconuts (65–70% light transmission). Average daily gain was 0.52 kg/ha/day when grazed at 2 steer/ha (380 kg/ha/year) over a 2-year period.

Grazing natural vegetation under coconuts almost invariably results in the invasion of unpalatable weeds and this leads to a rapid decline in animal production. If natural vegetation is grazed heavily, and unpalatable weeds are controlled by slashing, the proportion of grazing tolerant, low yielding grasses such as Axonopus compressus will develop, but animal production is generally low.

In Vanuatu, on-farm studies measured liveweight gain of young steers (200–300 kg liveweight) grazing native pasture, consisting largely of Axonopus compressus, Mimosa pudica and Desmodium canum, under coconuts with a light transmission of 70% (Macfarlane et al. 1994). Daily liveweight gains were 0.30–0.35 kg/ha/day at stocking rates of 1.5–2.0 animals/ha.

Pasture species for the coconut environment have been reviewed by Chen (1991), Reynolds (1993), Shelton et al. (1987), Stür and Shelton (1991), and Wong (1991). Recently, the ACIAR-funded project ‘Integration of Forages with Plantation Crops for Sustainable Ruminant Production’ identified the following species for grazing under coconuts:

Grasses—Brachiaria humidicola, Stenotaphrum secundatum, Brachiaria decumbens grown in mixture with

Legumes—Arachis pintoi, Arachis repens, Arachis glabrata, Desmodium heterophyllum.

Species with a similar growth habit which may also be suitable include Brachiaria dictyoneura, Brachiaria brizantha, Ischaemum aristatum, Stenotaphrum dimidiatum.

Cut-and-carry systems

Small backyard dairy and beef units are common in Bali, Indonesia, Philippines and Thailand, with the grasses Panicum maximum and Pennisetum purpureum being supplemented with leucaena, gliricidia and various by-products. These are widely used in the tropics because of the small size of holdings and the limited grazing area, the fragmentation of landholdings, a lack of fencing in cropping areas, and the low cost of labour. These grasses are particularly suitable for plantation crops when the trees are young and vulnerable to damage from grazing animals (Sophanodora and Tudsri 1991). Animal production in smallholder cut-and-carry systems is difficult to assess, depending largely on the experience of the operator. Rika et al. (1981) compared the growth rates of 12 Bali cattle leased individually to local farmers and fed cut natural vegetation, banana stem and coconut leaf (a local feeding system) with the growth rates of cattle grazing improved pasture in Bali (Table 3). Average daily gain of cattle in the local feeding system was similar to that at the highest stocking rate in the grazing trial but considerably lower than those obtained at lower stocking rates where animals were able to choose their own diets.

However, a comparison of a cut-and-carry feedlot system, a semi-feedlot system, and free grazing for beef cattle in Johore, Malaysia revealed higher daily liveweight gains for stall-fed animals (Sukri and Dahlan 1986). Trials were carried out with smallholders in West Johore, where coffee was grown as an intercrop under coconuts. Feed rations consisted of coffee by-products (30%), palm kernel cake (37%), urea (2%) and mineral–vitamin premix (1%) and various native forage species (Paspalum, Axonopus, Ottokloa, Ischaemum and Brachiaria) for grazing. Local x Jersey yearling males were used and the first trial lasted for 178 days. The animals under the feedlot system were confined and fed the feed ration ad lib.; the semi-feedlot treatment involved tethering and grazing on the native grasses for 5 hours daily before the animals received the same feed ration ad lib.; the
free-grazing animals were tethered to graze the native grasses. Average daily gains of the animals in the feedlot, semi-feedlot and free-grazing systems were 0.48, 0.37 and 0.15 kg respectively. The feedlot and semi-feedlot groups were extended for a further 116 days (trial 2) with average daily gains of 0.60 and 0.38 kg/animal respectively. An economic evaluation demonstrated that gross profit was higher for the feedlot animals than the semi-feedlot or grazing groups (Table 4). It was concluded that feedlot and semi-feedlot systems had great potential for increasing beef production among smallholder farmers and should avoid the major problem of low feed availability (and quality) in dry spells.

In Timor, tethered bulls fatten at an excellent rate of over 1 kg/day on an ad lib diet of leucaena leaves plus a metre of banana stem for moisture each day (Harrison 1986). The arrival of psyllids reduced leucaena growth in this system and leucaena has been partly replaced by other tree legumes such as Sesbania grandiflora, Acacia villosa and Gliricidia sepium.

Table 3. Average daily gain (kg/hd/day) of Bali cattle grazed at various stocking rates (cattle/ha) on improved pasture or fed according to local feeding systems (Rika et al. 1981).

<table>
<thead>
<tr>
<th>Feeding system</th>
<th>Stocking rate (animals/ha)</th>
<th>Average daily gain (kg/hd/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Period 1</td>
</tr>
<tr>
<td>Local feeding system</td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Cattle grazing</td>
<td>2.7</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>3.6</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>4.8</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>6.3</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Table 4. Economic evaluation of different feeding systems (Sukri and Dahlan 1986).

<table>
<thead>
<tr>
<th></th>
<th>Trial-1</th>
<th>Trial-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feedlot</td>
<td>Semi-feedlot</td>
</tr>
<tr>
<td>Expenditure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average feed ration intake (kg/day)</td>
<td>4.50</td>
<td>2.70</td>
</tr>
<tr>
<td>Cost of ration/kg (M$)</td>
<td>22.10</td>
<td>22.10</td>
</tr>
<tr>
<td>Cost of ration/day (M$)</td>
<td>0.99</td>
<td>0.60</td>
</tr>
<tr>
<td>Revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average daily gain (kg/days)</td>
<td>0.48</td>
<td>0.37</td>
</tr>
<tr>
<td>Revenue from gain (M$/day)</td>
<td>1.68</td>
<td>1.30</td>
</tr>
<tr>
<td>Gross profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross profit (M$/day)</td>
<td>0.69</td>
<td>0.70</td>
</tr>
<tr>
<td>Margin over free grazing (%)</td>
<td>30</td>
<td>32</td>
</tr>
</tbody>
</table>

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tillity in cut-and-carry feeding systems was addressed earlier.

Conclusions

Coconut plantations offer an excellent opportunity for integration of cattle with coconuts, particularly in the less populated areas where the land under coconuts is not fully utilised.

There are few constraints and, provided that adapted forages are planted to ensure a high quality, sustainable feed resource, cattle production under coconuts will be a profitable and sustainable form of land use.

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Livestock-based Agroforestry as an Alternative to Swidden Cultivation in Laos

B. Bouahom*

Abstract

It is a government policy objective in Laos to limit and eventually eliminate slash-and-burn shifting cultivation. Attempts by the government in the last decade to limit slash-and-burn cultivation have not been successful, due to a lack of an appropriate working program. This paper considers a livestock-based agroforestry system as an alternative to shifting cultivation.

Smallholders all over the country have good animal husbandry and indigenous knowledge, particularly in some mountainous areas. If this knowledge is used by government to link livestock and agroforestry it will be very useful for a forest rehabilitation campaign. This could help sustain the ecological stability and economical potential of the country.

The Lao People's Democratic Republic (PDR) is in the process of implementing a government policy to transform agriculture from a production system based on natural or semi-natural processes to a more market-oriented system. Government priorities for the agricultural sector are:

• to achieve food self-sufficiency and have a surplus for domestic markets;
• to limit (and eventually eliminate) slash-and-burn shifting cultivation;
• to increase exports of livestock products (mainly live cattle), tree crops, and other cash crops; and
• the promotion of integrated rural development.

Many tropical countries are attempting to regulate shifting cultivation by various means. In southern China, for instance, the swidden cultivators were encouraged to cultivate by ploughing with buffalo in permanent fields, thus ceasing to clear and burn forest. They were then encouraged to raise the yield per unit of land by introducing intensive cultivation. Unfortunately, the swidden cultivators did not know how to work with ploughs, buffaloes, draught power, or how to seed and transplant rice seedlings, so this attempt to end shifting cultivation failed (Guo 1990).

As in other tropical and semi-tropical countries, the attempts of the Lao Government in the last decade to limit and eventually eliminate slash-and-burn cultivation have not been successful, due to a lack of an appropriate working program. The area under shifting cultivation has not changed for the last decade (Fig. 1).

The Lao Government recognises that after forestry, the livestock and agricultural subsectors, which already play a significant role in the economy, have the greatest potential to increase the living standards of farmers, create employment and earn foreign exchange. This paper focuses on a feasibility study of a livestock-based agroforestry system as an alternative to shifting cultivation.

Livestock Production

There is a great potential to increase livestock production, especially ruminants, in the Lao PDR. Extensive lands throughout the country are well suited to pasture and fodder crops. An estimated 7 to 8 million ha of grazing land is underutilised (comprising natural grasslands, dipterocarp forest and barren lands) of which about 5 to 6 million ha are located in upland areas.

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Livestock production is predominantly traditional, and consists of two groups of smallholders who are mainly subsistence farmers (Pravongviengkham et al. 1989). The first group comprises more than 500 thousand smallholders living in lowland areas along the Mekong River. Buffalo and cattle are the most common livestock raised by smallholders—for home consumption, draught and as a ‘bank’ for sale in times of emergency. The smallholders cultivate an average of about 1.5 ha of paddy field per household and this is their main occupation.

The second group of subsistence farmers comprises 43% of the total population (about 250 thousand families), who live predominantly in the mountainous regions and practice slash-and-burn shifting cultivation. This group of farmers are mostly Lao Theung and Mong. They keep cattle and buffalo for home meat consumption and as a ‘savings bank’.

In 1993, there were about 1.2 million buffalo, 1.0 million cattle, 1.5 million pigs, 144 thousand goats/sheep and 9 million poultry (Fig. 2). Smallholders all over the country have good animal husbandry and indigenous knowledge, particularly in some mountainous areas. If this knowledge is used by government to link livestock and agroforestry it will be very useful for a forest rehabilitation campaign. This could help sustain the ecological stability and economical potential of the country.

The livestock industry currently experiences numerous constraints. Primary amongst these is the high incidence of diseases and poor management practices, i.e. poor nutrition and unsustainable production systems. Other important constraints are: insufficient competitive marketing network; insufficient access to credit and inputs; poor technology; and database and staff skill deficiencies (Phonvisay 1994).

**Forests**

The Lao PDR is rich in forest resources. Forest covered 70% of the country in 1940; 54% remained in 1973, 47% in 1981 and less than 43% or about 11 million ha was estimated to remain in 1993. Based on these figures, we can see that a forest area of approximately 200 to 300 thousand ha was destroyed annually. The rate of current deforestation is an indicator of how fast the country is extinguishing species, destroying watersheds, manipulating microclimates, and affecting carbon and nutrient cycles. If the rates of deforestation continue as steadily as is currently happening, by the year 2000 only 6 million ha will be left, or about 50% of existing forests in 1973. At present, the government is attempting to reforest the country, but it is a slow process.

**Causes of deforestation**

The main causes of deforestation are permanent conversion of forest to agricultural land; slash-and-burn shifting cultivation; logging; and demand for fuelwood. In Lao PDR the major causes are shifting cultivation and logging.

Shifting cultivation areas in 1993 covered approximately 225 thousand ha, of which more than 90% was in the eight northern mountainous provinces.
Agroforestry could be one of the appropriate approaches for agroecosystem sustainability, employment creation and increasing the income of the upland people.

**Agroforestry**

Agroforestry is a collective name for landuse systems and technologies in which woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economic interactions among the different components (Lundgren and Van Gelder 1983; Raitree 1987).

It is very important to get the concept and definition of agroforestry right so that misunderstanding between disciplines of landuse can be avoided. Cooperation is the mother of success in agroforestry, as indeed in any integrated development effort (Kalago 1990).

However, the ultimate goal of agroforestry is to contribute to sustainable land systems, maximise total productivity and income while maintaining the productive capacity of the natural resource base (Winterbottom and Hazelword 1987).

**Potential of agroforestry**

Potential benefits of agroforestry are varied: production of nitrogen, shade, production of wood (especially fuelwood), erosion control, rehabilitation of degraded land, forage/fodder, improvement of rural living standards and employment. Of the benefits listed here, rehabilitation of degraded land, erosion control, forage/fodder for livestock development, and improvement of rural levels and employment are most important for sustainable production in Lao PDR.

**Agroforestry models**

Researchers in agroforestry use many different approaches and models. But most agroforestry models are in the experimental period or hypothesis stage.

Amongst agroforestry models existing, Agregana (1987) proposed a comprehensive model of small-scale upland agroforestry as an alternative to shifting cultivation in upland areas. He identified four types of agroforestry:

- Agriculture-based agroforestry, where the primary activity involves principles of traditional agriculture.
- Forest-based agroforestry, where the primary activity involves preservation of the forest, and selective exploitation of forest products.
- Fishery-based agroforestry, where the primary activity involves principles of traditional fishery.
- Livestock-based agroforestry, where the primary activity involves raising of ruminant and nonruminant farm animals as the main source of income.

Many researchers are paying more attention to shifting cultivation and have proposed numerous agroforestry models; however, the basic information, research and extension packages for specific areas are still needed.

**Livestock-based agroforestry**

Livestock-based agroforestry in the upland and highland areas of the Lao PDR could be useful for erosion control, to limit forest degradation, to provide more stable incomes, to create employment, and to eliminate shifting cultivation.

At present, many rural development projects and nongovernment organisations are working in upland areas.
areas, especially in northern provinces of the country, with different approaches and methodologies. For instance, Xiengkhouang Rural Development Project has developed the ‘Cattle Bank’, where the project purchases cattle for farmers on credit, and provides technical assistance, such as vaccination and animal feed improvement, to the farmers (Archer 1994). The Lao-IRRI project evaluates different species of grasses, legumes and fodder trees in the upland area of Luangprabang province, with the objectives of improving fallow systems and increasing fodder availability for grazing animals. Various species have shown to be well adapted to the prevailing conditions: labiab (Lablab purpureus), pigeon pea (Cajanus cajan), Centrosema pubescens, Stylosanthes guianensis, Pueraria phaseoloides, Archis pintoi, Leucaena leuephala, and Brachiaria brizantha (Roder et al. 1993; Shelton and Humphreys 1972).

According to our preliminary study, income from livestock was more than 70% of total income per household in the upland area (Bouahom 1994). The upland area has the greatest potential for livestock development because there is more grazing land and lower human and animal population densities. Therefore, the following livestock-based agroforestry system could be an appropriate alternative to swidden cultivation.

The main components of livestock-based agroforestry are livestock, including ruminants and nonruminants, crops, fodder tree legumes, forests and marketing.

As slash-and-burn shifting cultivation is limited, labour will move into other crop production and animal raising. Rice for home consumption can be purchased by selling cash crops and livestock.

Crops produced will be used for consumption, as a feed for animals, and as cash crops. In the system, fodder trees could play a significant role in fodder and fuelwood supply, erosion control, and soil fertility improvement.

Ultimately, the livestock-based agroforestry system will help farmers get more income, increase employment and protect the environment.

Conclusions

It is very difficult to resettle upland people, who practice shifting cultivation, to lowland areas: many countries have tried unsuccessfully to do so. An alternative is to let people remain in their own areas and to use indigenous knowledge to implement appropriate technologies.

Upland farmers practice shifting cultivation because it is necessary for their survival in a difficult environment (Bouahom 1991). An attempt to reduce shifting cultivation should involve detailed step-by-step plans with multidisciplinary approaches, and should be focused on minimising shifting cultivation, and increasing income and employment of the upland farmers. Livestock-based agroforestry as a land management system could be made highly compatible with the upland agroecosystem, rural development, increasing living standards and employment of the people.

References


Smallholder Silvopastoralism in Indonesia

J.A. Weinstock*

Abstract

Silvopastoralism is the combination of agroforestry techniques with the raising of livestock. The tree component of this system can provide shade and fodder for the animal component, living fences, erosion control, soil enrichment (in the case of leguminous species), fuelwood, log timber and/or other wood products for home use or for sale, and can combat the intrusion of noxious weeds such as *Imperata cylindrica* grass. Smallholder silvopastoralism has had a long and diverse history in Indonesia that has included the use of a variety of tree species and agroforestry patterns for various purposes. Discussed herein are two examples, one from West Java that is subsistence oriented and one from West Timor that is oriented to the commercial market. The first exemplifies a resilient and ecologically stable polycultural silvopastoral system, while the latter is an example of a rather ecologically unstable monocultural system.

Brief History of Silvopastoralism in Indonesia

Agroforestry has existed in Indonesia for a very long time, with a rich variety of systems presently being found throughout the archipelago. The origins of using tree species in conjunction with livestock rearing in Indonesia is not known, but there is information on the history of the use of some specific tree species. In particular, leguminous tree species have played an important role in Indonesian smallholder livestock rearing during the past half century. Best known among these have been *Leucaena leucocephala*, *Gliricidia sepium*, *Gliridicia maculata*, *Albizia falcataria*, *Calliandra calothyrsus*, and *Sesbania grandiflora*.

In the 1930s the use of *L. leucocephala* was recommended by missionaries on the island of Flores, and it has been used since the beginning of the 19th century on Javanese and Sumatran plantations as a shade tree for coffee, kapok, vanilla and coconuts (Metzner 1976). More recently the use of improved fast growing varieties of *L. leucocephala* (known locally as lamtorogung as opposed to lamtoro biasa, or common leucaena) has been tried in rural development programs throughout the country. It has been used for a multitude of purposes including checking erosion, providing green manure to improve soil fertility, as fodder, and as a source of fuelwood. Much of the focus upon leucaena, as opposed to other leguminous species, occurred due to the large amount of attention which leucaena received in the popular media. During the early to mid-1980s countless articles appeared in magazines and newspapers about the tremendous and varied potential of the 'miracle tree' which could provide almost everything to everyone, from fertilizer and food, to fodder and fuelwood. In the mid-1980s a major government campaign was launched throughout Indonesia to plant lamtorogung.

For example, in integrated rural development programs for the province of West Java, leucaena was planted with a range of purposes in mind. Most commonly it was used in agricultural projects to control erosion along contours and terraces of sloping rainfed lands, as well as being coppiced for use as a green manure. Often these activities were undertaken in conjunction with livestock projects where the leucaena was coppiced for use as supplemental feed for small ruminants, primarily goats and sheep; planted as living fences (pagar hidup) either to keep livestock in or out of fields and home gardens; and the poles used to build livestock pens (kandang). An unplanned, although tacitly understood, side benefit has been the use of the leucaena wood by the villagers for their home cooking fires. While *L. leucocephala* seeds had been planted at some of the
Ministry of Agriculture Farmers Extension Stations (Bulai Penyuluhan Pertanian) beginning in the early 1980s, it was not until 1985 that widespread planting of *L. leucocephala* began. The rapid spread of the use of *L. leucocephala* in West Java occurred due to an edict by the governor that 5 t of lamtorogung seed were to be planted in the province during the 1985–86 fiscal year (1 April 1985 to 31 March 1986).

Recognition of the importance of using trees, especially leguminous species, in farming systems might be considered a dramatic move in many parts of the world, but in the case of Indonesia there has been a long history of using a rich diversity of agroforestry systems. Thus the governor’s order to undertake a massive campaign of leucaena planting in West Java province was not considered particularly radical or unusual. Farmers in West Java already were familiar with the unimproved variety of leucaena, known as lamtoro biasa, as well as various other leguminous tree species.

*Calliandra calothyrsus* was introduced to Indonesia from Central America in 1936 as a plantation forestry crop and now is widely found growing wild throughout the country (NAS 1980). *Calliandra* is easy to propagate and the coppiced foliage provides good fodder for livestock. The white flowered variety of *Calliandra* is planted at low altitudes, while the red flowered variety is more suited to higher elevations. *Gliricidia sepium* and *Gliricidia maculata* have been used extensively by the Ministry of Forestry in their ‘regreening’ program. *Gliricidia* spp. has the ability to grow amid the noxious *Imperata cylindrica* grass, locally known as alang-alang, and will eventually shade it out. With regard to livestock rearing, this property of *Gliricidia* spp. is valuable since *Imperata* grass has a high silica content which cuts the mouth of livestock grazing on it. Thus the coppiced *Gliricidia* spp. foliage provides a better animal fodder than the *Imperata* grass it displaces. Other leguminous tree species known and used by livestock smallholders in Indonesia are *Albizia falcataria* and *Sesbania grandiflora* (locally known as turi). *Albizia* often can be found in tea estates where it has long been used as a shade tree. Besides using its foliage as livestock fodder, the wood is straight and strong and farmers find it desirable for use as construction poles. *Sesbania grandiflora*, or *turi*, is a leguminous tree native to tropical Asia. It also is widely used for multiple purposes including living fences and for coppicing for animal fodder (NAS 1980).

The government-sponsored push for use of multiple purpose leguminous trees for agroforestry, including silvopastoral systems, in the mid-1980s actually had detrimental effects. Believing the international hype that *L. leucocephala* was a ‘miracle tree’, government authorities heavily promoted planting of this species. In many parts of Indonesia, as typified by West Java province, the existing smallholder agroecosystems were based upon a mix of leguminous tree species. Thus the promotion of a single species was a step towards the narrow genetic dependency of a monocultural system. The danger of reliance upon a monoculture became all too apparent by early 1986.

The new year opened with a flurry of news on the recently discovered psyllid insects (*Heuropropys* spp.), commonly known as ‘jumping lice’, which were infesting stands of leucaena around the world. Originating in the Caribbean, by 1984–85 psyllid infestations appeared in Hawaii and the Philippines. In 1985 psyllid infestation of leucaena was reported in the Bogor Botanical Gardens in West Java. According to reports, the psyllid insects only attack the foliage of leucaena and do not bother other leguminous species. Even certain varieties of *L. leucocephala*, mainly the giant varieties from northwest Mexico, have shown a high resistance to the psyllid (NFTA 1986). In March of 1986 widespread reports of psyllid infestations of leucaena were coming in from around the province of West Java. The spread of the psyllid infestation continued eastward, reaching the islands of Flores and Timor by mid-year. Likewise, the infestation spread to the north, reaching Aceh province in northern-most Sumatra by September where coffee plantations were threatened as their leucaena shade cover disappeared under the defoliation of the psyllids.

The psyllid infestation of *L. leucocephala* had serious repercussions for smallholder livestock rearing in eastern Indonesia, as will be discussed below. Fortunately, the heavy promotion by the government of *L. leucocephala* used as a monoculture had yet to have an impact in West Java. Multi-species silvopastoral systems still predominated among smallholder livestock rearing by the time the psyllid infestation reached western Indonesia, thus tree and foliage losses were minimal. Subsequently, smallholders in West Java had adequate foliage from other leguminous tree species which they could coppice to maintain their animals without any serious impositions (Weinstock n.d.).

Incorporation of tree species cultivation into agricultural systems has taken a rich and diverse variety of forms varying from one Indonesian island to another, and often even from one set of villages to another. Local variations in agroforestry systems frequently have developed in response to a combination of biophysical limitations and socioeconomic imperatives. High levels of precipitation, steep slopes and easily erodible soils in one area may dictate the development of one type of agroforestry system, while in another area seasonal drought may be the predominant factor in development of another type of agroforestry system. Likewise, population pressure, limited access to land, and economic incentives have
encouraged development of specific types of market-oriented agroforestry systems in Java, while in some of the outer islands low population densities and the availability of extensive areas of land, but poor market infrastructure, has led to the development of quite different types of agroforestry systems.

Farmers in West Java have favoured intensive silvopastoral systems for goats and sheep in response to limited access to land but good agronomic conditions and well developed market infrastructure. Poor agronomic conditions and restricted market infrastructure, but the availability of extensive land areas, has led to farmers in areas such as on western Timor Island favouring an extensive silvopastoral system for beef cattle. How each of these silvopastoral systems has developed and functions, and how their development has been influenced by socioeconomic factors will be discussed in this paper.

**Smallholder Livestock in West Java**

High population densities in rural West Java have meant that most farmers have very small land holdings. Thus, what little land to which a farmer does have access, either through ownership or rental, must be devoted to intensive agricultural production for subsistence needs. Wherever adequate water is available and land can be levelled, *sawah* (wet rice) will be cultivated since this is the most productive agricultural system and rice is the dietary staple. Only land without access to irrigation will be used for dryland agriculture. Even in these areas, the need to produce dryland rice, vegetables and fruit for home consumption and local market sales takes precedent. Hence the first choice of livestock for West Java smallholders typically will be chickens, ducks and other fowl which can free-range among horticultural crops and in household yards. These livestock also have the advantage of being inexpensive to purchase and require minimal maintenance.

Ownership of large livestock is desirable among West Java smallholders not only for the economic advantage they provide, but also for sociocultural reasons. Buffalo, cattle, sheep and goat ownership provides the small farmer with social prestige and a living 'bank'. A farmer owning such livestock often commands more respect from fellow villagers than someone who has a nice village house but no animals. The animals owned by such smallholders are not raised in an economically rational manner, such as among commercial livestock operations where the animals are fattened to a specific age or weight size and then sold. More often the small farmer keeps his animals until such time as money is needed to pay for a wedding, to go on the haj, celebrate a religious holiday or fulfill some other sociocultural obligation. But how can a farmer with little or no land to spare for pasture raise large livestock?

While some buffalo and cattle are raised by smallholders in West Java, especially because of their value for use as draught animals, the rearing of very large livestock has been limited. These animals are not only quite expensive and financially beyond the means of most small farmers in West Java, but landholdings are too small to provide even the minimal pasture land and paddock space needed. Thus the large livestock of choice in West Java have been goats, and secondarily tropical varieties of sheep. These animals do not require large paddocks and can survive either with no pasture land or through browsing foliage on the fringes of fields, village lanes and house yards. Traditionally, goats and sheep were allowed to roam free, but this has caused conflicts between neighbours as these animals damage trees, shrubs and crops. Thus increasingly farmers have been building small pens (*kandang*) to hold their animals, or tying their animals to stakes to limit the animal's range. Rearing goats and sheep in pens solves the need for pasture land but creates the problem of providing fodder for the animals. Silvopastoralism, or the use of specific tree species in conjunction with livestock rearing, has provided part of the solution to this problem.

Wild grasses growing along roads, fields and village lanes provide a source of some fodder, and planting of specific varieties of grasses, such as *Setaria* or *rumput gajah* (elephant grass), along the borders of fields also provides additional fodder, although this may not be enough. To supplement these grasses, especially during the dry season, West Java farmers have turned to the use of the foliage of leguminous species of trees as a source of fodder. As mentioned above, among the leguminous trees whose foliage has been used by West Java farmers are *C. calothyrsus*, *G. sepium*, *G. maculata*, *S. grandiflora*, *L. leuco cephalia*, and *A. falcataria* (Weinstock 1988).

**Silvopastoralism in West Timor**

The eastern part of Indonesia does not face the intense population pressure encountered in West Java, instead smallholders face a different set of constraints with regard to the rearing of livestock. Taking the West Timor region of Nusa Tenggara Timor (NTT) Province as an example, in most villages there are adequate land areas to graze livestock. Thus, unlike livestock smallholders in West Java, farmers in West Timor are not restricted to goat and sheep rearing but are free to choose large livestock such as cattle and water buffalo. Traditionally Bali cattle, a domesticated variety of the indigenous wild banteng cattle, have been the livestock of choice among West Timor farmers. With assistance from foreign livestock projects over the past two decades there has been a dramatic increase not only in the numbers of
Bali cattle, but also in improved local and imported strains of cattle. Thus, smallholder livestock rearing in West Timor has become more commercial and market-oriented than among smallholders in West Java.

Constraints faced by livestock smallholders in West Timor are poorer agronomic conditions, including seasonal drought as well as poorer soils, and limited market infrastructure. While farmers in West Java may face a dry season of up to 3 months, West Timor has an annual dry season which can last for 8 months. In addition, West Timor has poorer soils than found in most of West Java. Such an agronomic situation provides livestock smallholders in West Timor with a serious challenge.

In addition, transport both within the island and between the island and other islands is difficult and expensive. Taking into account the availability of grazing lands and that the major market for animal products, primarily meat, lies outside of Timor Island (mainly in Java), farmers in West Timor have opted for raising cattle rather than smaller livestock such as goats and sheep. This makes sense not only in terms of economies of scale; (large meat animals instead of small ones), but also since cattle shipped to distant markets suffer less ailments than do goats and sheep. Cattle endure the stress of transport better than goats and sheep, suffer less weight loss and are more likely to arrive alive at the slaughter houses near the market (in this case Surabaya).

To survive the annual dry season, livestock smallholders in West Timor have long relied on silvopastoral techniques. As mentioned earlier, the use of *L. leucocephala* was promoted in NTT Province by missionaries in the 1930s and is now widespread throughout the region. During the early 1980s hybrid varieties of leucaena, or *lamtorogung*, were planted in addition to, or in replacement of, the older varieties of leucaena which are referred to as *lamtoro biasa*. Unlike the multispecies mixes of leguminous trees found in West Java, in West Timor the leucaena plantings and wild propagates almost always have been pure monocultural stands.

During the dry season the stands of leucaena are coppiced to provide fodder for smallholder cattle. In addition, during the dry season banana plants are cut down and the chopped up sections of the trunk feed to the cattle. The purpose of feeding cattle banana trunks is not as a fodder so much as to provide a source of water since the banana trunk contains a high percentage of stored moisture. Thus the combination of banana trunks and coppiced leucaena foliage provide the dry season dietary staple for smallholder livestock in West Timor until the onset of the infestation of psyllid insects (*Hetropsylla* spp.), or "jumping lice" destroyed this system.

Livestock smallholders in West Java suffered minimally, if at all, when the psyllid infestation struck in 1985–86 since they were less dependent upon the coppiced foliage of leguminous trees and had a variety of species of such trees, most of which were unaffected by this infestation. Conversely, for livestock smallholders in West Timor, this infestation was disastrous. Leucaena trees were quickly defoliated by the psyllids, leaving farmers with little else to feed their cattle. Many smallholders were forced to sell their animals as the psyllid infestation continued through the long annual drought season.

The psyllid infestation ran its course and many leucaena trees in Indonesia recovered from the initial defoliation. This occurred where farmers left the trees alone during the period of infestation. Unfortunately the seriousness of the situation often was compounded in West Timor by livestock smallholders who radically coppiced leucaena trees. This appears to have been done either out of desperation for fodder to feed their animals, or because of the mistaken belief by farmers that such action would eliminate the psyllids. The trees which were radically coppiced or even cut down to ground level usually died.

**Conclusions**

Livestock smallholders throughout Indonesia have long had experience with agroforestry in a variety of locally developed silvopastoral systems. Each of these systems has developed not only due to the influences of site specific biophysical characteristics, but also due to sociocultural and economic factors. Whether livestock smallholders develop a system which is subsistence oriented or one which has a dominant commercial market orientation also is dictated by these factors. As shown by the West Java example, some Indonesian smallholder silvopastoral systems have been multispecies (polycultural)-based and subsequently have been resilient and ecologically stable. The West Timor example typifies a single species (monocultural)-based silvopastoral system which has been prone to the negative influence, in this case the infestation of "jumping lice" in the mid-1980s. Countless other variations of silvopastoral systems, which fall between the two extremes described in this paper, can be found in Indonesia.

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Social Forestry: Concepts and Implications

M. Kaomini*

Abstract

Environmental damage and threats to forest sustainability are a major concern in Indonesia just as they are internationally. The cause of such damage is often the result of a conflict of interest between local people and the national interest. Alternative forest management strategies which benefit forest communities and the nation as a whole therefore must be found. A social forestry program orientated to community welfare and forest preservation is an alternative forest management system. This approach promotes self-reliance, increased community welfare, and awareness of the importance of forest functions and the need for resource conservation.

In recent years, environmental damage has threatened the sustainability of forests. The Indonesian Government therefore has acted to expand forestry activities to safeguard production levels, but at the same time ensure the resource is conserved. These objectives are not easily met since forest resources are under increasing pressure (Nasendi 1989). The problem may be caused by:

• forest encroachments such as illegal wood gathering, unrestrained livestock grazing, illegal land occupancy (Nasendi 1989);
• an increasing commercial orientation within the forest community regarding forest products (Nasendi 1989); and
• the extensive clearing by shifting cultivators, over exploitation by concessionaires, and forest fires (Wangsadidjaja and Ismanto 1991).

Besides these direct factors, indirect factors are contributing to the problem:

• an expanding population has increased demand for forest land and forest products; and
• levels of awareness concerning the need for conservation and protection of the environment are low.

Government regulations are now in place to prevent misuse of the forest but these regulations are difficult to enforce, and commonly conflicts of interests arise between and among local people, the forestry sector, and other development sectors. It means the conventional forest management system has apparently failed to cope with the problem satisfactorily (Wangsadidjaja and Ismanto 1991; Kartasubrata et al. 1993).

In order to improve the forest management, alternative management strategies are required. These alternatives need to have benefits to local people and the nation as a whole. Several factors need to be considered in order for any development program to succeed:

• a decrease in conflicts between resource users and authorities protecting natural resources (Royal Forest Department 1989);
• support for local organisations living near important resources so that they may participate in the management and administration of those resources and hence play a part in protecting the environment (Royal Forest Department 1989); and
• a change in the role of department officials from policing to organising and providing technical and custodial assistance (Wangsadidjaja and Ismanto 1991).

Therefore a social forestry program which improves management practices is a new approach.

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being tried in many countries such as Latin America, Africa, and Asia.

Characteristics of Social Forestry Programs

According to Nasendi (1989), ‘Social forestry is a participatory activity which involves the forest community in forest land and resource management, and aims to increase local prosperity and increase and diversify forest utilisation, without causing environmental degradation’.

There are other definitions for social forestry, but all of them have similar characteristics (Arihadi 1992; Kartasubrata et al. 1993; Nasendi 1989; Wangsadidjaja and Ismanto 1991). Some of these are:

- orientation to the community’s welfare and forest preservation;
- a focus on the high degree of interdependence between the forest communities and the forest;
- providing individual communities or community organisations with responsibility for the management of the forest in their area;
- strategies to transform the relationship between forest communities and forest managers from an adversarial one to a partnership (mitra sejajar); and
- a bottom-up development approach where the potential, self-confidence, and ability of the community to organise and develop themselves according to their own priorities are central goals.

Objectives of Social Forestry Programs

According to Hoe (1993), Kartasubrata et al.(1993), Peluso (1992), Perum Perhutani (1992) and Nasendi (1989), the objectives of a social forestry program are:

- to attract the participation of millions of farmer households to the protection of existing natural forests and to be participators in environmental conservation in a nationwide schedule of regreening denuded hillsides;
- to develop the capability, skill and participation of the community to use forest production and to manage the land in an efficient way whether these communities are in forest land areas or not;
- to preserve forest, land, and water in order to gain an equitable distribution of income in the community, and to achieve sustainable economic growth;
- to improve relations between forestry field workers and forest farmers through equal partnership, bottom-up, and top-down communication; and
- to create diverse, sustainable forests, free of disturbance, at the same time as improving the living conditions of local people, particularly those below the poverty line.

Types of Social Forestry

There are several types of social forestry depending on the nature of land ownership, management, and the enterprise objective (Nasendi 1989).

Participatory forestry

The forest area is managed by the government or professional foresters, and the community participates primarily as labourers. This type of activity is most suited to densely populated areas with limited land availability, such as Java. An example is Perum Perhutani’s forest village program (Pembangunan Masyarakat Desa Hutan, PMDH).

Village forestry

Forest land is managed by the people through existing social institutions (traditional, religious, cooperative and community organisations). This type of management is more suited to the areas outside Java, with lower population densities. An example is the Dusun Hutan (village forest) in Irian Jaya.

Community forestry

An example of this type of management is the people’s forest (hutan rakyat). The forest is managed by landowners, and could be developed in densely or sparsely populated regions.

Farmer forestry

Management is handled by more formal community groups such as small-scale industrial cooperatives.

Tree farming

This type of management stresses intercropping of trees and food crops. The trees are planted on private land to produce for personal use, or for sale as handicraft wood, firewood etc.

Scope of Activities

In order to achieve its goals, the social forestry program covers several activities:

- establishment and development of a forest farmers’ group (Kelompok Tani Hutan, KTH);
- extension, through leadership and example;
- planting trees, vegetation (reforestation);
- preserving the forest;
- managing, using and distributing forest production;
- managing and marketing forest production; and
• creating inventories of forest resources, resource potential, community forest, and integrated farming activities, and mapping resources.

In the social forestry system, local people are invited to participate in the decision-making process concerning such things as the species to be planted, method of planting, design of the plantation and nature of rotations.

These activities differ depending on whether the area is outside or inside forest land (Nasendi 1989). In the forest area the aim is to apply the participatory management model to intensify agroforestry activities and to increase capital and technological inputs. In privately owned forest, activities concentrate on the introduction and expansion of rational cultivation techniques to increase land productivity as well as the quality of the environment. Forestry officials function primarily as an information resource.

In Indonesia, there are differences in field-level implementation in Java and in the Outer Islands, from both a technical and nontechnical point of view. The outer island program requires planning, organisation and development of a working system to encourage involvement and support of agencies outside the forestry apparatus (Nasendi 1989).

### Organisation

The organisation of social forestry differs from place to place, depending on the type of social forestry involved. Since a social forestry program involves the forest community the organisation needs to be cross sectoral involving government and nongovernment agencies and the local farmers.

People involved in the program are organised into groups of forest farmers (*Kelompok Tani Hutan*, KTH), headed by a chief. The presence of the institutions are to facilitate the needs of KTH.

The technical field staff, and the social forestry community organisers (*Penyuluh lepangan Perhutanan Social*, PLPS) are the spearhead of the social forestry program at the local level. The PLPS are functional facilitators and motivators who provide extension, guidance and coordination to the forest farmer groups. They act as catalysts to motivate the participation of local farmers in the program.

### References


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