An *Ex Post* Economic Impact Assessment of Planted Forages in West Africa

ILRI Impact Assessment Series 2

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Summary

In the late 1970s and early 1980s the International Livestock Centre for Africa (ILCA) and its national research partners were instrumental in developing and promoting the concept of planting forage legumes in an attempt to help agropastoralists in West Africa alleviate the feed stress experienced by their ruminant animals during the dry season. The 'fodder bank' was one (but by no means the only) method developed, whereby an area of the farmer's land was fenced and planted to *Stylosanthes* or other legumes, which could be used for strategic feeding during the early dry season. Some cropping systems were also developed in which a cereal was subsequently planted in the fodder bank to make use of the nitrogen fixed by the legume. Research funds were spent on this activity until 1993, and various studies have shown adoption of this technology in a number of countries of West Africa, although no comprehensive study of the adoption of this technology had yet been done.

In 1995, ILCA and ILRAD (the International Laboratory for Research on Animal Diseases) combined to form a new institute, the International Livestock Research Institute (ILRI). An *ex post* assessment of the fodder bank technology in West Africa was carried out to document the impact that ILRI, its national partners and other organisations have had and continue to have at the farm level, which could be used to demonstrate the value of investment in agricultural research programmes. Accordingly, a study was designed with two main activities: a literature survey to quantify production impacts of the fodder bank technology, and the commissioning of a consultant to travel extensively in the region to collect up-to-date information on the number of adopters of the technology from national agricultural research and extension programmes in the region.

To date, about 27,000 adopters have been identified growing forage legumes on some 19,000 ha in the 15 countries for which we currently have information. Using modest estimates of production impact of forage legumes on meat and milk production from a herd simulation model and on maize, millet and sorghum grain and residue from the literature, commodity price data, elasticities of supply and demand, and estimates of research costs were combined in an economic surplus model with the number of adopted hectares of forage legumes that could reasonably be attributed to the activities of ILRI and its national partners. The baseline analysis indicates that on an expenditure of research resources of just over US$ 7 million, the total net benefits to society that had accrued up to 1997 amounted to US$ 16.5 million, with an internal rate of return of some 38%. These figures may be conservative, for the adoption data are likely to be conservative and the estimated production impacts are modest. Various sensitivity analyses are carried out to test the robustness of these estimates of impact. Partly because research resource expenditure by ILRI on this technology is now zero, projecting adoption trends to the year 2014 results in at least a doubling of the estimated total benefits realised to date.

In many places, the problems facing farmers wishing to adopt forage legumes are serious. Planted forage legumes will undoubtedly occupy niches in the farming systems of West

Africa, but for the future farmers will increasingly make more use of crop residue material in their quest for feed resources. Despite this, the impact of adopted fodder banks has paid for the research that went into their development at least three times over, and this will increase substantially in the next few years, given current adoption trends. A further lesson from this work is that the lag associated with the diffusion of this technology is considerable–at least 15 years–and may be much longer than is generally anticipated.

1 Introduction

The importance of livestock as a means of sustenance, traction power and transport, as a substantial source of nutrients as manure for agriculture, and as a means of hedging against risk and uncertainty in the lives of the people of sub-Saharan Africa, has been appreciated for centuries. However, livestock development in Africa faces many constraints, among which the most widespread is shortage of feed supply (Winrock International 1992). A sustainable solution to feed deficiencies is essential for the huge livestock potential of the continent to be realised. With this understanding, the Subhumid Programme of the International Livestock Centre for Africa (ILCA) at Kaduna, Nigeria, in the late 1970s developed the concept of a fodder bank as one solution to the problem of inadequate nutrition, especially during the dry season, in West Africa (Mohamed-Saleem 1986).

A fodder bank is a small area of forage legumes established and managed by an agropastoralist near the homestead as a feed supplement for livestock during the dry season. Inadequate nutrition during this season (arising from ingested forage with a crude protein content of less than 7%) causes animals to produce less milk and lose weight, and increases calf mortality and reduces conception rates. For a large part of the dry season, fodder banks can maintain a crude protein content of more than 9% (Mohamed-Saleem and de Leeuw 1994). As a result, animals with access to a fodder bank perform better than those kept on natural pasture. In addition, the legume (commonly *Stylosanthes* spp) accumulates soil nitrogen through biological fixation in the root nodules. The legume can also have beneficial impacts on the physical properties of the soil such as bulk density, infiltration rates and field moisture capacity. As a result, crops grown in plots previously planted as a fodder bank commonly produce higher yields than those cultivated outside such areas. The major benefits of fodder banks can be summarised as follows: increases in crop and crop residue yields (for this analysis, we consider maize, millet and sorghum), increases in milk yield and weight gain (or reduced body weight loss), increased calving rates, decreased age at first calving, and increased calf and cow survival rates. Estimates of most of these benefits can be obtained from the substantial literature on fodder banks.

This study assesses, in an indicative way, the impact of fodder banks and forage legume technology in countries of West Africa. The economic surplus method is used to estimate the social rate of return to public investment in research on fodder banks and the distribution of that return amongst producers and consumers. Subsequent sections of this report describe the technology of fodder banks, the economic surplus method, sources of data and the results of the analyses.

2 Description of the technology

A fodder bank is supposed to be established, managed and utilised as follows (Tarawali and Mohamed-Saleem 1994): a farmer (i) selects and fences an area of land (the recommendation is 4 ha, but this area could be more or less depending on needs and herd size) using either metal posts or live poles; (ii) prepares land for planting by confining animals overnight in the fenced area, by grazing down for 1 or 2 weeks following seed broadcast, by burning, and by using 150 kg/ha of superphosphate fertilisers; (iii) broadcasts scarified seeds at a seeding rate of 10–15 kg/ha; and (iv) at the beginning of the dry season during the labour-slack period, constructs peripheral fire traces to protect the bank from burning.

Good management of a fodder bank consists of (i) allowing animals to graze the fodder bank early in the wet season to control fast growing grasses until the legume is well established, and withdrawing animals when *Stylosanthes* starts flowering to promote high seed production; (ii) allowing forage to bulk up by deferring grazing until the dry season; and (iii) ensuring sufficient seed drop and stubble for regeneration in the following season. To utilise the fodder bank according to extension recommendations, a farmer allows pregnant and lactating animals (up to a maximum of 5 per hectare) to graze the fodder bank for 2.5 h/day during the dry season.

Only three cultivars are recommended for use in a fodder bank: *Stylosanthes guianensis* cv Schofield, *S. guianensis* cv Cook and *S. hamata* cv Verano. Of these, Schofield and Cook are susceptible to anthracnose disease while Verano is less susceptible. Other promising species have been identified in evaluation trials over the years such as *Centrosema pascuorum*, *Chamaecrista rotundifolia* and *Aeschynomene histrix*.

Attractiveness of the technology

Local tropical grasses are the only available alternative herbaceous cover to compare with *Stylosanthes*. Various features make *Stylosanthes* legumes superior to grasses (Bayer 1986): they grow on relatively infertile soils with the low nitrogen and low phosphorus contents that are common in West Africa; they secure soil nitrogen through biological fixation in the root nodules; and they have higher dry-matter digestibility and voluntary intake by animals.

Yield

Several fodder banks consistently produced 4–6 t dry matter (DM)/ha over several years with a 50–70% legume content. Mohamed-Saleem and Suleiman (1986) reported an average DM yield of 6–8 t/ha in some places in Nigeria during the first year of establishment. Mani (1992) reported that after 1, 2 , 3, 4 and 5 years of establishment the respective average DM yield was 5.2, 4.6, 5.5, 5.2 and 5.3 t/ha and average *Stylosanthes* content was 59, 66, 64, 61 and 62%. Tarawali and Mohamed-Saleem (1994) found the average DM yield and *Stylosanthes* composition of fodder banks in ILCA's case study areas to be 6.3 t/ha and 60%, respectively.

Affordability

Compared with other supplementary feeds such as oilseed cake and other agro-industrial products, S*tylosanthes* is less costly, more abundant and more readily available.

Benefits

The benefits of *Stylosanthes* are achieved through three main channels: increase in total herbage, extension of the period of production of the pasture and increase in nitrogen (N) content (Mani et al 1993). Mohamed-Saleem and von Kaufmann (1995) estimated the internal rate of return of establishing a fodder bank in the subhumid zone of Nigeria to be 22% using 1989 market prices and incorporating the benefits of improved herd productivity alone. When the benefits of reduced forced sales and increased crop yields are included, their estimate of the internal rate of return reached 36%. In the mid-1980s in the subhumid zone of Nigeria, about 75% of the costs of establishment of a typical 4 ha fodder bank were estimated to be associated with the costs of fencing (Otsyina et al 1987).

3 Methods for estimating social returns

A widely accepted procedure for economic evaluation of benefits and costs of a technological change is the economic surplus method (e.g. see Alston et al 1995). The basic idea behind the economic surplus method is that technology adoption reduces the per unit cost of production, and hence shifts the supply function of the commodity down and to the right. If the market for the commodity is perfectly competitive, this will lead to an increase in the quantity exchanged in the market and a fall in price. As a result, consumers benefit from the price reduction and producers may benefit from selling a greater quantity.

When computing the economic surplus of a successful research activity in a closed economy, economists usually refer to a diagram of the type shown in Figure 1. The demand for the commodity is denoted by *D*, the pre-research supply curve is *S*, while the post-research supply curve is *S'*. The initial equilibrium is denoted as (P_0, Q_0) while the post-research equilibrium is (P_1, Q_1).

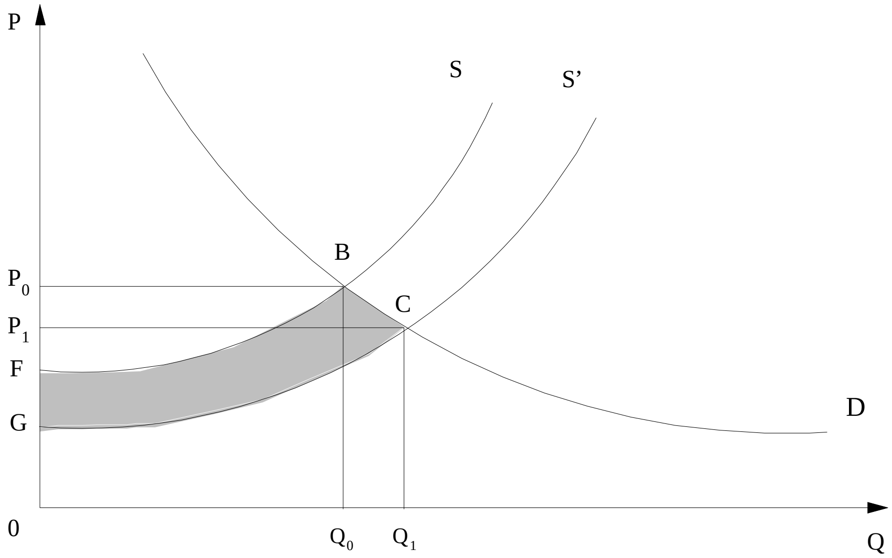

Figure 1. *Effects of technological change on the supply curve.*

The change in the Marshallian consumer surplus (ΔCS) is the area P_1P_0BC. This is given by:

$$\Delta CS = \int_{P_1}^{P_0} D(P)dP$$

where *D(P)* denotes the demand function. The initial producer surplus is given by the difference between total revenue (area OP_0BQ_0) and variable cost (the area below the supply curve between *O* and Q_0). The new producer surplus is the difference between the new total revenue (area OP_1CQ_1) and the new variable cost (the area below the new supply curve between O and Q_1). The change in the producer surplus (ΔPS) is the difference between the new and the initial producer surpluses. Formally, the change in the producer surplus is given by:

$$\Delta PS = P_1 Q_1 - \int_0^{Q_1} S'(Q)dQ - P_0 Q_0 + \int_0^{Q_0} S(Q)dQ$$

where S(Q) denotes the pre-research inverse supply function and S'(Q) is the post-research inverse supply function. The change in total economic surplus (ΔTS) is the sum of the changes in producer and consumer surplus (the shaded area GFBC). Thus:

$$\Delta TS = \int_{P_1}^{P_0} D(P)dP + P_1 Q_1 - \int_0^{Q_1} S'(Q)dQ - P_0 Q_0 + \int_0^{Q_0} S(Q)dQ$$

To apply this method empirically, the forms of the supply and demand functions have to be specified. A fairly flexible functional form that is widely used for estimation of supply and demand is the constant elasticity (CE) specification. An inverse supply function of the CE type is written as:

$$P = aQ^{1/\varepsilon}$$

where P and Q are price and quantity, respectively, ε measures the elasticity of supply, and *a* is a constant supply shifter. The flexibility of this functional form stems from the fact that it is generated by any production function that is homogenous of any degree. It is also attractive for estimation because a logarithmic transformation makes it linear and hence amenable to estimation by ordinary least squares.

The establishment of a fodder bank enhances productivity and hence reduces the per unit cost of production. The after-establishment supply curve can be written as:

$$P = a(1-k)Q^{1/\varepsilon}$$

where *k* measures the pivotal shift in supply and is related to the productivity change, *h*, according to the formula:

$$k = 1 - (1+h)^{-(1+\varepsilon)/\varepsilon}$$

The way in which we estimate changes in productivity as a result of fodder bank establishment is described below. Similarly, a CE demand function is assumed:

$$Q = aP^{-\gamma}$$

where γ is the price elasticity of demand.

Plugging these functional forms in the above formulae, the changes in consumer surplus, producer surplus, and economic surplus are obtained:

$$\Delta CS = \frac{1}{1-\gamma} P_0 Q_0 [1-(P_1/P_0)^{1-\gamma}]$$

$$\Delta PS = P_1 Q_1 - P_0 Q_0 + \frac{\varepsilon}{1+\varepsilon} P_0 Q_0 [1-(1-k)(Q_1/Q_0)^{(1+\varepsilon)/\varepsilon}]$$

$$\Delta TS = \Delta CS + \Delta PS$$

The new equilibrium price and quantity are related to the initial equilibrium according to:

$$P_1 = P_0 (1-k)^{\varepsilon/(\varepsilon+\gamma)}$$

$$Q_1 = Q_0 (1-k)^{-\gamma\varepsilon/(\varepsilon+\gamma)}$$

4 Data and sources

To calculate the social benefits of fodder bank adoption using the economic surplus method, it is necessary to estimate the parameters of the supply and demand curves for the various products benefiting from the establishment and use of a fodder bank. This includes estimating elasticities of supply and demand and the rates of shifts in the supply functions of milk, meat, maize grain and residue, millet grain and residue and sorghum grain and residue. In the absence of specific data we have to rely on the literature to obtain such estimates. In addition, we require data on the number of fodder banks established in each year, the prices of all these products and the research costs involved.

The following data were obtained from a survey in the countries in West Africa where fodder banks were introduced and adopted:

1. The number of fodder banks established each year in each country in each agro-ecological zone.
2. Data on prices of maize, sorghum, millet, milk and meat in each year in the areas where fodder banks were adopted and data on the prices of maize, sorghum and millet residues.

To calculate the rates of shift in the supply functions, the change in the level of production per hectare is estimated. This number is then multiplied by the total number of hectares of each product inside the fodder bank in each year. The result is then compared with the total production of the country in each year to obtain the percentage change in the level of production attributed to the establishment of fodder banks.

Estimating benefits

Milk yield

Tarawali and von Kaufmann (1987) reported that lactation yields in Nigeria were 300 kg without supplement and 312 kg with supplement (an increase of 12 kg or 4%). Otchere (1986) estimated the total amount of milk taken from dams supplemented with a fodder bank in Nigeria to be 9.6 litres (9.3%) more than that from the control group (113.2 and 103.6 litres, respectively). Because the recommended management of a fodder bank consists of grazing 5 lactating cows per hectare, the total increase in milk yield as a result of fodder bank supplementation is $5 \times 9.6 = 48$ litres/ha per year. This excludes the milk consumed by calves, which is about 24 litres more with fodder bank supplementation. If this is included, total milk yield increases to 169 litres/ha per year. In this study we use Otchere's (1986) estimates because those of Tarawali and von Kaufmann (1987) are less conservative and less comprehensive in the sense that they did not include milk consumed by calves.

Weight gain or reduced body weight loss

Tarawali and von Kaufmann (1987) reported weight gains of animals at one year as 98 kg without supplement and 103 kg with supplement (an increase of 5%). Bayer (1986) compared weight losses of a control group to a herd grazing a fodder bank. He found that by the end of the dry season, the two groups differed by 20 kg/head and this difference was statistically significant at the 5% level. If we use Bayer's estimates, we arrive at an increase of live weight of 100 kg/ha as a result of fodder bank establishment and use. Fodder banks are also used for feeding traction animals and supplementing small ruminants. For example, Ikwuegbu et al (1994) showed that West African Dwarf goats on *Stylosanthes*-based pastures gained 1 kg more weight during the wet season than those on fallows (at 4 does per ha). Because of lack of data on number of traction animals and goats and other key production parameters, we restrict our analysis to benefits outlined in this section only. We recognise, however, that there is strong evidence that the use of 'mini' fodder banks for feed supplementation has substantial potential for improving the growth performance of goats in the subhumid zone (e.g. see Ikwuegbu et al 1995).

Calving rate and calf survival

Tarawali and von Kaufmann (1987) reported calving percentages of 54% without supplement and 58% with a fodder bank supplement (an increase of 8%). They also reported an increase of 20% in calf survival for animals on fodder bank supplement (72% without supplement vs 86% with supplement).

Cow survival

Tarawali and von Kaufmann (1987) reported 92% cow survival without and 96% with supplement (an increase of 4%). To convert the benefits from increased calving rate and reduced mortality rates into milk and meat, we used the ILCA Herd Model (von Kaufmann et al 1990). The model uses data on herd structure and offtake rates and simulates the dynamics of a herd over a period of 10 years using two scenarios: one with the calving and mortality rates without a supplement and the other with a supplement. A summary of input data is shown in Table 1, taken from survey data from 1984 in Kaduna, Nigeria (R. von Kaufmann, ILRI, personal communication). The results of the model run showed that the increase in calving rate and reduction in mortality rates as a result of supplementation translate into 4 kg of live weight per hectare and 12.6 kg of milk per hectare.

Table 1. *ILCA herd model input and output data.*

Age class	Herd structure	Live weights (kg)	Slaughter offtake (%)	Breeding offtake (%)
A. Base herd structure, live weights and offtake rates				
Females 1 year	4.0	51.0	1.0	0.0
Females 2 years	3.7	75.0	1.0	0.0
Females 3 years	3.3	112.0	1.0	0.0
Females 4 years	3.0	212.0	1.0	0.0
Females 5 years	4.0	260.0	5.0	0.0
Females >5 years	16.6	260.0	5.0	0.0
Males 1 year	3.9	53.0	2.0	0.0
Males 2 years	3.5	79.0	3.0	0.0
Males 3 years	3.2	140.0	6.0	0.0
Males 4 years	2.1	220.0	26.0	0.0
Males 5 years	2.2	240.0	51.0	0.0
Males >5 years	0.2	260.0	75.0	0.0
Total	49.7			

B. Female production data and mortality rates	Without fodder bank supplement	With fodder bank supplement
Calving rate	53.80%	58.10%
Age at 1st calving	60 months	60 months
Lactation offtake	244 litres	244 litres
Lactation length	270 days	270 days
Grazing area	50 ha	50 ha
Cattle 0–1 years mortality	29.20%	13.70%
Cattle 1–2 years mortality	7.80%	4.00%
Cattle 2 years of mortality	7.80%	4.00%

C. Live weight and milk offtakes, results of 10-year non-steady state simulations	Impact of fodder bank supplement (‘With’ minus ‘Without’)
Mean annual carcass offtake rate (kg/ha)	4.1
Mean annual milk offtake rate (litres/ha)	12.6

Crop yields

Tarawali (1991) estimated that 45 kg of nitrogen per hectare is transferred from the *Stylosanthes* legume to the maize crop. *Stylosanthes* also improves the physical properties of the soil through increasing the organic matter content, resulting in lower bulk density and higher infiltration rates and field moisture capacity. As a result, crops grown on fodder banks or experiment stations commonly produce higher yields than those cultivated outside fodder banks. Tarawali and Mohamed-Saleem (1994) have shown that once a productive *Stylosanthes* pasture is established, it can subsequently be cropped for at least two years and revert to a similar *Stylosanthes* pasture without requiring re-seeding. We will assume that all countries under study adhere to this system of rotation. This means that for each hectare of fodder bank in the analysis that follows, 0.75 ha is used for *Stylosanthes* legumes and 0.25 ha is used for crop production. We further assume that the 1 ha is allocated to the production of each of the three crops according to the share of land that each occupies nationally.

Estimates of increases in crop yield as a result of fodder bank establishment varied considerably from one study to another. However, benefits to crops were confirmed at various sites and across agro-ecological zones, with effects on yields lasting up to two years (Mohamed-Saleem 1994). Fodder bank management practices had a strong influence on yields of subsequent crops.

The increase in yields of maize grain as a result of fodder banks located in northern Nigeria (Hassane 1995) are shown in Table 2. In this study, no significant effects were found on sorghum yields. Tarawali and von Kaufmann (1987) also found positive effects of fodder banks on maize grain yield. The average maize grain yield inside and outside a fodder bank was 4659 and 2545 kg/ha, respectively, implying a productivity effect of 2114 kg/ha (83%). Tarawali (1991) found average maize grain yields of 820 kg/ha outside fodder banks and 1720 kg/ha inside fodder banks, an increase of 900 kg/ha (109.8%) in yield. Table 3 shows positive effects on grain and residue yields for three cereals in subhumid Nigeria (data from Ikwuegbu et al 1994).

Table 2. *Maize grain yields (kg/ha) under different management in two zones of Nigeria.*

Zone	Adjacent natural fallow with fertiliser (A)	Fodder bank (B)	(B)–(A)	Fodder bank with fertiliser (C)	(C)–(A)
	kg/ha				
Subhumid	633	739	106	2700	2067
Semi-arid	327	413	86	611	284

Source: Hassane (1995).

Table 3. *Grain and residue yields in subhumid Nigeria*.

Product	Maize (kg/ha)	Sorghum (kg/ha)	Millet (kg/ha)
Grain			
Previous *Stylosanthes* pasture	2245	1533	724
Old fallow	1654	1476	475
Difference	591 (+36%)	57 (+4%)	249 (+52%)
Residue			
Previous *Stylosanthes* pasture	3330	4780	3660
Old fallow	3100	4550	3340
Difference	230 (+7%)	230 (+5%)	320 (+10%)

Source: Ikwuegbu et al (1994).

The estimates of Ikwuegbu et al (1994) of the productivity effects of fodder banks on sorghum grain yield are consistent with those of Mohamed-Saleem et al (1986). We use these in our analyses, as well as those for millet. However, the estimates of the productivity effects on maize grain yields are on the low side when compared with those of Tarawali and von Kaufmann (1987), Tarawali (1991) and Hassane (1995). For this study we use the mean of the productivity effects on maize grain yield of the four studies (1418 kg/ha). We calculate the productivity effects on residue yield in the same way.

Residue yield

Fodder banks can have significant effects on maize stover yields. Tarawali and Kaufmann (1987) reported average maize residue yields of 7.4 t DM/ha inside the fodder bank compared with 4.3 t DM/ha outside, a difference of 3.1 t DM/ha (75%). However, Mohamed-Saleem et al (1986) showed the effects on fodder yield of sorghum to be less than those on sorghum grain yield. For sorghum and millet residue we use the results of Ikwuegbu et al (1994) and we take the average of the difference reported in Tarawali and Kaufmann (1987) and Ikwuegbu et al (1994) in order to obtain the productivity effect on maize residue yield.

Improved soil structure makes tillage easier, and could be expected to have an impact in terms of reducing farm work. Such benefits are not included in this analysis because we do not have ready estimates of the reduced number of hours from easier tillage. The productivity effects used in the analysis are summarised in Table 4.

Table 4. *Productivity effects used in the analysis.*

Product	Productivity effect
Milk (litres/ha)[1]	182
Live weight (kg/ha)[1]	104
Maize grain (kg/ha)	1,418
Sorghum grain (kg/ha)	57
Millet grain (kg/ha)	249
Maize residue and herbage (kg/ha)	1,679
Sorghum residue and herbage (kg/ha)	230
Millet residue and herbage (kg/ha)	320

1. Milk and liveweight estimates include the values obtained from the herd model calculations outlined in the text (and see Table 1).

Because there are no published data on crop residues, we need to estimate their baseline production levels in the absence of fodder banks. From the studies cited above, residue and herbage yields of maize, sorghum and millet, when sown on fallow land, are 3685, 4550 and 3340 kg/ha, respectively. Multiplying these by the areas under crop production gives us the baseline levels of production that are used in this analysis.

Fertiliser saved

Tarawali (1991) estimated that maize planted outside the fodder bank required 45 kg/ha of nitrogen to produce the same yield as that of maize on unfertilised plots within the legumes pastures. This effect is included in the higher crop yields used in the analysis below. However, using less fertiliser, apart from its possible positive environmental effects, saves foreign exchange (since it is imported) which is in short supply in most of West African countries. The total amount of fertiliser saved, and hence the foreign exchange saved in each year as a result of fodder banks, are likely to be substantial.

Elasticities of supply and demand

Estimates of elasticities of supply and demand for Nigeria were obtained from Singh and Subramanian (1986). The elasticities of demand for millet and sorghum are 0.08 and 0.05, respectively. The respective estimates for the elasticities of supply for these two commodities are 0.25 and 0.3.

An ACIAR (Australian Centre for International Agricultural Research) database (G. Lubulwa, ACIAR, personal communication) reports the same elasticities of supply and demand for sheep and goat meat for several countries of West Africa. These are 1.76 (supply) and –1.0 (demand), respectively. In the absence of a better alternative we use the estimate of the price elasticity of supply of meat in this study. Tambi (1996) estimated the elasticity of demand for meat in Cameroon at 1.8. This estimate was used in our study. The ERS/USDA (Economic Research Service/United States Department of Agriculture) database (G. Lubulwa, ACIAR, personal communication) gives elasticities of supply and demand for milk in sub-Saharan Africa as 0.7 and –0.5, respectively.

Delgado and Reardon (1991) estimated demand elasticities for grain (sorghum, millet and maize) from aggregate data in Mali, Senegal and Burkina Faso at –0.07,–0.11, –0.50, respectively. We take the estimates for Senegal to represent the elasticity of demand for maize for all West Africa. Jaeger (1986) estimated a Cobb–Douglas farm production function for West Africa and arrived at an average rate of return to scale of 1.02, implying an elasticity of supply of 0.98. We assume that this is an approximate measure of the elasticity of supply of maize. The elasticities used in this study are summarised in Table 5. Elasticities of supply and demand for crop residue are assumed to be the same as those for grains.

Table 5. *Elasticities used in the analysis.*

Elasticity	Milk	Meat	Maize	Millet	Sorghum
Supply	0.7	1.76	0..98	0.25	0.3
Demand	–0.5	–1.8	–0.11	–0.08	–0.05

Research costs

Research costs associated with developing and testing of fodder banks were estimated from annual summary expenditure budgets going back to 1975, when ILCA started operations (G. O'Donoghue, ILRI, personal communication). The total costs, with an overhead of 18%, of the West African programmes from 1977 to 1997 are shown in Table 6; note that total ILRI expenditures for Niger and Nigeria (1995–97) have been split arbitrarily between the two programmes for these years.

Table 6. *Research costs (US$ '000s) of ILCA's (1975–94) and ILRI's (1995–97) West African research programmes.*

Year	Semi–arid Niger	Subhumid Mali	Subhumid Nigeria	Humid Nigeria	Overhead (18%)	Total costs	Costs attributed to fodder bank research[1]
1978	0	300	0	0	54	354	18
1979	0	345	0	0	62	407	20
1980	0	345	0	0	62	407	20
1981	0	345	9	0	64	418	22
1982	0	349	169	249	138	905	195
1983	79	838	795	1,062	499	3,273	863
1984	106	781	1,066	857	506	3,316	1,103
1985	102	728	749	812	430	2,821	798
1986	125	941	735	693	449	2,943	790
1987	125	997	498	451	373	2,444	556
1988	183	973	611	497	408	2,672	664
1989	405	924	606	696	474	3,105	668
1990	529	1016	776	579	522	3,422	827
1991	565	819	686	528	468	3,066	241
1992	683	668	768	554	481	3,154	253
1993	707	411	571	498	394	2,581	188
1994	622	0	498	368	268	1,756	0
1995	700	0	700	0	252	1,652	0
1996	700	0	744	0	260	1,704	0
1997	600	0	552	0	207	1,359	0
Total	6,231	10,780	10,533	7,844	6,370	41,758	7,226

1. See text for details of calculation.

The proportion of these research costs that had been expended on fodder bank research were estimated as follows (obtained from a consensus of personal communications from G. Tarawali, J. Smith, M.A. Mohamed-Saleem and R. von Kaufmann, ILRI):

- 80% of the budget for subhumid Nigeria was spent on fodder bank research for the years 1982 to 1990, while 20% was spent in 1981, 1991 and 1992; we assumed that 10% of the research costs for the years 1978 to 1980 were related to fodder bank activities
- none of the work in Niger during these years was associated directly with fodder banks
- a small proportion of the budget (5%) in Mali and humid Nigeria was spent on fodder bank research during these years
- 1993 was the last year of any direct expenditures on fodder bank research.

These proportions are applied to the expenditures in Table 6 to give, in the last column, the research costs used in the analysis that are directly attributable to fodder bank activities, totalling some US$ 7.2 million. In the analyses presented in Chapter 6, research costs of ILRI's partners and other institutions are not taken into account.

Costs of establishing fodder banks

Fodder banks can require substantial capital investment to establish, depending on how this is done, and the analysis needs to take account of these costs. For this analysis, all cost changes are embedded in the supply function. It is assumed that the technical change of fodder banks is neutral, in the sense that it does not affect the way that inputs are mixed in production and that technical change does not affect input prices. The costs of the technical change, however, include the research costs, to which we add the costs of establishing fodder banks.

From the work done on adoption rates and patterns (Chapter 5), it is clear that establishment costs vary widely throughout the region, depending on the materials used for fencing off the fodder bank and the source of labour used. Otsyina et al (1987) estimated the capital costs of establishment of a 4-ha fodder bank with metal posts and strainers in Nigeria to be in the region of US$ 145/ha, with an annual recurrent maintenance cost of about US$ 21/ha, in 1987 prices. G. Tarawali (ILRI, personal communication) reported some establishment costs much higher than these levels, situations where fodder banks have been established with minimal input costs using local fencing materials and household labour, and other situations where the legume is simply undersown with no fencing at all. In the absence of detailed country- and system-level data, a single establishment cost of US$ 150/ha is used, which is taken to represent a weighted average of establishment costs in the region, with a small amount of maintenance being charged (US$ 20/ha) in subsequent years.

Commodity prices, exchange rates, and national production figures

Some costs and prices for the commodities of interest (maize, sorghum, millet grain and residue, milk and meat) were collected by country for the years 1977 to 1997. In some countries these were broken down by agro-ecological zone. These commodity prices were converted to US dollar equivalents using exchange rates extracted from appropriate issues of the United Nations Statistics Department’s Monthly Bulletin of Statistics. Many countries in West Africa have gone through substantial economic upheaval over the last 20 years, with occasional wild fluctuations in product prices in both local currency and, once converted using local exchange rates, dollar equivalents. To complement the prices obtained so far, we are still searching for prices for some countries for some commodities for the years in question. Where we have adequate price information for a country, we use this in the analyses; where price information is incomplete, we use prices collected for Ghana for 1977 to 1997 for all commodities (including crop residues), expressed in US dollars (see Appendix 2).

As noted above, prices for commodities were collected for countries where this information is available. Estimated costs of cereal residues are rare because, until recently, these feed resources were free in most countries. Unlike cereal residues, grain legume residues fetch higher prices than their grains in semi-arid areas, especially in the peak dry season. For instance, in Kano, farmers are adopting cowpea for dry season cultivation in irrigated areas. Fodder is sold after grain harvest in situ, i.e. animals enter the field upon payment of about N 500 (about US$ 6 in late 1997) per 0.5 ha. Uptake of this practice has increased from 1 farmer in 1993 to 1500 in 1997.

Time series data of national production of maize, sorghum, millet and cattle meat and milk were downloaded from the FAOSTAT database and supplemented with the appropriate issues of the FAO Production Yearbook. All these data are shown in Appendix 3 in terms of total production, hectares planted, animal numbers and average production per hectare or per animal for the 17 countries of West Africa for the years 1977 to 1997.

5 Adoption rates and patterns

Adoption of fodder bank and legume technology has been addressed for various regions in particular countries by a variety of authors such as Tarawali and von Kaufmann (1987) and Ajileye et al (1994). According to Mohamed-Saleem and von Kaufmann (1995), the total number of fodder banks in the region in 1990 was 530. Between 1987 and 1991, a total of 637 fodder banks were established under farmer-managed supervised loans of the World Bank Second Livestock Development Project (Ajileye et al 1994). What was missing was a comprehensive effort to gather data from extension and government sources for all the countries of West Africa in which significant plantings of legume forages have taken place. This work was carried out by G. Tarawali from March to August 1997, and this chapter summarises findings by country. A map showing the countries of the region appears as Figure 2

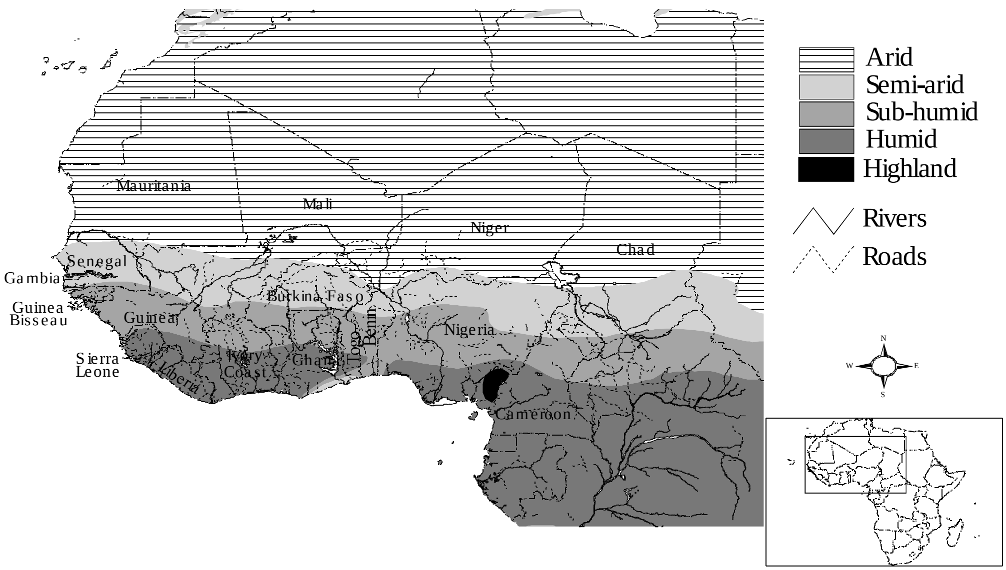

Figure 2. *Countries and climatic zones of West Africa.*

Benin

In Benin farmers are adopting Stylosanthes spp, Centrosema, Pueraria and Mucuna for soil improvement, fodder and as cover crops. Other species such as Aeschynomene histrix have been tested on station and are now ready to be taken to farmers for adoption through the extension service. In the north of Benin, fodder banks varying between 0.5 and 2.0 ha are used mainly for feeding traction animals and those that are too weak or sick to graze. In the south, farmers are given *Stylosanthes* seed to plant at 100–200/m^2. They are expected to multiply these seeds and expand their fodder banks with time. This scheme, which started in 1988, has attracted about 10,000 farmers and covers 1500 ha of land. With this type of system, no credit facilities were required to promote the technology since the capital requirement is very low. Fencing is done using local materials and family labour is provided for this operation. *Mucuna*, one of the herbaceous legumes promoted by the non-governmental organisation (NGO) Sasakawa Global 2000 in the West African region for soil improvement and controlling noxious weeds such as *Imperata cylindrica*, raised the interest of 10,000 farmers (1000 ha) between 1988 and 1996. The legume is usually planted as a short fallow crop in exhausted farmlands and in areas infested by *Imperata*. After a season's growth, the *Mucuna* suppresses the weed and enriches the soil with nitrogen and organic matter, thereby making the land suitable for crop production. The foliage and pods are judiciously used as livestock feed. These 1000 ha of *Mucuna* are excluded from the analysis, as there was no direct ILRI involvement in this activity.

Burkina Faso

In the subhumid zone 30 to 900 fodder banks (45–1350 ha) were established between 1985 and 1989. Data on the evolution of fodder banks from 1985 to 1989 were not available, nor was there information from 1989 onwards. The number of adopters should be greater than 1000 by 1997, because ORSTOM (Office de la recherche scientifique et technique Outre-Mer) and other institutions such as CIRDES/EMVT (Centre international de recherche–développement sur l’élevage en zone subhumide/Elevage et médecine vétérinaire des pays tropicaux) are currently promoting the use of herbaceous legumes as improved fallows and livestock feed. The forages used are mostly *Stylosanthes, Desmodium, Centrosema, Panicum* and *Brachiaria*. They are usually incorporated in the farming system either as sole crops or as intercrops for fodder and reactivating degraded land; some have also been tested in upland and lowland rice-based systems.

Cameroon

In Cameroon, the highest adoption of improved forages in the farming system is in the humid zone where HPI (Heifer Project International) is promoting this technology to farmers for dairying, soil improvement and seed production. There was an increase in adoption from 10 farmers on 5 ha in 1986 to over 2000 farmers covering 420 ha of land in 1997. Forage adoption has not been as successful in the northern subhumid and semi-arid zones of

Cameroon, where fodder bank adopters increased from 1 in 1979 to about 12 in 1989. The huge difference in adoption between the ecoregional zones is attributable to an NGO that is promoting the adoption of forages in the humid zone; in the subhumid and semi-arid zones this role is played by national agricultural research systems (NARS) which have limited resources. In the humid zone of Cameroon, herbaceous legumes such as *Desmodium, Lablab* and *Stylosanthes* can take 2 to 3 years before re-establishment.

Chad

In Chad, pasture development programmes with farmers started in the 1980s with funding from the World Bank and the French government. On-farm/on-station tests of grasses and legumes consisting mainly of *Panicum maximum, Cenchrus ciliaris, Chloris gayana, Macroptilum atropurpureum, M. lathyroides, Clitoria ternata, Cajanus cajan, Leucaena leucocephala, Lablab purpureus, Stylosanthes hamata* etc were conducted between 1987 and 1990 by the Laboratoire de recherches vétérinaire et zootechnique (LRVZ). The results obtained in 1987 prompted the establishment of an extension programme in 1988. This activity promoted mainly *Lablab purpureus,* which proved to be the most adaptable amongst the candidates tested. Eleven plots varying in size from 0.5 to 1 ha were established and this number increased to 54 in 1990. The herbage was used for dry season supplementation of cattle especially in the months of March, April and May.

Promotion of *Lablab* slowed down in 1991 because of poor follow-up by a weak extension service. This resulted in the whole extension system in Chad being restructured between 1992 and 1993, leading to the emergence of a new body called Direction de l'organization pastorale (DOP). With this new image, promotion of forages such as *Lablab, Mucuna,* cowpea etc was reactivated in 1994. About 900 active associations and groups have been formed with the assistance of DOP, whose primary role is to provide facilities (including forage production) to livestock keepers.

In addition to introducing improved materials, DOP is also encouraging agropastoralists to establish and protect natural pastures especially in drier areas in a programme called 'Perimetre pastoral pilote' (PPP). The concept here is that huge areas of rangelands are demarcated with local trees such as *Acacia* and the vegetation within this perimeter is divided into paddocks to facilitate controlled rotational grazing. These communal paddocks are exploited by both sedentary and transhumant cattle thereby helping to solve the problem of competition for feed resources that used to exist between the two groups. In the late dry season, when the pasture is nearly exhausted, the transhumants move their animals to wetter areas while the remaining herbage is adequate to see the neighbouring sedentary herds through to the rainy season. Four sites have been developed in the Massaguet, Darqi, N'gora and Dobali regions with 5600, 6500, 6200 and 6000 ha, respectively. This strategy could be improved by including adaptable exotic legumes in the mixtures.

ILCA/ILRI contributed some of the materials tested in Chad. There were also many ILCA/ILRI publications in the LRVZ library, including a copy of the 1993 research protocols, signifying that there was some positive interaction between ILCA/ILRI and the NARS in Chad. One of the consultants (Dr Lassine Diarra) employed by the World Bank to assist in organising the pasture development programme in Chad is an ex-ILCA/Mali staff member. The establishment of fodder banks recommended to the GTZ (Deutsche Gessellschaft für Technische Zusammenarbeit) project in Abeche by another World Bank consultant, Dr Boubakarr Hassane (former ILCA research student), is yet to start. Collaborators from LRVZ and DOP in Chad made a request for more germplasm and support for the forage seed multiplication unit which is currently addressing the seed demands of farmers and NGOs (mainly *Lablab, Cajanus cajan, Stylosanthes, Andropogon* etc). Training in all aspects of pasture development is also one of their needs.

Côte d'Ivoire

Fodder banks consisting of *Stylosanthes* grown in association with other cover crops such as *Andropogon gayanus, Macroptilium atropurpureum* and *Panicum maximum* were introduced to agropastoralists at several sites in north and central Côte d'Ivoire starting in 1985, when an estimated 42 adopters participated in the programme. The active period of this work in the north was from 1985 to 1989 but adoption came to a standstill from 1990 following the closure of SODEPRA (Société de développement des productions animales), Côte d'Ivoire's national extension agency. A GTZ-sponsored ecofarm project which operated mainly in central Côte d'Ivoire increased the number of adopters by 8 in 1989. Fodder banks in Côte d'Ivoire were reactivated after the formation of ANADER (Agence nationale d'appui au développement rural) in 1995, the extension agency which replaced SODEPRA. ANADER is now working closely with GTZ to establish 56 *Stylosanthes*-based fodder banks (10 ha each) by 1998. Observations made during field visits showed that a good stand of *Stylosanthes* in the ecofarm fodder banks succeeded in suppressing the persistent weed *Imperata* in the same way *Mucuna* does in Benin.

The total cost of an ecofarm that includes 10 ha of *Stylosanthes*-based pasture, 10 crossbred cows (plus a shed), fencing made up of *Gmelina* and barbed wire, and a house for the farmer, is about 10 million CFA (about US$ 18,000 in late 1997). In this system, the farmer provides the land and all the facilities are provided on a loan recovery basis. There is no direct integration of cropping into the fodder bank system amongst most of the farmers but the concept is being developed in a feasibility study which recommends the introduction of a cereal such as maize into a well-managed *Stylosanthes guianensis* fallow after only one year of establishment of the legume.

The Gambia

The visit was targetted at the International Trypanotolerance Centre (ITC), Development Livestock Services (DLS) and the National Agricultural Research Institute (NARI). DLS and ITC have been establishing feed gardens consisting of *Pennisetum purpureum*, *Leucaena* and *Gliricidia* at both on-station and village levels since 1993. These materials are trimmed, dried and fed in the form of hay mainly to small ruminants.

Currently, The Gambia is benefitting from a grant offered by the Islamic Development Bank of Saudi Arabia to establish 1000 ha of improved pastures in 15 villages. Hopefully, about 1000 farmers will benefit from this generosity. The fodder banks in this scheme consist of *Andropogon*, *Cenchrus ciliaris*, *Stylosanthes hamata*, *Centrosema pascuorum*, *Chaemacrista rotundifolia* etc sown in strips. NARI is also evaluating herbaceous legumes on station for adaptation with the hope of introducing promising candidates to farmers in rice-based systems.

ITC is keen on pasture development and has even recruited a forage agronomist. Plans for the immediate future include the development of year-round feeding strategies for crossbred cows and small ruminants. The centre is soliciting inter-institutional collaboration with ILRI/IITA on feed resources. The Director General of ITC suggested developing a joint proposal for funding.

Ghana

Forages were introduced in the humid and subhumid zones of Ghana as early as 1977, largely on institutional farms. In 1977, 10 organisations (250 ha) were practising the concept in the humid zone and 22 (660 ha) in the subhumid zone (these early adopters were omitted from subsequent analysis as ILCA's work had barely started then). There was a general increase in the adoption rate in all zones by 1997. In order to promote their activities, the Animal Production Department in collaboration with the World Bank imported about 2000 kg of *Stylosanthes* seeds from Australia in 1993, and this germplasm has been progressively distributed and multiplied, mainly to peri-urban dairy farmers. In view of the usual recommendation to sow 10 kg/ha (the general recommendation for good-quality seed), this quantity of seed could cover 200 ha of land. Assuming that the World Bank is adopting the 4–ha size fodder banks as in Nigeria, this could lead to another 50 potential adopters in Ghana. One of the activities of the Animal Production Department is to improve the natural range by introducing *Stylosanthes*; in Tamale (northern Ghana) such a system has succeeded in introducing the legume on a 5-km radius. The cost of establishing a fodder bank in Ghana, excluding fencing, is in the range of US$ 200 to 300.

In the humid zone, the forages are undersown in tree–crop plantations. On arable farms, the legumes (mainly *Centrosema*, *Lablab* and *Stylosanthes*) are grown in rotation with maize and need to be resown every 2 years. The forages are fed to dairy cattle, traction animals and small ruminants. Some seed production activities are also practised. In the slightly drier subhumid zone, all three cereals (maize, sorghum and millet) are grown in rotation with a wide range of legumes (*Stylosanthes*, *Lablab*, *Cajanus cajan*, *Centrosema* and *Macroptilium atropurpureum*). Annual and biennial legumes are replanted every 2 years while the perennial legumes are renewed after 3 years. The fodder banks and crop residues are grazed by cattle and small ruminants.

Guinea

Fodder banks were promoted in the Boke region in the subhumid zone of Guinea through RABAOC (Réseau de recherche sur l'alimentation du bétail en Afrique occidentale et centrale) in 1992, although in the mid-1980s some forage screening had been done on station using seeds from Bouaké (Côte d'Ivoire) and CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia). Adoption of fodder banks has been progressing well in the subhumid zone of Guinea since their introduction in 1992 from 1 (5 ha) in the first year to 82 in 1997 with a total area of 559 ha (the average size of each fodder bank is about 7 ha). These improved pastures consist mainly of *Panicum maxiumum* C1 and *Stylosanthes guianensis* CIAT 184. The *P. maximum* is usually planted as a sole crop (12 kg/ha) while the legume (4–7 kg/ha) is introduced into natural pastures without applying fertiliser. The strategy which was developed on station and recommended to all smallholder farmers is to improve the natural range by incorporating *Stylosanthes* or other leguminous species, and to set aside other areas of improved pasture (fodder banks) for the strategic feeding of sick animals, suckling calves etc.

The work at the Boke Centre is also supported by a large seed multiplication exercise involving a wide range of forages (*Panicum*, *Brachiaria*, *Stylosanthes* and *Centrosema*). A total of 3 ha is under seed production with an output of 850 kg per year. The average cost of establishing fodder banks in Guinea using local fencing materials is between US$ 300 and 400/ha, most of which are labour costs. Introduction of a crop phase in rotation with the *Stylosanthes*-based pasture has not been fully developed, probably because of a lack of awareness of the high yield increases that could be derived from such a system.

Guinea Bissau

In Guinea Bissau, three different bodies were found to promote the use of forages in agropastoral systems. The Holland–Bissau joint project 'Projet agro-silvo-pastoral' (PASP) has been introducing plots of *Leucaena* to villagers since 1996 in addition to testing species such as *Stylosanthes*, *Cajanus cajan*, *Lablab* etc for adaptability and relative performance. The project started with 10 farmers in 1996, each acquiring a 50 m × 50 m plot; this number increased to 30 in 1997. Before these activities started, some accessions and guidance were received from scientists in a Dutch-sponsored project in Sikasso (Mali) which had interacted extensively with ILCA/ILRI over the years. PASP plans to introduce *Andropogon/Stylosanthes* mixtures in forest areas in order to improve the quality of the natural pasture. In intensively cultivated areas, PASP hopes to enhance the adoption of *Lablab*/maize intercrop. Scientists in the project are looking for a small number of best-bet forage material (with background information) that could be transferred directly to farmers' fields.

Fa Madinga, a Belgian-sponsored project situated near Bafata, was boosting small ruminant production by encouraging small-scale farmers to establish fodder banks of *Andropogon, Hyparrhenia*, *Leucaena* and *Stylosanthes*. These activities started in 1992 and by 1995 a total of 30 plots, each about 0.25 ha, was recorded.

The Institut national de recherche agricole (INRA) also introduced fodder banks of *Andropogon* for small ruminant production amongst farmers in 1994 and the number rose to 12 by 1996 but these activities ceased because of withdrawal of funds. However, farmers continued to keep their fodder banks and even supplied materials to others.

INRA also multiplies seeds of *Stylosanthes*, *Cajanus cajan*, *Sesbania* etc. A total of about 1 ha is set aside for seed production and this germplasm is usually distributed to NGOs and farmers. Colleagues in Guinea Bissau requested more germplasm for diversification and in-country training on pasture development and crop–livestock interactions.

Mali

Adoption of herbaceous legumes in the cropping systems in Mali started in 1977 with 10 (2 ha) farmers through an FAO/CMDT (Food and Agriculture Organization of the United Nations/ Compagnie malienne pour le développement des textiles) project; the species promoted then were cowpea (*Vigna unguiculata*), *Dolichos* and *Siratro*. The number of participating farmers rose to 951 (381 ha) in 1987, then to 1317 (648 ha) by 1991 and to 1421 (700 ha) in 1996. During 1989 and 1991, CMDT promoted the use of leguminous crops such as *Stylosanthes*, *Lablab* and *Panicum* amongst 280 farmers. The cost of establishing a fodder bank in Mali depends on the species. *Stylosanthes*-based pastures cost about CFA 50,000 (about US$ 100)/ha while *Lablab* pastures cost about CFA 25,000 (about US$ 50)/ha. Local materials are commonly used for fencing. Farmers in Mali also try to avoid the need to fence fodder banks by growing *Stylosanthes* between crop fields. This may have encouraged an increase in uptake since fencing has been a serious deterrent to adoption because of the high cost and labour demand. After 2 or 3 years of a leguminous phase, the area is cropped with a cereal such as maize, sorghum or millet. The forage is commonly used to feed traction and dairy animals.

Mauritania

In Mauritania, the concept of exploiting cultivated pastures for livestock production started in 1989 according to records and responses from key collaborators during intensive interviews. Traditionally, the local herds of cattle are fed from rainfall-dependent natural pastures consisting mainly of Cenchrus. However, over the years, the diminishing amount of rainfall (200 mm per annum) in this Sahelian country has caused cattle owners to cultivate irrigated pastures along the River Senegal in the southern part of the country. This effort is being promoted by both small- and large-scale farmers through the formation of co-operatives. To date, there are 39 livestock co-operatives in Mauritania and each consists of about 100 participants, meaning that currently 3900 people are benefiting from pasture development programmes. Each beneficiary is expected to exploit about 0.25 ha for his or her herd. Thus a total of 975 ha is being exploited by co-operatives. The government of Sweden provided a grant of US$ 5 billion to support 108 co-operatives by 1998, but this target is far from being reached because of some implementation problems.

It is the inverse relationship between the growing animal numbers and the diminishing natural pasture that has forced co-operatives and research and development agencies to exploit cultivated pastures usually grown along the River Senegal. For instance, the National Research Centre of Agronomy and Agricultural Development (CNRADA) based in Kalde (south of Mauritania, near the Senegal river) has been testing forages such as *Panicum maximum*, *Pennisetum purpureum*, *Stylosanthes guianensis*, *Macroptylum lathyroides*, cowpea, sorghum, *Lablab purpureus*, *Clitoria ternata*, *Cajanus cajan* etc on station since 1990. Extension of the technology to farmers started in 1994 with about 5 participants and this number grew to about 30 in 1997. Each farmer was encouraged to grow about 0.25 ha of forages consisting mainly of a cowpea/sorghum intercrop and *Lablab purpureus* for feeding their animals.

Because of a low animal population in Mauritania, most of the livestock needs in the country are being supplemented by larger herds from Mali. Similarly, some of the research staff in animal science and other areas were trained in Mali, where ILCA/ILRI had a country programme. Such interactions with ILCA/ILRI may have had a positive effect on the feed resources programme in Mauritania. Even some of the germplasm was supplied by ILCA/ILRI.

Niger

Traditionally, cowpea is the main fodder crop in Niger, the world's third highest producer of this crop. Cowpea is grown primarily for grain (human consumption) and the haulms (animal feed). However, in areas south of Niamey where there is a higher density of livestock because of the River Niger, the legume is grown mainly for fodder and it is sometimes intercropped with millet. Since 1990, INRAN (Institut national de recherche agronomique du Niger), the national research institute, has developed an efficient structure for distributing cowpea germplasm directly to farmers and development organisations. A total of 5600 kg of cowpea seed is being distributed each year. It is expected that every end user benefits from 1–3 kg (average 2 kg) of the grain. This means that a total of 2800 farmers benefit each year and since the recommended seed rate is 15 kg/ha, an area of 373 ha is cultivated annually. Cowpea hay is usually used as supplementary feed to range grazing, an area that is excluded from the analysis as ILRI had no or very limited direct input to this activity.

Other local species such as *Commelina*, *Cenchrus*, *Alysicarpus* and *Zornia* are commonly harvested from the range and stored or sold for feeding, especially traction animals and donkeys.

A reasonable number of projects in Niger are working with farmers to introduce pastures and trees in degraded soils. One such group is DED (Deutsche Entwicklung Dienst) a German-sponsored project which has been adopting participatory approaches since 1990. Basically, the group encourages farmers to plant traditional and adaptable trees such as *Acacia* and *Aristida* and local grasses such as *Pennisetum pedicellatum* and *Cenchrus biflorus* for feeding animals, and for soil conservation and fuel. The grasses are either grazed directly or cut and carried as hay. Farmers weed and protect more valuable species such as *Alysicarpus* in the same way *Stylosanthes* is nurtured in fodder banks. No fencing is required by the farmers and labour to maintain trees or pastures is provided free of charge by the farmers themselves. The farmers frequently collect seeds to expand to new areas and resow in patches within the existing fields. Since 1990, a total of 62 sites covering an area of over 15,000 ha has been developed in Niger (this area is omitted from the analysis, as these sites involve mainly managed natural pasture).

Other projects working in similar areas are Project Keita (an FAO project sponsored by Italy), the GTZ-sponsored project ‘Projet protection intégrée des ressources agrosilvopastorales’ (PASP), and the World Bank–Niger-sponsored PRSAA (Programme de renforcement des services d’appui à l’agriculture), but these development agencies have only recently introduced livestock components into their activities.

Nigeria

In Nigeria fodder banks were being exploited for livestock and crop production in all the agro-ecological zones since around 1982. By 1993 adoption was higher in the subhumid zone (589 smallholder farmers on 2467 ha) and semi-arid zone (3539 farmers on 1220 ha) than in the humid zone (38 adopters on 228 ha). Nationally, by 1997 a total of 4166 adopters and an area of 3915 ha were covered in Nigeria. Until 1992, the promotion of forages (fodder banks) in Nigeria was mainly under the supervision and sponsorship of the National Livestock Projects Division (NLPD) and the World Bank. Under Nigeria’s unified extension system, this responsibility was transferred to the Agricultural Development Project (ADP), which was basically an extension mechanism for crops but currently incorporating a livestock component. This change-over of activities probably accounted for the sharp decline in the rate of adoption between 1992 and 1997, but it is anticipated that after this slack period, adoption rates will escalate again. The semi-arid zone has the highest number of adopters, while the subhumid zone has the larger area. This is attributed to the fact that the promotion of the 4 ha fodder banks using mainly *Stylosanthes* in the subhumid zone is for cattle production, while in the semi-arid zone, *Lablab* (one of the most adaptable species in the zone) is established in smaller plots of less than 1 ha within the farm for both soil improvement and livestock feed.

The species used in Nigeria in the fodder bank system include *Stylosanthes*, *Lablab*, *Centrosema* and *Panicum*. The method of establishment ranges from sole cropping in the natural range to intercropping and undersowing. The cost of fodder bank establishment in selected states in Nigeria using wooden posts was about ₦ 14,000 (some US$ 600) in 1994. In a typical 4-ha fodder bank in Nigeria, re-establishment of the legume is done using a 2- to 3-year crop–forage rotation to avoid invasion of *Stylosanthes* by fast growing nitrophilous grasses. Integrating cropping into the fodder bank system usually leads to a legume-dominant pasture and serves as a cheap way of renovating leguminous pastures for both labour and inputs. Land preparation and weeding usually meant for growing crops could benefit the legume; likewise the phosphorus commonly applied to crops. Being self-seeding, no additional labour is required for resowing nor is any further purchase of *Stylosanthes* seed necessary.

Senegal

To alleviate the dry season feed constraint on livestock, CIRAD (Centre de coopération internationale en recherche agronomique pour le développement), ORSTOM and various NGOs have been advising agropastoralists to grow mainly *Andropogon* and *Panicum* (0.25 ha plots) and a limited quantity of *Stylosanthes* for late dry season supplementation. In addition, the pastoralists are also encouraged to sow large areas of the forest with *Andropogon/Panicum* to improve the natural range. This concept is similar to that used in Guinea. The number of fodder banks has increased to 31 (14.8 ha), and the effort to promote the concept is continuing. Leguminous crops such as *Stylosanthes* are not widely used in these agropastoral systems simply because seeds are not available. The rate of adoption is also limited by lack of *Panicum* seeds and *Andropogon* cuttings. Seeds or cuttings are supplied free and no fertiliser is applied. Fencing is done entirely using local materials (bamboo) and almost all the costs of establishment are taken up by labour.

Sierra Leone

Baseline surveys are currently being conducted in Sierra Leone to understand the livestock production systems with a view to promoting research, which has remained dormant for several decades. In the government's new agenda, forage research and development are a priority, but testing and extending forage interventions to farmers lie mainly in plans for the future in this country.

Togo

Exploitation of legume-based technologies started in the humid zone of Togo in 1983 with 23 adopters (40 ha), and the concept diffused to the subhumid zone from 1984 onwards. At the last count in 1992, a total of 80 farmers (10.6 ha) had incorporated forage legumes into their cropping systems in the subhumid zone, while adoption in the humid zone had stagnated at 28. The species exploited in the humid zone are mainly *Leucaena*, *Gliricidia* and *Cajanus cajan*. These shrubs are grown in association with maize and part of the foliage is incorporated into the soil to improve soil fertility; the other portion is used to feed small ruminants. The stems provide firewood for the farmers. This technology could be related to alley farming. In the northern subhumid zone, *Stylosanthes* has been successfully introduced amongst the smallholder farmers to alleviate nutritional stress in traction animals, especially in the dry season, and to improve soil fertility. The legume is re-established every 2 years in Togo. Records on the further adoption of forages beyond 1992 could not be accessed, but the adoption trend is likely to continue or increase in view of the growing awareness of the exploitation of this concept in the region.

Summary of the adoption data

In summary, the forage legume technology promoted originally by ILCA is diffusing slowly in the whole of West Africa, including in countries such as Senegal and Guinea, where ILCA has had no direct influence (country adoption data are shown in cumulative form in Appendix 4). The national and international organisations mentioned in this chapter, other than ILCA, ILRI and national agricultural research and extension systems, as being involved with the development and dissemination of forage legume technology in the region (the list is clearly not exhaustive, but only indicative) are listed in Table 7. The data suggest that the fodder bank concept is increasingly being accepted as one option for solving the problems of livestock nutrition and soil conservation. The highest number of forages were in Nigeria (4166), Cameroon (2200) and Mali (1421), whereas the largest areas were recorded for Nigeria (3915 ha) and Burkina Faso (1380 ha). The large number of adopters but small area in Cameroon reflects that only small areas of land were planted with the legume partly due to land shortage and intensive cultivation, typical of the humid zone environment. In Nigeria, adopters exploit larger areas of land mainly for forage production, especially in the subhumid and semi-arid zones where land availability does not seem to be a serious problem. Adoption was lowest in The Gambia, Senegal and Guinea, largely because forage production and adoption have only been recently introduced in these countries. For the whole of West Africa, a total of about 27,000 smallholder farmers covering an area of about 19,000 ha were recorded (Figure 3). Most of the adoption is concentrated in the subhumid zone and uptake of forage technology in all three agro-ecological zones was only readily apparent in Nigeria and, to a lesser extent, in Cameroon. In the impact analysis a number of hectares were omitted (described above), notably in Benin, Ghana and Niger, where ILRI was clearly not involved in the uptake of these forages. These hectares were also omitted from the analysis because the research costs and benefits associated with work carried out by ILRI's partners and other institutions are not taken into account. The area used in the impact analysis presented was thus just under 16,500 ha.

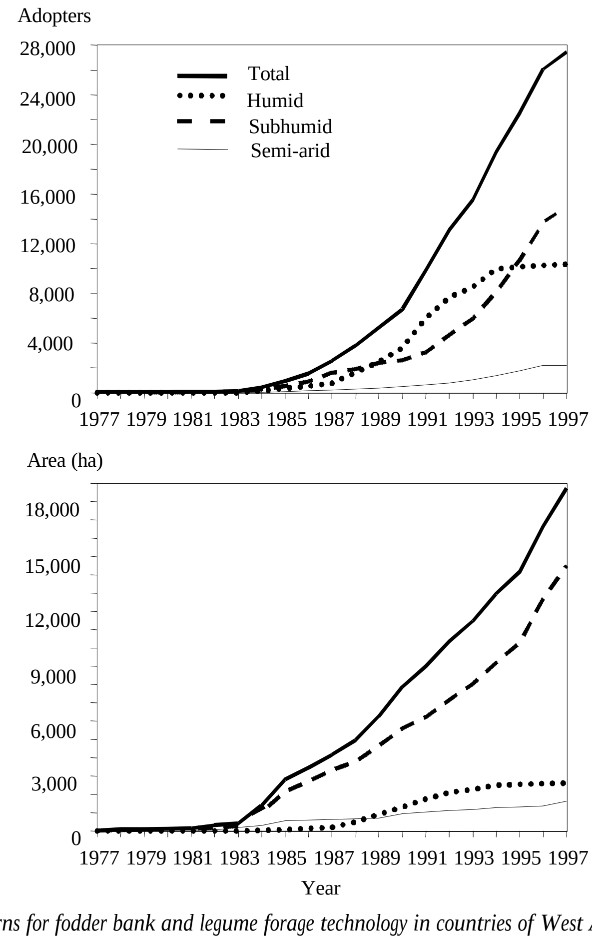

Figure 3. *Adoption patterns for fodder bank and legume forage technology in countries of West Africa.*

Table 7. *National and international organisations and projects mentioned in the text, excepting national agricultural research and extension systems, that have been involved in development and delivery of forage legume technology in West Africa.*

Organisation or project	Country
Centre de coopération internationale en recherche agronomique pour le développement (CIRAD)	Senegal
Centre international de recherche–développement sur l'élevage en zone subhumide (CIRDES)	Burkina Faso
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Guinea
Deutsche Entwicklung Dienst (DED)	Niger
Deutsche Gessellschaft für Technische Zusammenarbeit (GTZ)	Chad, Côte d'Ivoire, Niger
Development Livestock Services (DLS)	The Gambia
Direction de l'Organization Pastorale (DOP)	Chad
Elevage et médecine vétérinaire des pays tropicaux (EMVT)	Burkina Faso
Fa Madinga	Guinea Bissau
Food and Agriculture Organization of the United Nations (FAO)	Mali
Heifer Project International (HPI)	Cameroon
International Centre for Tropical Agriculture (CIAT)	Guinea
International Trypanotolerance Centre (ITC)	The Gambia
Islamic Development Bank	The Gambia
Laboratoire de recherches vétérinaire et zootechnique (LRVZ)	Chad
Office de la recherche scientifique et technique Outre-Mer (ORSTOM)	Burkina Faso, Senegal
Programme de renforcement des services d'appui à l'agriculture (PRSAA)	Niger
Projet agro-silvo-pastoral (PASP)	Guinea Bissau
Project Keita (FAO, Italy)	Niger
Projet protection intégrée des ressources agrosilvopastorales (PASP)	Niger
Réseau de recherche sur l'alimentation du bétail en Afrique occidentale et centrale (RABAOC)	Guinea
Sasakawa Global 2000	Benin
World Bank	Chad, Ghana, Niger, Nigeria

6 Application of the economic surplus model to estimate impact

The previous chapters have specified a complete set of data with which to run an economic surplus model. With this, we can make an estimate of the producer and consumer surplus arising from the adoption of fodder bank technology in West Africa, and we can also estimate the returns to the preceding research investment. There are four steps to the process:

Step 1. For each of the eight commodities (milk, meat, maize grain, millet grain, sorghum grain, maize residue, millet residue and sorghum residue), we calculate the productivity impacts on national production in each year of the analysis from 1977 to 1997 arising from adoption of the appropriate number of hectares of fodder bank. It is assumed that once a fodder bank is established it is not abandoned and hence does not revert to natural pasture.

Step 2. For each commodity, given the percentage productivity impact on national production as a result of fodder bank adoption as calculated in step 1, we calculate the changes in producer, consumer and total surplus in each year, using the equations in Chapter 3 and the elasticities in Table 5.

Step 3. We then sum the surpluses for each commodity to give the total annual surpluses arising from adoption of fodder bank technology for the countries considered.

Step 4. Finally, we take the total surplus for each year, subtract from it the appropriate research costs (as in Table 6) and establishment costs, and discount the net benefit stream, if appropriate, then calculate the net present value of that stream and the internal rate of return of the 'investment' in fodder bank research and development.

Baseline analysis

For the standard baseline analysis, the productivity impacts are rather small, on a regional basis (as might be expected). Thus for the 15 countries used in the analysis, for maize grain, an estimated 1400 t of the transnational maize grain production in 1997 is attributable to fodder banks, or 0.012% of regional production. Similarly for milk, an additional 2250 t is attributable to fodder banks, or 0.14% of regional production, as is an additional 1300 t of meat, or 0.18% of regional production.

Time series data for producer, consumer and total surpluses for maize, meat and milk are shown in Figure 4. Note that all of the producer surpluses, except for meat, are negative, i.e. consumers are reaping most of the benefits that accrue to society through cheaper commodities. Meat is the exception, where both consumer and producer surpluses are positive; this follows directly from the magnitude of the elasticity of demand for meat shown in Table 5 (also see Appendix 1). The net benefit stream from 1977 to 1997 is shown in Figure 5. For this stream of benefits, the internal rate of return was calculated to be

38%, with total net benefits of about US$ 16.5 million arising from total research costs of US$ 7.2 million. Negative producer surpluses at the societal level contrast somewhat with the fact that fodder banks are profitable at the individual farm level, even after the small commodity price reductions modelled in the analysis (see Figure 1). The negative producer surpluses are a direct consequence of the form of the supply and demand functions used (the constant elasticity specification, see Chapter 3). Other than using a different specification of the essentially unknown functional form, it may be noted that the economic surplus is a static model, and that in the adoption process, early adopters may reap more benefits than later adopters before the new supply-and-demand equilibrium is actually reached.

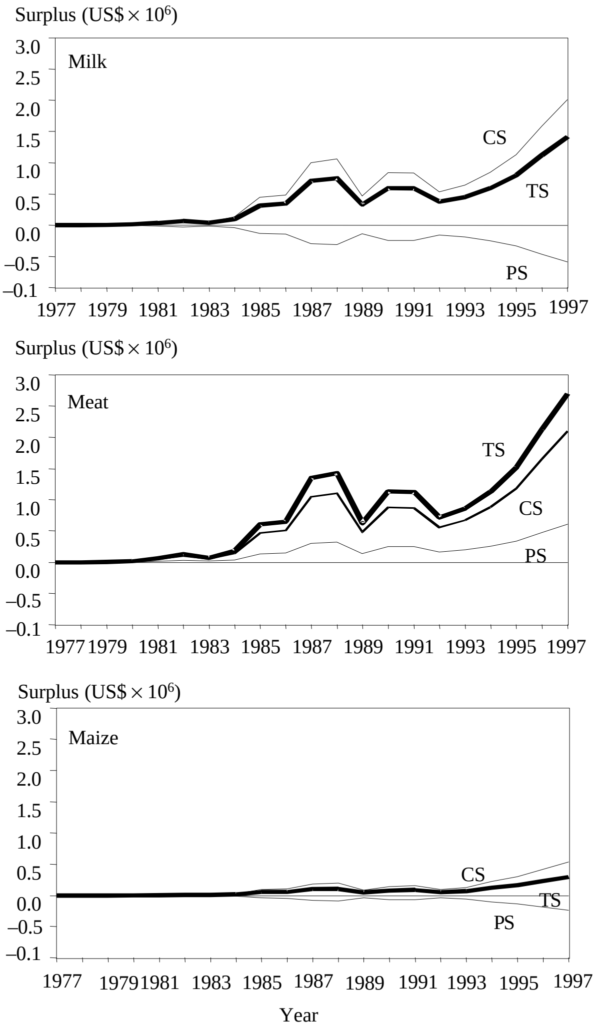

Figure 4. *Baseline fodder bank impact analysis: Consumer surplus (CS), producer surplus (PS) and total surplus (TS) for three commodities in countries of West Africa.*

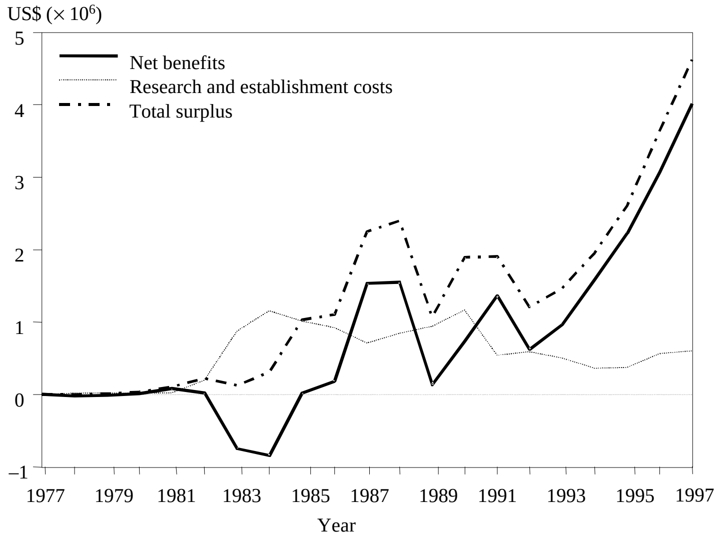

Figure 5. *Baseline fodder bank impact analysis results.*

Sensitivity analysis

A number of sensitivity analyses to investigate the robustness of this estimate of impact and investment returns were carried out. In particular, we looked at what effect different numbers of adopters would have on the analysis. We assumed that the number of hectares reported as being under fodder banks was (i) overestimated by 20% and then (ii) underestimated by 20% (Table 8). A 20% increase in the number of adopted hectares increases the internal rate of return (IRR) by 15% and the total net benefits by 29%; reducing the number of adopters by 20% decreases the IRR by 12% and the total net benefits by 29%. While the results of the analysis are clearly sensitive to the extent of adoption, a wide range of adoption leads to the conclusion that investment in fodder bank research has been profitable to date and in view of future adoption, will become even more so.

The 20% changes made above were also applied to the productivity estimates, and resulted in very similar figures and the same conclusions (because of the small percentage changes in regional productivity, the calculated impacts are close to linear, whether applied to the number of hectares of adoption or to the productivity changes arising as a result of adoption). Of course, it is the case that all the data used in the analysis have uncertainty attached to them, but adoption numbers and productivity impacts are particularly uncertain.

A sensitivity analysis was also carried out with respect to the elasticities of demand, for which information is certainly lacking. Increasing the elasticities of demand for milk, maize, millet and sorghum to 2.0 resulted in negligible changes in net present value, from which we concluded that the results of the analysis are relatively insensitive to the values used for the elasticities of demand.

Table 8. *Summary of baseline analysis and sensitivity analyses.*

	Baseline analysis	20% increase in number of adopters (ha)	20% decrease in number of adopters (ha)
Internal rate of return (%)	38	53	26
Total net benefits by 1997 (US$ × 10^6)	16.51	21.28	11.76
Consumer surplus, 1997 (US$ × 10^6)	5.34	6.41	4.27
Producer surplus, 1997 (US$ × 10^6)	–0.71	–0.86	–0.57
Total economic surplus, 1977 (US$ × 10^6)	4.62	5.55	3.7
Net present value in 1997 dollars (US$ × 10^6)	11.82	14.7	8.95
Benefit:cost ratio	3.3	3.6	2.93

Future adoption

The aggregate adoption curves shown in Figure 3 mask a great deal of country-by-country variation (see Appendix 4). However, the adoption lag is considerable. ILRI had little to do with diffusion in Guinea, Cameroon and Mali, but adoption started in 1992 in Guinea and in the late 1970s in Mali (Figure 6). A question of some importance is, what is the likely equilibrium number of adopters of forage legumes in the region? There are no more research costs associated with the technology, so for future years the net benefit stream is equal to the gross benefit stream (Figure 5), discounted at an appropriate rate.

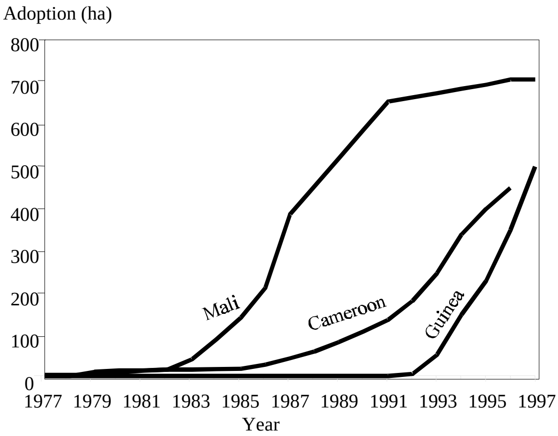

Figure 6. *Adoption of fodder banks in Mali, Cameroon and Guinea.*

There are at least two ways to approach this question, both somewhat crude but providing information on possible future adoption levels. One way is to consider the potential area of forage legumes in West Africa, and then take a 'reasonable' percentage (perhaps 10%) as adopters, in view of the difficulties faced in adopting forage legumes in many places (see Chapter 7), and then another 'reasonable' percentage (perhaps another

10%) of land actually planted to legumes, given the fact that they are a component of a cropping system etc. Thus an upper limit might be 1% or less of viable land that is planted to forage legumes. Land areas highly suitable to *Stylosanthes* can be extracted and broken down by agro-ecological zone and by country (van Velthuizen and Fischer 1995). For West Africa as a whole, these authors define 5.3 million ha as being highly suitable for Verano *Stylosanthes* under low input conditions. One per cent of this is 53,000 ha, indicating that the 19,000 ha of adopted legumes reported to date amounts to a little over a third of what could be expected, assuming that 1% of highly suitable land is planted.

A second approach is to study individual country adoption curves, to see if extrapolations can be made into the future to the point where all country adoption curves are flattening off, assuming that a standard ‘S’ shaped adoption curve is appropriate for every country. From the aggregate adoption curve of Figure 3, it is difficult to extrapolate. If 1997 is ignored, the number of adopters appears to be in the middle of the S-shaped curve (the more-or-less linear part), indicating that if 1997 is near the point of inflexion, then about 40,000 adopters could be expected by 2010 or so. Assuming that the number of hectares planted per adopter remains constant, then this implies about 32,000 ha or so. This is probably not unreasonable; from the figures from Nigeria and Côte d’Ivoire, for example (Appendix 4), the rate of increase in the number of hectares adopted has slowed down substantially, while for countries such as Guinea, substantial further adoption could be expected, given that the lag time by country (time from first adoption to maximum number) can be 15 years or so.

The impact of both these adoption scenarios (the resulting adoption curves are shown in Figure 7) was quantified. For simplicity, the rate of increase in production of all commodities was fixed at 1.5% per year for the period 1998 to 2014, and for these years 1997 commodity prices were used. The future portion of the net benefit stream was discounted at 10% to give a net present value in 1997 dollars. The analysis results from the high and low adoption projections (Figure 7) are summarised in Table 9. Even taking the low projection, the total returns to fodder bank research are greatly increased compared with Table 8, and result in substantial increases in the total net present value.

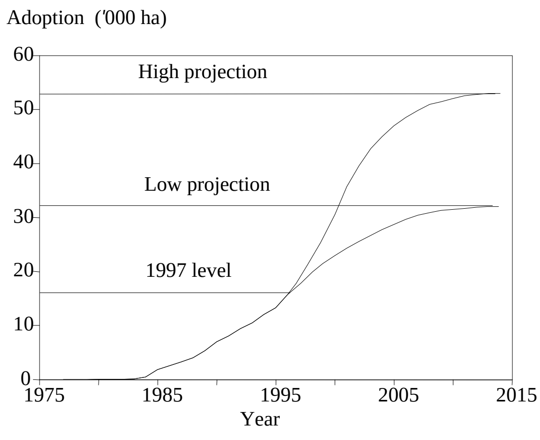

Figure 7. *Two adoption scenarios for forage legumes in West Africa to 2014.*

Table 9. *Summary of baseline analysis and adoption projections to 2014.*[1]

	Baseline analysis	'Low' adoption projection to 2014	'High' adoption projection to 2014
Total net benefits (US$ $\times 10^6$)	16.5	138	188
Net present value of past and future benefits in 1997 dollars (US$ $\times 10^6$, discount rate 10%)	11.8	65.3	81
Benefit:cost ratio	3.3	7.1	7.2

1. 'Low' adoption projection (Figure 7) finishes at 32,000 ha in 2014. 'High' adoption projection finishes at 53,000 ha in 2014.

Analysis by agro-ecological zone

Rather more refined impact analyses could be carried out on the basis of agro-ecological zones, in addition to the regional analyses performed above. The adoption data have been collected on this basis (Appendix 4), but considerably more effort would be needed on adjusting the productivity impacts to use in each zone (humid, subhumid and semi-arid). Local variations in commodity prices would also need to be taken into account, and these data are also hard to come by. These analyses could then be run by agro-ecological zone in the future, and the results mapped.

7 Discussion

The analyses described indicate that the fodder bank technology, even though not taken up in great numbers by the agropastoralists of West Africa, has more than paid for the research resources expended on its development through increased meat, milk and cereal production.

These analyses should certainly be viewed as being indicative rather than definitive, in a number of respects. In Chapter 4, it was noted that there are still substantial data shortages, particularly with respect to commodity prices and elasticities of supply and demand. Lack of country-level and production system-level information on costs of fodder bank establishment and methods of utilisation (and their relative preponderance), meant that broad-brush assumptions had to be made concerning regional-level establishment and utilisation methods. In addition, there is a sense in which the analysis performed is likely to result in fairly conservative estimates of the true (but unknown) benefits of fodder bank technology. We certainly have not identified all the adopters, and we have taken account of only some (although probably the most important) of the benefits that arise from fodder bank utilisation by large ruminants; the benefits of fodder bank utilisation by small ruminants have not been dealt with at all in this study.

Many institutions and organisations have been involved with forage legumes in West Africa for many years, for a wide variety of purposes. The total expenditure of research and development resources on forage legumes, going back to the 1930s, may be large, and ILRI's investment is clearly only a part of this total. However, in contrast to some other forage legume initiatives, the ILCA/ILRI forage legume 'recipe' was always clearly aimed at strategic supplementation of livestock during times of stress, with the soil and crop benefits being regarded as desirable bonuses for the farmer (M.A. Mohamed-Saleem, ILRI, personal communication). The adoption data collected during this study were screened to omit those data that could reasonably clearly be traced to the activities of other organisations and/or that involved obviously different methods of utilisation, but inevitably there will still be overlap. It is true, however, that the attribution problem (what proportion of fodder bank adoption can be directly attributed to the activities of ILRI) is extremely difficult to deal with adequately, and highlights both the importance of using conservative estimates of productivity impacts and the importance of performing sensitivity analyses on the results.

Given the apparent benefits of planted forage legumes, even allowing for the weaknesses of the analyses conducted during this study, it may well be asked why adoption has not been even more widespread than it has. Various authors have identified a number of constraints to adoption in West Africa:

- *Lack of extension information.* The fact that farmers are unaware of the fodder bank technology and programmes has been identified as an important factor hindering adoption of the technology (Mohamed-Saleem and von Kaufmann 1995).

- *Inappropriate land tenure*. This is another important factor hindering the adoption of the technology (Mohamed-Saleem and von Kaufmann 1995). Land facilitates access to credit because it can be used as collateral for a loan. In addition, secure land rights are a pre-requisite for any long-term investment, and their absence will militate against adoption of relatively capital-intensive technologies such as fodder banks.
- *Fencing materials*. Fencing can represent nearly 80% of total input costs for establishing a fodder bank (Otsyina et al 1987). In some countries fencing materials are expensive and the procurement and delivery of inputs for establishing a fodder bank are difficult. The use of local materials requires additional labour, which some farmers will have difficulty fitting into already busy schedules.
- *Shortage of labour*. During the early rainy season labour is required for crop production, and there is a shortage of agricultural mechanisation (including animal traction) in many West African countries. Additional labour is required for including fodder banks in the farming system and this is often not available, especially for farmers with young families. In fact, Thomas and Sumberg (1995) follow Berry (1993) in identifying limited labour availability, in terms of total quantity and seasonal availability, as probably the single most important factor affecting the course of agrarian change (including agricultural intensification) in sub-Saharan Africa in general. Analyses of the adoption of legume technology in terms of changes in labour requirements are not well-developed to date.
- *Disease constraints*. Kraaling animals overnight for several nights is sometimes rejected by farmers for fear of nematodes in the dung infecting cattle (Mohamed-Saleem 1994). In some zones, *Stylosanthes* is not particularly resistant to diseases and pests. An important disease is anthracnose and important pests are termites, leaf-eating beetles, leaf hoppers (eating flowers) and blister beetles (Adeoti et al 1994).
- *Credit and seed availability*. Unlike in Nigeria and Côte d'Ivoire, where credit facilities have aided the diffusion of legume-based technologies, in countries such as Cameroon, Senegal, Guinea and Mali, such incentives have not been found. In addition, high interest rates with the many restrictive conditions often imposed by credit programmes prevent farmers from exploiting loan schemes. Lack of sufficient seed in some countries is also regarded as an impediment to adoption, and efforts to encourage local seed production are needed (Tarawali et al 1998).
- *Land scarcity*. In intensively cultivated areas farmers cannot leave land fallow for even one year; farmers thus find it difficult to include planted legumes in their cropping systems unless they adopt other practices such as intercropping or sequential cropping.
- *Invasion by grasses and weeds.* When established in association with grasses such as *Panicum maximum*, the legume in the fodder bank, unless well managed, will be suppressed leading to a grass-dominant pasture of lower nutritional value. In addition, aggressive and noxious weeds, notably *Imperata cylindrica* and *Sida acuta*, sometimes invade fodder

banks leading to a complete displacement of the desired leguminous species. Such problems have in the past led to many fodder banks being abandoned.

- *Fires*. Burning, especially during the dry season, is a very common practice in West African rangelands. There are concerns that fodder banks reserved for supplementation of cattle in the late dry season face the risk of being wiped out by fire at the time they are needed most; this can contribute substantially to the perceived riskiness of investing in a fodder bank.

Given this array of problems, it is perhaps not surprising that the diffusion of fodder banks in the region has been slow and modest; what is surprising is the indication that the lag in the adoption of fodder bank technology in individual countries seems to be of the order of 15 to 20 years. This is a considerable length of time, and probably much longer than may have been expected.

ILRI is no longer investing research resources directly into fodder bank technology research and development. In the absence of direct research effort, the question of whether there is a role for ILRI and other institutions and organisations to promote this technology in the coming years is certainly relevant, but it is not particularly easy to answer directly. As Thomas and Sumberg (1995) note, considerable resources have been devoted to screening and testing forage legumes throughout sub-Saharan Africa over the last 40 years; given the large picture of rather limited use of legumes by smallholders, they wonder about the justification for this expenditure. There may certainly be a role in information dissemination and training of national research partners and those working in extension services. There is also likely to be an important role in helping NARS to secure and multiply germplasm. ILRI still has substantial commitments to research on legumes in mixed farming systems through research programmes in the semi-arid and subhumid zones of West Africa, however. The role of legumes may also change dramatically in West African farming systems over the next 40 years. The agropastoral systems of West Africa will come under enormous pressure primarily from population growth, and the question of adequate forage resources for a rapidly expanding cattle population is very complex. Solutions are unlikely to come from any one source, but are more likely to involve greater integration of crop and livestock enterprises, particularly through increased use of crop residues. Within this milieu, planted forage legumes may occupy an expanding niche. Even if this niche never becomes very large, the research that ILCA carried out on fodder banks in the 1980s and early 1990s has already more than paid for itself, particularly in terms of benefits for consumers in West Africa.

References

Adeoti A., Tarawali S. and Mohamed-Saleem M.A. 1994. Development of management strategies for stylo with emphasis on pests and diseases. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop. Proceedings of the Regional Workshop on the Use of* Stylosanthes *in West Africa, held in Kaduna, Nigeria, 26–31 October 1992*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 123–128.

Ajileye E.O., Uza D.V. and Farooqi M.A. 1994. An assessment of farmers' adoption rate and potential impacts of stylo-based feed production systems. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop*. *Proceedings of the Regional Workshop on the Use of* Stylosanthes *in West Africa, held in Kaduna, Nigeria, 26–31 October 1992*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 311–316.

Alston J., Norton G. and Pardey P. 1995. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Cornell University Press, Ithaca, New York, USA. 585 pp.

Bayer W. 1986. Utilization of fodder banks. In: von Kaufmann R., Chater S. and Blench R. (eds), *Livestock System Research in Nigeria's Subhumid Zone. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 351–364.

Berry S. 1993. *No Condition is Permanent: The Social Dynamics of Agrarian Change in Sub-Saharan Africa*. University of Wisconsin Press, Madison, Wisconsin, USA. 258 pp.

Delgado C.L. and Reardon T. 1991. *Cereal Consumption Shifts and Policy Changes in Developing Countries: General Trends and Case Studies from the West African Semi-Arid Tropics*. IFPRI Reprint 255. IFPRI (International Food Policy Research Institute), Washington DC, USA.

FAO (Food and Agriculture Organization of the United Nations). 1990–1998. FAOSTAT-PC. *FAOSTAT Statistics Database.* Accessed in June 1997. FAO, Rome, Italy.

Hassane B. 1995. *On-farm Evaluation of Fodder Bank Adoption among Agropastoralists in Northern Nigeria*. Unpublished PhD dissertation, Department of Range Science, Utah State University, Logan, Utah, USA. 155 pp.

Ikwuegbu O. Tarawali G. and Iji P. 1994. Sustaining a crop-livestock farming system in the subhumid zone of Nigeria by matching feed from improved *Stylosanthes*-based pastures and livestock production. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop. Proceedings of the Regional Workshop on the Use of* Stylosanthes *in West Africa, held in Kaduna, Nigeria, 26–31 October 1992*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 167–174.

Ikwuegbu O.A. Tarawali G. and Rege J.E.O. 1995. Effects of fodder banks on growth and survival of West African Dwarf goats under village conditions in subhumid Nigeria. *Small Ruminant Research* 17:101–109.

Jaeger W.K. 1986. *Agricultural Mechanization: The Economics of Animal Draft Power in West Africa*. Westview Press, Boulder, Colorado, USA. 199 pp.

von Kaufmann R., McIntire J. and Itty P. 1990. *ILCA Bio-Economic Herd Model For Microcomputer.* User's Manual. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Mani R. 1992. *Optimal Utilization of Legume Fodder Banks and Low Quality Roughages by Grazing Cattle.* PhD thesis, University of Melbourne, Parkville, Australia. 192 pp.

Mani R.I., von Kaufmann R.R., Egan A.R., Oyedipe E.O., Dixon R.M. and Holmes J.H.G. 1993. Optimal utilization of fodder banks for the reproductive efficiency of Bunaji cattle: Effect of dry season forage legume supplementation on weight and reproductive performance. In: Adamu A.M., Mani R.I., Osinowo O.A., Adeoye K.B. and Ajileye E.O. (eds), *Proceedings of a Workshop on Forage Production and Utilization in Nigeria, Zaria, Nigeria, 11–14 February 1991*. National Livestock Projects Division, Federal Ministry of Agriculture and Water Resources, Kaduna, Nigeria. pp. 135–150.

Mohamed-Saleem M.A. 1986. The establishment and management of fodder banks. In: von Kaufmann R., Chater S. and Blench R. (eds), *Livestock System Research in Nigeria's Subhumid Zone. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 326–350.

Mohamed-Saleem M.A. 1994. *Stylosanthes* for pasture development: An overview of ILCA's experience in Nigeria. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop. Proceedings of the Regional Workshop on the Use of* Stylosanthes *in West Africa, held in Kaduna, Nigeria, 26–31 October 1992*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 17–23.

Mohamed-Saleem M.A and von Kaufmann R. 1995. Fodder banks: improving the nutrition of cattle in the subhumid zone of West Africa. In: Ruiz M.E., Sere C. and Li Pun H. (eds), *Global Workshop on Animal Production Systems*. Research and Development Collection 26. IICA (Inter-American Institute for Co-operation on Agriculture) and RISPAL (Latin American Research Network for Animal Production Systems), San José, Costa Rica. pp. 25–54.

Mohamed-Saleem M.A. and de Leeuw P.N. 1994. Stylo-based pasture development for agropastoral production systems. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop. Proceedings of the Regional Workshop on the Use of* Stylosanthes *in West Africa, held in Kaduna, Nigeria, 26–31 October 1992*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 139–145.

Mohamed-Saleem M.A. and Suleiman H. 1986. Nigeria and West Africa fodder banks: dry season feed supplementation for traditionally managed cattle in the sub-humid zone. *World Animal Review* 59:11–17.

Mohamed-Saleem M.A., Otsyina R. and von Kaufmann R. 1986. Some methods for improving fodder by incorporating forage legumes in cereal cropping systems in the Nigerian subhumid zone. In: Haque I., Jutzi S. and Neate P.J.H. (eds), *Potentials of Forage Legumes in Farming Systems of Sub-Saharan Africa. Proceedings of a Workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 363–378.

Otchere E. 1986. The effects of supplementary feeding of traditionally managed Bunaji cows. In: von Kaufmann R., Chater S. and Blench R. (eds), *Livestock System Research in Nigeria's Subhumid Zone. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 204–212.

Otsyina R.M., von Kaufmann R., Mohamed-Saleem M.A. and Suleimann H. 1987. *Manual on Fodder Bank Establishment and Management*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Singh I. and Subramanian J. 1986. Agricultural household modelling in a multicrop environment: Case studies in Korea and Nigeria. In: Singh I., Squire L. and Strauss J. (eds), *Agricultural Household Models.* Johns Hopkins University Press, London, UK.

Tambi E. 1996. The dynamics of household beef consumption in Cameroon. *Agricultural Economics* 14:11–19.

Tarawali G. 1991. The residual effect of *Stylosanthe*s fodder banks on maize yield at several locations in Nigeria. *Tropical Grasslands* 25:26–31.

Tarawali G. and von Kaufmann R. 1987. *Fodder Banks: Benefits to Ruminant and Crop Production.* Paper presented at the Regional Seminar on Forages and Ruminant Nutrition, held at Ngaoundere, Cameroon, 16–20 November 1987. 15 pp.

Tarawali G. and Mohamed-Saleem M.A. 1994. Establishment techniques for Stylo-associated cropping systems. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop. Proceedings of the Regional Workshop on the Use of Stylosanthes in West Africa, held in Kaduna, Nigeria, 26–31 October 1992.* ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 183–192.

Tarawali G., Dembélé E., N'Guessan B. and Youri A. 1998. The use of *Stylosanthes* by smallholder farmers for sustainable food production in subhumid West Africa. Manuscript in revision.

Thomas D. and Sumberg J. 1995. A review of the evaluation and use of tropical forage legumes in sub-Saharan Africa. *Agriculture, Ecosystems and Environment* 54:151–163.

van Velthuizen H.T. and Fischer G.W. 1995. *Potential of Forage Legumes in Land-use Intensification Towards Sustainable Crop–Livestock Production Systems in West Africa.* IIASA Working Paper 95–80. IIASA (International Institute for Applied Systems Analysis), Laxenburg, Austria. 109 pp.

Winrock International. 1992. *Assessment of Animal Agriculture in Sub-Saharan Africa.* Winrock International Institute for Agricultural Development, Morrilton, Arkansas, USA. 125 pp.

Appendix 1 Changes in producer surplus and elasticity of demand

Under the assumptions of the economic surplus model used in the analysis, whether producers gain or lose from fodder bank technology depends on the magnitude of the elasticity of demand for the various commodities affected by the technology.

If the elasticity of demand (γ) is greater (less) than one, the change in producer surplus is positive (negative). This can be shown by substituting equilibrium quantity and price into the equation for the change in producer surplus and rearranging. Thus:

$$\Delta PS = P_0 Q_0 [(1-k)^{(1-\gamma)\varepsilon/(\varepsilon+\gamma)} - 1]$$

Since $0<k<1$, ΔPS is greater (less) than zero if, and only if, γ is greater (less) than one.

Appendix 2 Sample commodity prices, Ghana (US$)

	Grain (per kg)			Residue (per kg)			Meat	Milk
	MZ	SG	ML	MZ	SG	ML	(per kg)	(per litre)
1977	0.55	0.82	0.6	0.06	0.1	0.07	5.5	1.65
1978	0.56	0.9	0.93	0.07	0.11	0.11	5.6	1.68
1979	0.8	1.1	1.12	0.1	0.13	0.13	8	2.4
1980	1.92	3.17	2.49	0.23	0.38	0.3	11.9	5.8
1981	3.6	4.44	4.41	0.43	0.53	0.53	36	10.8
1982	3.71	6.1	6.3	0.44	0.73	0.75	37.1	11.1
1983	0.73	0.76	0.69	0.09	0.09	0.08	7.3	2.19
1984	0.47	0.81	0.95	0.06	0.1	0.11	4.7	1.41
1985	0.41	0.49	0.7	0.05	0.06	0.08	4.1	1.23
1986	0.33	0.36	0.43	0.04	0.04	0.05	3.3	0.99
1987	0.53	0.54	0.58	0.06	0.06	0.07	5.3	1.59
1988	0.45	0.51	0.63	0.05	0.06	0.08	4.5	1.35
1989	0.15	0.24	0.32	0.02	0.03	0.04	1.5	0.45
1990	0.21	0.24	0.29	0.03	0.03	0.03	2.1	0.63
1991	0.18	0.25	0.31	0.02	0.03	0.04	1.8	0.54
1992	0.1	0.13	0.16	0.01	0.02	0.02	1	0.3
1993	0.11	0.17	0.19	0.01	0.02	0.02	1.1	0.33
1994	0.13	0.16	0.2	0.02	0.02	0.02	1.3	0.39
1995	0.16	0.18	0.21	0.02	0.02	0.03	1.6	0.48
1996	0.19	0.19	0.27	0.02	0.02	0.03	1.9	0.57
1997	0.21	0.24	0.28	0.03	0.03	0.03	2.1	0.63

MZ = maize; SG = sorghum; ML = millet.

Appendix 3 FAO production data for West Africa, 1977–1995

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
1977															
Benin	308,000	730	225,000	12,000	416	5,000	98,000	775	76,000	94,000	106	10,000	91,000	109	10,000
Burkina Faso	90,000	822	74,000	900,000	394	355,000	1,064,000	596	635,000	210,000	100	21,000	434,000	175	76,000
Cameroon	532,000	896	477,000	109,000	752	82,000	314,000	777	244,000	310,000	138	43,000	117,000	495	58,000
Chad	10,000	1,000	10,000	527,000	483	255,000	606,000	526	319,000	230,000	108	25,000	407,000	270	110,000
Côte d'Ivoire	538,000	479	258,000	75,000	560	42,000	48,000	645	31,000	230,000	139	32,000	88,000	113	10,000
The Gambia	3,000	666	2,000	25,000	640	16,000	5,000	600	3,000	35,000	114	4,000	29,000	172	5,000
Ghana	256,000	1,070	274,000	208,000	600	125,000	175,000	748	131,000	116,000	112	13,000	114,000	131	15,000
Guinea	65,000	1,076	70,000	35,000	1,371	48,000	20,000	1,250	25,000	120,000	100	12,000	200,000	185	37,000
Guinea Bissau	12,000	666	8,000	13,000	615	8,000	14,000	714	10,000	20,000	100	2,000	47,000	170	8,000
Liberia	0	0	0	0	0	0	0	0	0	18,000	111	2,000	5,000	200	1,000
Mali	89,000	876	78,000	846,000	510	432,000	571,000	558	319,000	350,000	120	42,000	408,000	245	100,000
Mauritania	8,000	500	4,000	8,000	250	2,000	52,000	365	19,000	110,000	118	13,000	220,000	350	77,000
Niger	8,000	750	6,000	2,729,000	414	1,130,000	733,000	466	342,000	260,000	119	31,000	450,000	184	83,000
Nigeria	610,000	1,273	777,000	3,089,000	834	2,579,000	3,480,000	955	3,326,000	1,007,000	216	218,000	1,122,000	239	269,000
Senegal	54,000	1,037	56,000	828,000	413	342,000	115,000	678	78,000	260,000	123	32,000	244,000	348	85,000
Sierra Leone	13,000	1,076	14,000	9,000	1,000	9,000	7,000	1,571	11,000	58,000	86	5,000	69,000	246	17,000
Togo	124,000	1,000	124,000	154,000	733	113,000	0	0	0	32,000	125	4,000	30,000	233	7,000
1978															
Benin	441,000	777	343,000	13,000	230	3,000	95,000	652	62,000	96,000	114	11,000	93,000	118	11,000
Burkina Faso	116,000	931	108,000	768,000	492	378,000	1,098,000	578	635,000	215,000	102	22,000	445,000	175	78,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Cameroon	537,000	746	401,000	126,000	809	102,000	364,000	843	307,000	320,000	140	45,000	120,000	500	60,000
Chad	20,000	750	15,000	530,000	486	258,000	610,000	527	322,000	240,000	120	29,000	416,000	269	112,000
Côte d'Ivoire	564,000	468	264,000	78,000	576	45,000	49,000	653	32,000	250,000	136	34,000	96,000	104	10,000
The Gambia	8,000	1,625	13,000	29,000	862	25,000	6,000	833	5,000	35,000	114	4,000	29,000	172	5,000
Ghana	205,000	1,063	218,000	157,000	592	93,000	160,000	756	121,000	113,000	115	13,000	112,000	133	15,000
Guinea	70,000	1,000	70,000	35,000	1,285	45,000	20,000	1,100	22,000	120,000	100	12,000	206,000	184	38,000
Guinea Bissau	10,000	600	6,000	12,000	500	6,000	20,000	650	13,000	20,000	100	2,000	48,000	166	8,000
Liberia	0	0	0	0	0	0	0	0	0	18,000	111	2,000	6,000	166	1,000
Mali	43,000	2,395	103,000	546,000	957	523,000	369,000	1,048	387,000	335,000	128	43,000	440,000	245	108,000
Mauritania	9,000	555	5,000	14,000	142	2,000	95,000	305	29,000	130,000	123	16,000	230,000	347	80,000
Niger	11,000	818	9,000	2,727,000	411	1,123,000	796,000	466	371,000	290,000	120	35,000	460,000	200	92,000
Nigeria	519,000	921	478,000	2,273,000	1,069	2,431,000	3,433,000	697	2,396,000	1,130,000	216	245,000	1,158,000	239	277,000
Senegal	56,000	964	54,000	926,000	707	655,000	129,000	1,155	149,000	279,000	125	35,000	251,000	370	93,000
Sierra Leone	13,000	1,076	14,000	9,000	1,000	9,000	7,000	1,571	11,000	58,000	86	5,000	70,000	257	18,000
Togo	118,000	1,177	139,000	102,000	372	38,000	110,000	645	71,000	30,000	133	4,000	29,000	241	7,000
1979															
Benin	424,000	724	307,000	13,000	461	6,000	88,000	715	63,000	98,000	112	11,000	94,000	117	11,000
Burkina Faso	110,000	900	99,000	768,000	492	378,000	1,106,000	590	653,000	210,000	119	25,000	455,000	175	80,000
Cameroon	545,000	748	408,000	128,000	812	104,000	369,000	840	310,000	323,000	142	46,000	155,000	496	77,000
Chad	25,000	800	20,000	465,000	496	231,000	535,000	442	237,000	230,000	126	29,000	426,000	269	115,000
Côte d'Ivoire	584,000	470	275,000	80,000	575	46,000	51,000	647	33,000	280,000	135	38,000	100,000	110	11,000
The Gambia	6,000	1,666	10,000	29,000	586	17,000	6,000	500	3,000	35,000	114	4,000	29,000	172	5,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Ghana	358,000	1,061	380,000	250,000	596	149,000	211,000	748	158,000	120,000	116	14,000	117,000	128	15,000
Guinea	80,000	1,000	80,000	35,000	1,428	50,000	20,000	1,250	25,000	115,000	104	12,000	212,000	183	39,000
Guinea Bissau	12,000	666	8,000	15,000	666	10,000	25,000	600	15,000	20,000	100	2,000	49,000	163	8,000
Liberia	0	0	0	0	0	0	0	0	0	18,000	111	2,000	6,000	166	1,000
Mali	46,000	1,652	76,000	570,000	752	429,000	384,000	825	317,000	298,000	127	38,000	477,000	245	117,000
Mauritani	9,000	555	5,000	14,000	142	2,000	96,000	218	21,000	133,000	120	16,000	240,000	350	84,000
Niger	12,000	750	9,000	2,922,000	429	1,255,000	717,000	489	351,000	332,000	102	34,000	467,000	199	93,000
Nigeria	425,000	1,155	491,000	2,565,000	918	2,357,000	2,686,000	1,041	2,797,000	1,253,000	219	275,000	1,188,000	239	284,000
Senegal	68,000	676	46,000	812,000	522	424,000	113,000	849	96,000	290,000	124	36,000	253,000	359	91,000
Sierra Leone	13,000	923	12,000	9,000	1,000	9,000	7,000	1,571	11,000	59,000	84	5,000	71,000	253	18,000
Togo	137,000	1,160	159,000	104,000	471	49,000	116,000	750	87,000	32,000	125	4,000	30,000	233	7,000
1980															
Benin	365,000	742	271,000	13,000	538	7,000	89,000	629	56,000	108,000	111	12,000	104,000	115	12,000
Burkina Faso	116,000	905	105,000	720,000	487	351,000	957,000	571	547,000	215,000	102	22,000	463,000	174	81,000
Cameroon	497,000	832	414,000	132,000	757	100,000	381,000	868	331,000	330,000	142	47,000	184,000	500	92,000
Chad	30,000	833	25,000	428,000	467	200,000	492,000	508	250,000	230,000	126	29,000	436,000	270	118,000
Côte d'Ivoire	468,000	811	380,000	54,000	629	34,000	36,000	583	21,000	310,000	135	42,000	106,000	113	12,000
The Gambia	6,000	1,000	6,000	26,000	961	25,000	6,000	833	5,000	35,000	114	4,000	29,000	172	5,000
Ghana	440,000	868	382,000	139,000	589	82,000	261,000	505	132,000	125,000	112	14,000	120,000	133	16,000
Guinea	90,000	1,000	90,000	35,000	1,428	50,000	20,000	1,250	25,000	115,000	104	12,000	220,000	186	41,000
Guinea Bissau	12,000	1,000	12,000	18,000	722	13,000	28,000	642	18,000	20,000	100	2,000	50,000	180	9,000
Liberia	0	0	0	0	0	0	0	0	0	13,000	153	2,000	6,000	166	1,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Mali	41,000	1,097	45,000	660,000	616	407,000	446,000	674	301,000	306,000	120	37,000	585,000	244	143,000
Mauritania	8,000	625	5,000	13,000	230	3,000	87,000	321	28,000	132,000	128	17,000	240,000	350	84,000
Niger	15,000	666	10,000	3,072,000	444	1,364,000	768,000	479	368,000	368,000	100	37,000	481,000	199	96,000
Nigeria	465,000	1,404	653,000	2,824,000	867	2,450,000	3,286,000	1,122	3,690,000	1,644,000	225	370,000	1,211,000	239	290,000
Senegal	78,000	730	57,000	951,000	474	451,000	132,000	772	102,000	246,000	126	31,000	250,000	348	87,000
Sierra Leone	13,000	923	12,000	9,000	1,555	14,000	7,000	1,571	11,000	60,000	83	5,000	73,000	246	18,000
Togo	150,000	920	138,000	163,000	263	43,000	126,000	753	95,000	31,000	129	4,000	29,000	206	6,000
1981															
Benin	433,000	662	287,000	12,000	583	7,000	94,000	606	57,000	110,000	109	12,000	106,000	122	13,000
Burkina Faso	143,000	832	119,000	922,000	480	443,000	1,089,000	605	659,000	220,000	95	21,000	470,000	174	82,000
Cameroon	442,000	975	431,000	129,000	689	89,000	371,000	706	262,000	320,000	131	42,000	189,000	497	94,000
Chad	40,000	875	35,000	187,000	609	114,000	216,000	662	143,000	250,000	124	31,000	446,000	269	120,000
Côte d'Ivoire	490,000	816	400,000	58,000	551	32,000	34,000	558	19,000	312,000	137	43,000	111,000	108	12,000
The Gambia	8,000	1,625	13,000	29,000	1,206	35,000	6,000	1,166	7,000	35,000	114	4,000	30,000	166	5,000
Ghana	372,000	1,016	378,000	157,000	757	119,000	198,000	661	131,000	125,000	112	14,000	124,000	129	16,000
Guinea	90,000	1,000	90,000	35,000	1,371	48,000	20,000	1,250	25,000	113,000	97	11,000	225,000	186	42,000
Guinea Bissau	16,000	812	13,000	20,000	700	14,000	30,000	666	20,000	21,000	95	2,000	51,000	176	9,000
Liberia	0	0	0	0	0	0	0	0	0	15,000	133	2,000	6,000	166	1,000
Mali	69,000	884	61,000	700,000	780	546,000	472,000	855	404,000	313,000	140	44,000	640,000	245	157,000
Mauritania	8,000	500	4,000	8,000	500	4,000	122,000	295	36,000	154,000	129	20,000	245,000	351	86,000
Niger	16,000	687	11,000	3,038,000	432	1,314,000	982,000	327	322,000	370,000	108	40,000	513,000	200	103,000
Nigeria	438,000	1,490	653,000	1,708,000	1,570	2,682,000	2,077,000	1,619	3,364,000	1,510,000	217	329,000	1,221,000	239	292,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Senegal	78,000	1,217	95,000	1,033,000	764	790,000	144,000	1,361	196,000	294,000	125	37,000	225,000	360	81,000
Sierra Leone	13,000	1,076	14,000	10,000	1,600	16,000	7,000	1,571	11,000	61,000	81	5,000	76,000	250	19,000
Togo	153,000	986	151,000	97,000	412	40,000	125,000	640	80,000	36,000	138	5,000	31,000	225	7,000
1982															
Benin	421,000	648	273,000	14,000	571	8,000	94,000	638	60,000	112,000	107	12,000	108,000	120	13,000
Burkina Faso	135,000	822	111,000	909,000	485	441,000	1,048,000	581	609,000	265,000	94	25,000	479,000	175	84,000
Cameroon	460,000	1,093	503,000	150,000	633	95,000	441,000	646	285,000	340,000	135	46,000	176,000	500	88,000
Chad	41,000	731	30,000	200,000	620	124,000	231,000	675	156,000	250,000	124	31,000	456,000	269	123,000
Côte d'Ivoire	520,000	826	430,000	56,000	535	30,000	35,000	542	19,000	255,000	137	35,000	122,000	106	13,000
The Gambia	9,000	1,888	17,000	38,000	1,105	42,000	8,000	1,000	8,000	36,000	111	4,000	30,000	166	5,000
Ghana	373,000	927	346,000	172,000	441	76,000	216,000	398	86,000	140,000	114	16,000	139,000	129	18,000
Guinea	90,000	1,000	90,000	35,000	1,285	45,000	20,000	1,100	22,000	115,000	104	12,000	231,000	186	43,000
Guinea Bissau	15,000	666	10,000	25,000	640	16,000	40,000	650	26,000	22,000	90	2,000	53,000	169	9,000
Liberia	0	0	0	0	0	0	0	0	0	18,000	111	2,000	6,000	166	1,000
Mali	47,000	1,893	89,000	813,000	747	608,000	549,000	817	449,000	321,000	143	46,000	666,000	244	163,000
Mauritania	7,000	571	4,000	3,000	666	2,000	122,000	286	35,000	143,000	132	19,000	245,000	351	86,000
Niger	11,000	636	7,000	3,084,000	419	1,293,000	1,135,000	316	359,000	320,000	109	35,000	523,000	200	105,000
Nigeria	556,000	1,125	626,000	1,698,000	1,570	2,666,000	2,290,000	1,620	3,710,000	1,688,000	215	364,000	1,239,000	239	297,000
Senegal	78,000	974	76,000	870,000	548	477,000	121,000	892	108,000	300,000	123	37,000	226,000	371	84,000
Sierra Leone	14,000	1,071	15,000	10,000	1,600	16,000	8,000	1,500	12,000	63,000	95	6,000	78,000	256	20,000
Togo	175,000	862	151,000	50,000	1,040	52,000	94,000	893	84,000	40,000	125	5,000	32,000	218	7,000
1983															
Benin	453,000	622	282,000	15,000	400	6,000	106,000	537	57,000	114,000	114	13,000	110,000	118	13,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Burkina Faso	125,000	568	71,000	928,000	421	391,000	1,083,000	564	611,000	260,000	107	28,000	488,000	174	85,000
Cameroon	475,000	1,029	489,000	100,000	610	61,000	400,000	625	250,000	340,000	144	49,000	172,000	500	86,000
Chad	37,000	783	29,000	320,000	462	148,000	371,000	533	198,000	258,000	120	31,000	467,000	269	126,000
Côte d'Ivoire	550,000	745	410,000	54,000	481	26,000	33,000	515	17,000	308,000	136	42,000	125,000	112	14,000
The Gambia	7,000	1,285	9,000	25,000	1,040	26,000	7,000	1,000	7,000	36,000	111	4,000	30,000	166	5,000
Ghana	400,000	430	172,000	175,000	228	40,000	220,000	254	56,000	150,000	113	17,000	150,000	133	20,000
Guinea	90,000	1,000	90,000	38,000	1,315	50,000	21,000	1,190	25,000	120,000	100	12,000	238,000	184	44,000
Guinea Bissau	16,000	625	10,000	27,000	666	18,000	35,000	657	23,000	22,000	90	2,000	54,000	166	9,000
Liberia	0	0	0	0	0	0	0	0	0	22,000	136	3,000	6,000	166	1,000
Mali	126,000	1,142	144,000	815,000	728	594,000	580,000	868	504,000	343,000	131	45,000	568,000	244	139,000
Mauritania	6,000	500	3,000	2,000	500	1,000	90,000	233	21,000	132,000	128	17,000	250,000	348	87,000
Niger	11,000	636	7,000	3,136,000	418	1,311,000	1,107,000	320	355,000	321,000	109	35,000	528,000	250	132,000
Nigeria	1,058,000	970	1,027,000	1,773,000	1,569	2,783,000	2,280,000	1,620	3,694,000	1,862,000	221	412,000	1,258,000	239	301,000
Senegal	71,000	859	61,000	709,000	404	287,000	75,000	866	65,000	310,000	125	39,000	233,000	360	84,000
Sierra Leone	14,000	1,071	15,000	16,000	1,375	22,000	12,000	1,333	16,000	64,000	93	6,000	74,000	256	19,000
Togo	216,000	671	145,000	55,000	927	51,000	89,000	898	80,000	32,000	125	4,000	29,000	241	7,000
1984															
Benin	469,000	808	379,000	14,000	785	11,000	111,000	747	83,000	116,000	112	13,000	112,000	133	15,000
Burkina Faso	121,000	636	77,000	723,000	514	372,000	965,000	615	594,000	255,000	105	27,000	498,000	174	87,000
Cameroon	207,000	1,811	375,000	28,000	642	18,000	357,000	568	203,000	400,000	150	60,000	178,000	500	89,000
Chad	22,000	818	18,000	268,000	414	111,000	437,000	469	205,000	230,000	113	26,000	370,000	270	100,000
Côte d'Ivoire	595,000	873	520,000	63,000	650	41,000	37,000	621	23,000	315,000	136	43,000	130,000	115	15,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
The Gambia	9,000	1,444	13,000	33,000	1,181	39,000	7,000	1,142	8,000	34,000	117	4,000	28,000	178	5,000
Ghana	724,000	961	696,000	231,000	575	133,000	252,000	682	172,000	162,000	117	19,000	162,000	129	21,000
Guinea	90,000	1,111	100,000	38,000	1,500	57,000	22,000	1,363	30,000	125,000	104	13,000	231,000	186	43,000
Guinea Bissau	16,000	625	10,000	20,000	800	16,000	33,000	636	21,000	23,000	130	3,000	55,000	163	9,000
Liberia	0	0	0	0	0	0	0	0	0	18,000	111	2,000	6,000	166	1,000
Mali	89,000	1,146	102,000	910,000	557	507,000	387,000	956	370,000	470,000	121	57,000	490,000	244	120,000
Mauritania	6,000	500	3,000	5,000	600	3,000	87,000	287	25,000	121,000	132	16,000	190,000	347	66,000
Niger	9,000	333	3,000	3,026,000	254	771,000	1,098,000	214	236,000	200,000	120	24,000	320,000	300	96,000
Nigeria	1,050,000	1,139	1,196,000	2,133,000	1,570	3,349,000	2,827,000	1,629	4,608,000	1,945,000	219	426,000	1,270,000	239	304,000
Senegal	83,000	1,180	98,000	903,000	421	381,000	100,000	900	90,000	300,000	123	37,000	220,000	350	77,000
Sierra Leone	13,000	1,076	14,000	17,000	1,352	23,000	15,000	1,266	19,000	58,000	86	5,000	69,000	246	17,000
Togo	239,000	928	222,000	59,000	1,288	76,000	167,000	712	119,000	38,000	131	5,000	32,000	218	7,000
1985															
Benin	489,000	889	435,000	16,000	562	9,000	111,000	738	82,000	120,000	108	13,000	116,000	120	14,000
Burkina Faso	143,000	993	142,000	974,000	602	587,000	1,077,000	740	798,000	308,000	107	33,000	503,000	170	86,000
Cameroon	186,000	1,666	310,000	61,000	967	59,000	437,000	775	339,000	415,000	134	56,000	208,000	500	104,000
Chad	42,000	833	35,000	491,000	513	252,000	460,000	671	309,000	250,000	116	29,000	380,000	271	103,000
Côte d'Ivoire	533,000	900	480,000	66,000	606	40,000	36,000	611	22,000	320,000	137	44,000	135,000	118	16,000
The Gambia	17,000	1,529	26,000	50,000	1,100	55,000	13,000	923	12,000	36,000	111	4,000	30,000	166	5,000
Ghana	579,000	1,008	584,000	185,000	605	112,000	202,000	717	145,000	170,000	117	20,000	170,000	129	22,000
Guinea	90,000	1,111	100,000	39,000	1,487	58,000	23,000	1,391	32,000	130,000	100	13,000	225,000	186	42,000
Guinea Bissau	15,000	666	10,000	20,000	900	18,000	25,000	800	20,000	23,000	130	3,000	56,000	178	10,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Liberia	0	0	0	0	0	0	0	0	0	13,000	153	2,000	6,000	166	1,000
Mali	109,000	1,284	140,000	841,000	1,035	871,000	425,000	1,108	471,000	457,000	118	54,000	434,000	244	106,000
Mauritania	3,000	333	1,000	10,000	800	8,000	150,000	486	73,000	132,000	128	17,000	210,000	347	73,000
Niger	8,000	375	3,000	3,169,000	457	1,450,000	1,142,000	288	329,000	170,000	100	17,000	275,000	298	82,000
Nigeria	1,556,000	1,173	1,826,000	2,346,000	1,570	3,684,000	3,062,000	1,603	4,911,000	2,019,000	216	438,000	1,291,000	239	309,000
Senegal	101,000	1,455	147,000	1,146,000	670	768,000	190,000	957	182,000	300,000	123	37,000	220,000	359	79,000
Sierra Leone	13,000	1,076	14,000	17,000	1,352	23,000	18,000	1,111	20,000	58,000	86	5,000	69,000	246	17,000
Togo	200,000	910	182,000	66,000	1,121	74,000	146,000	650	95,000	39,000	128	5,000	30,000	233	7,000
1986															
Benin	443,000	853	378,000	28,000	642	18,000	111,000	801	89,000	119,000	109	13,000	114,000	131	15,000
Burkina Faso	165,000	939	155,000	1,171,000	580	680,000	1,330,000	760	1,011,000	325,000	104	34,000	508,000	171	87,000
Cameroon	202,000	1,925	389,000	59,000	1,237	73,000	511,000	1,058	541,000	468,000	113	53,000	213,000	497	106,000
Chad	45,000	777	35,000	508,000	543	276,000	470,000	636	299,000	350,000	148	52,000	390,000	269	105,000
Côte d'Ivoire	600,000	700	420,000	66,000	606	40,000	36,000	611	22,000	300,000	136	41,000	142,000	119	17,000
The Gambia	11,000	1,545	17,000	45,000	1,133	51,000	9,000	1,000	9,000	38,000	131	5,000	32,000	187	6,000
Ghana	472,000	1,184	559,000	156,000	705	110,000	176,000	727	128,000	170,000	117	20,000	170,000	129	22,000
Guinea	90,000	1,111	100,000	39,000	1,512	59,000	23,000	1,391	32,000	130,000	100	13,000	225,000	186	42,000
Guinea Bissau	13,000	769	10,000	20,000	900	18,000	25,000	800	20,000	24,000	125	3,000	58,000	172	10,000
Liberia	0	0	0	0	0	0	0	0	0	12,000	83	1,000	6,000	166	1,000
Mali	129,000	1,651	213,000	822,000	980	806,000	418,000	1,112	465,000	468,000	132	62,000	448,000	245	110,000
Mauritania	4,000	750	3,000	10,000	600	6,000	160,000	525	84,000	108,000	138	15,000	250,000	348	87,000
Niger	9,000	666	6,000	3,239,000	426	1,383,000	1,094,000	329	360,000	150,000	160	24,000	272,000	349	95,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Nigeria	1,723,000	1,006	1,735,000	2,618,000	1,570	4,111,000	3,347,000	1,620	5,425,000	1,981,000	142	283,000	1,316,000	239	315,000
Senegal	95,000	1,136	108,000	856,000	586	502,000	137,000	963	132,000	320,000	125	40,000	248,000	358	89,000
Sierra Leone	14,000	571	8,000	17,000	1,352	23,000	18,000	1,111	20,000	53,000	94	5,000	69,000	246	17,000
Togo	197,000	644	127,000	116,000	706	82,000	127,000	1,031	131,000	37,000	135	5,000	30,000	233	7,000
1987															
Benin	392,000	706	277,000	31,000	677	21,000	118,000	771	91,000	118,000	110	13,000	114,000	131	15,000
Burkina Faso	176,000	744	131,000	1,168,000	541	632,000	1,176,000	721	848,000	339,000	106	36,000	570,000	156	89,000
Cameroon	202,000	1,915	387,000	30,000	866	26,000	335,000	704	236,000	480,000	129	62,000	218,000	500	109,000
Chad	38,000	763	29,000	464,000	461	214,000	375,000	634	238,000	335,000	152	51,000	400,000	270	108,000
Côte d'Ivoire	643,000	676	435,000	68,000	602	41,000	37,000	621	23,000	270,000	137	37,000	147,000	122	18,000
The Gambia	13,000	1,153	15,000	44,000	1,136	50,000	9,000	777	7,000	42,000	119	5,000	35,000	171	6,000
Ghana	548,000	1,091	598,000	235,000	736	173,000	272,000	757	206,000	175,000	114	20,000	175,000	131	23,000
Guinea	90,000	1,000	90,000	35,000	1,514	53,000	20,000	1,400	28,000	130,000	100	13,000	225,000	186	42,000
Guinea Bissau	11,000	909	10,000	20,000	1,000	20,000	15,000	1,000	15,000	25,000	120	3,000	61,000	163	10,000
Liberia	0	0	0	0	0	0	0	0	0	12,000	83	1,000	6,000	166	1,000
Mali	118,000	1,516	179,000	782,000	887	694,000	491,000	1,044	513,000	470,000	129	61,000	459,000	244	112,000
Mauritania	2,000	500	1,000	20,000	350	7,000	116,000	775	90,000	110,000	136	15,000	253,000	351	89,000
Niger	14,000	571	8,000	3,017,000	330	997,000	1,342,000	272	366,000	150,000	200	30,000	292,000	369	108,000
Nigeria	1,134,000	1,261	1,430,000	3,829,000	1,019	3,905,000	3,179,000	1,715	5,455,000	1,920,000	139	267,000	1,342,000	239	321,000
Senegal	99,000	1,151	114,000	946,000	729	690,000	128,000	867	111,000	315,000	123	39,000	254,000	358	91,000
Sierra Leone	11,000	1,000	11,000	15,000	1,333	20,000	18,000	1,055	19,000	53,000	94	5,000	69,000	246	17,000
Togo	225,000	764	172,000	128,000	554	71,000	136,000	720	98,000	40,000	125	5,000	31,000	225	7,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
1988															
Benin	486,000	870	423,000	35,000	657	23,000	133,000	729	97,000	121,000	107	13,000	116,000	129	15,000
Burkina Faso	277,000	819	227,000	1,277,000	639	817,000	1,295,000	779	1,009,000	345,000	107	37,000	600,000	151	91,000
Cameroon	187,000	1,962	367,000	60,000	1,000	60,000	512,000	816	418,000	492,000	138	68,000	224,000	500	112,000
Chad	50,000	860	43,000	580,000	544	316,000	347,000	743	258,000	405,000	153	62,000	410,000	270	111,000
Côte d'Ivoire	659,000	698	460,000	70,000	614	43,000	38,000	631	24,000	270,000	137	37,000	159,000	119	19,000
The Gambia	13,000	1,230	16,000	44,000	1,090	48,000	8,000	875	7,000	46,000	130	6,000	39,000	179	7,000
Ghana	540,000	1,390	751,000	228,000	609	139,000	226,000	712	161,000	172,000	116	20,000	172,000	127	22,000
Guinea	90,000	788	71,000	32,000	1,500	48,000	18,000	1,388	25,000	130,000	100	13,000	225,000	186	42,000
Guinea Bissau	6,000	1,333	8,000	17,000	1,529	26,000	10,000	1,600	16,000	27,000	111	3,000	64,000	171	11,000
Liberia	0	0	0	0	0	0	0		0	9,000	111	1,000	6,000	166	1,000
Mali	143,000	1,503	215,000	1,196,000	836	1,000,000	679,000	989	672,000	500,000	130	65,000	474,000	244	116,000
Mauritania	11,000	636	7,000	13,000	538	7,000	164,000	658	108,000	113,000	141	16,000	260,000	350	91,000
Niger	10,000	500	5,000	3,518,000	501	1,766,000	1,475,000	379	560,000	160,000	181	29,000	329,000	370	122,000
Nigeria	1,556,000	1,336	2,080,000	4,349,000	1,180	5,136,000	4,247,000	1,220	5,182,000	2,008,000	117	236,000	1,376,000	239	329,000
Senegal	110,000	1,118	123,000	893,000	543	485,000	130,000	846	110,000	317,000	126	40,000	260,000	361	94,000
Sierra Leone	10,000	1,100	11,000	24,000	875	21,000	24,000	833	20,000	53,000	94	5,000	69,000	246	17,000
Togo	267,000	1,108	296,000	119,000	470	56,000	181,000	657	119,000	38,000	131	5,000	33,000	212	7,000
1989															
Benin	479,000	885	424,000	34,000	676	23,000	138,000	768	106,000	124,000	112	14,000	118,000	127	15,000
Burkina Faso	221,000	1,162	257,000	1,278,000	507	649,000	1,362,000	727	991,000	335,000	110	37,000	630,000	147	93,000
Cameroon	208,000	1,860	387,000	60,000	1,083	65,000	487,000	704	343,000	504,000	140	71,000	229,000	502	115,000
Chad	20,000	950	19,000	525,000	340	179,000	433,000	547	237,000	370,000	154	57,000	420,000	269	113,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Côte d'Ivoire	675,000	711	480,000	74,000	608	45,000	44,000	568	25,000	250,000	136	34,000	165,000	121	20,000
The Gambia	11,000	1,272	14,000	53,000	962	51,000	10,000	1,100	11,000	47,000	127	6,000	39,000	179	7,000
Ghana	567,000	1,261	715,000	244,000	737	180,000	286,000	751	215,000	170,000	117	20,000	171,000	128	22,000
Guinea	94,000	755	71,000	34,000	1,529	52,000	19,000	1,421	27,000	125,000	104	13,000	225,000	186	42,000
Guinea Bissau	10,000	1,000	10,000	18,000	944	17,000	12,000	750	9,000	28,000	107	3,000	68,000	176	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	166	1,000
Mali	175,000	1,285	225,000	1,083,000	777	842,000	774,000	944	731,000	530,000	130	69,000	483,000	244	118,000
Mauritania	4,000	750	3,000	28,000	500	14,000	147,000	755	111,000	117,000	136	16,000	273,000	351	96,000
Niger	4,000	750	3,000	3,566,000	373	1,333,000	1,617,000	260	422,000	170,000	176	30,000	344,000	380	131,000
Nigeria	1,600,000	1,332	2,132,000	4,000,000	1,192	4,770,000	4,954,000	975	4,831,000	2,396,000	90	218,000	1,417,000	239	339,000
Senegal	93,000	1,408	131,000	953,000	670	639,000	131,000	969	127,000	330,000	124	41,000	267,000	359	96,000
Sierra Leone	10,000	1,100	11,000	24,000	958	23,000	25,000	840	21,000	58,000	86	5,000	69,000	246	17,000
Togo	268,000	1,070	287,000	126,000	769	97,000	195,000	784	153,000	43,000	116	5,000	35,000	228	8,000
1990															
Benin	458,000	895	410,000	37,000	594	22,000	136,000	727	99,000	140,000	107	15,000	120,000	133	16,000
Burkina Faso	177,000	1,457	258,000	1,022,000	439	449,000	1,288,000	583	751,000	330,000	112	37,000	650,000	146	95,000
Cameroon	199,000	1,854	369,000	60,000	1,050	63,000	387,000	850	329,000	517,000	139	72,000	235,000	497	117,000
Chad	30,000	966	29,000	488,000	344	168,000	439,000	637	280,000	410,000	153	63,000	430,000	269	116,000
Côte d'Ivoire	691,000	719	497,000	76,000	618	47,000	45,000	577	26,000	227,000	136	31,000	178,000	101	18,000
The Gambia	11,000	1,272	14,000	51,000	921	47,000	13,000	615	8,000	48,000	125	6,000	40,000	175	7,000
Ghana	465,000	1,189	553,000	124,000	604	75,000	215,000	632	136,000	172,000	116	20,000	172,000	127	22,000
Guinea	90,000	866	78,000	20,000	2,000	40,000	24,000	1,000	24,000	127,000	102	13,000	228,000	184	42,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Guinea Bissau	13,000	1,076	14,000	20,000	850	17,000	13,000	846	11,000	30,000	100	3,000	71,000	169	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	166	1,000
Mali	170,000	1,158	197,000	1,213,000	607	737,000	809,000	656	531,000	550,000	129	71,000	500,000	244	122,000
Mauritania	4,000	750	3,000	12,000	250	3,000	91,000	505	46,000	122,000	139	17,000	278,000	348	97,000
Niger	6,000	333	2,000	4,606,000	241	1,111,000	2,238,000	125	281,000	212,000	150	32,000	350,000	400	140,000
Nigeria	1,500,000	1,221	1,832,000	4,350,000	1,180	5,136,000	4,000,000	1,046	4,185,000	2,444,000	83	204,000	1,464,000	239	351,000
Senegal	117,000	1,136	133,000	865,000	583	505,000	173,000	907	157,000	341,000	126	43,000	274,000	361	99,000
Sierra Leone	11,000	1,181	13,000	26,000	923	24,000	37,000	567	21,000	58,000	86	5,000	69,000	246	17,000
Togo	296,000	962	285,000	143,000	405	58,000	184,000	625	115,000	42,000	119	5,000	37,000	216	8,000
1991															
Benin	464,000	928	431,000	44,000	613	27,000	147,000	782	115,000	142,000	112	16,000	123,000	130	16,000
Burkina Faso	187,000	1,684	315,000	1,209,000	702	849,000	1,362,000	908	1,238,000	340,000	111	38,000	660,000	175	116,000
Cameroon	250,000	1,800	450,000	60,000	1,050	63,000	520,000	769	400,000	518,000	140	73,000	235,000	497	117,000
Chad	47,000	936	44,000	617,000	489	302,000	496,000	735	365,000	420,000	154	65,000	440,000	270	119,000
Côte d'Ivoire	684,000	752	515,000	80,000	612	49,000	45,000	600	27,000	239,000	138	33,000	188,000	95	18,000
The Gambia	17,000	1,176	20,000	56,000	1,035	58,000	13,000	923	12,000	47,000	127	6,000	39,000	179	7,000
Ghana	610,000	1,527	932,000	209,000	535	112,000	263,000	916	241,000	179,000	117	21,000	179,000	128	23,000
Guinea	90,000	944	85,000	10,000	2,000	20,000	19,000	1,000	19,000	133,000	97	13,000	236,000	186	44,000
Guinea Bissau	11,000	1,181	13,000	23,000	1,217	28,000	13,000	1,000	13,000	31,000	96	3,000	71,000	169	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	166	1,000
Mali	186,000	1,381	257,000	1,262,000	705	890,000	741,000	1,039	770,000	570,000	129	74,000	520,000	244	127,000
Mauritania	4,000	500	2,000	8,000	250	2,000	121,000	479	58,000	140,000	142	20,000	279,000	351	98,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Niger	2,000	500	1,000	4,390,000	417	1,833,000	2,176,000	212	463,000	215,000	158	34,000	370,000	400	148,000
Nigeria	1,550,000	1,225	1,900,000	3,000,000	1,165	3,497,000	4,000,000	1,086	4,346,000	2,506,000	81	205,000	1,514,000	237	360,000
Senegal	91,000	1,131	103,000	879,000	674	593,000	100,000	780	78,000	349,000	126	44,000	277,000	361	100,000
Sierra Leone	12,000	916	11,000	28,000	785	22,000	39,000	564	22,000	58,000	86	5,000	69,000	246	17,000
Togo	255,000	905	231,000	133,000	375	50,000	192,000	734	141,000	42,000	119	5,000	39,000	230	9,000
1992															
Benin	470,000	978	460,000	40,000	650	26,000	143,000	769	110,000	143,000	111	16,000	125,000	128	16,000
Burkina Faso	252,000	1,353	341,000	1,204,000	651	784,000	1,414,000	913	1,292,000	350,000	114	40,000	675,000	174	118,000
Cameroon	210,000	1,809	380,000	55,000	1,000	55,000	500,000	760	380,000	520,000	140	73,000	236,000	500	118,000
Chad	69,000	1,289	89,000	567,000	516	293,000	523,000	739	387,000	430,000	155	67,000	450,000	268	121,000
Côte d'Ivoire	650,000	827	538,000	85,000	600	51,000	48,000	583	28,000	249,000	136	34,000	200,000	100	20,000
The Gambia	12,000	1,500	18,000	41,000	1,121	46,000	13,000	923	12,000	48,000	125	6,000	40,000	175	7,000
Ghana	607,000	1,204	731,000	210,000	633	133,000	307,000	843	259,000	174,000	114	20,000	174,000	132	23,000
Guinea	90,000	1,044	94,000	5,000	2,000	10,000	14,000	928	13,000	140,000	100	14,000	250,000	184	46,000
Guinea Bissau	11,000	909	10,000	27,000	851	23,000	12,000	916	11,000	33,000	121	4,000	71,000	169	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	166	1,000
Mali	192,000	1,005	193,000	1,027,000	566	582,000	820,000	734	602,000	600,000	130	78,000	537,000	245	132,000
Mauritania	3,000	666	2,000	6,000	500	3,000	90,000	555	50,000	100,000	200	20,000	275,000	349	96,000
Niger	2,000	500	1,000	4,989,000	358	1,788,000	2,531,000	152	387,000	215,000	162	35,000	380,000	400	152,000
Nigeria	1,500,000	1,133	1,700,000	3,300,000	969	3,200,000	4,000,000	1,025	4,100,000	2,570,000	81	210,000	1,570,000	235	370,000
Senegal	105,000	1,095	115,000	774,000	576	446,000	131,000	893	117,000	352,000	125	44,000	280,000	360	101,000
Sierra Leone	13,000	846	11,000	28,000	857	24,000	40,000	550	22,000	58,000	86	5,000	69,000	246	17,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Togo	260,000	1,115	290,000	150,000	500	75,000	170,000	641	109,000	42,000	119	5,000	42,000	214	9,000
1993															
Benin	500,000	1,100	550,000	50,000	600	30,000	140,000	885	124,000	143,000	111	16,000	125,000	128	16,000
Burkina Faso	280,000	1,492	418,000	1,200,000	635	763,000	1,300,000	944	1,228,000	360,000	113	41,000	690,000	175	121,000
Cameroon	230,000	1,869	430,000	56,000	1,071	60,000	500,000	780	390,000	538,000	137	74,000	240,000	500	120,000
Chad	82,000	1,219	100,000	558,000	419	234,000	512,000	597	306,000	440,000	154	68,000	455,000	270	123,000
Côte d'Ivoire	650,000	830	540,000	85,000	611	52,000	50,000	600	30,000	250,000	136	34,000	208,000	100	21,000
The Gambia	16,000	1,250	20,000	52,000	1,019	53,000	15,000	800	12,000	48,000	125	6,000	40,000	175	7,000
Ghana	637,000	1,508	961,000	204,000	970	198,000	310,000	1,058	328,000	180,000	116	21,000	180,000	127	23,000
Guinea	90,000	1,055	95,000	5,000	2,000	10,000	10,000	1,000	10,000	145,000	103	15,000	256,000	183	47,000
Guinea Bissau	13,000	1,000	13,000	31,000	838	26,000	15,000	933	14,000	35,000	114	4,000	73,000	164	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	166	1,000
Mali	200,000	1,375	275,000	900,000	767	691,000	750,000	925	694,000	620,000	130	81,000	555,000	245	136,000
Mauritania	4,000	1,250	5,000	20,000	550	11,000	150,000	713	107,000	100,000	200	20,000	250,000	348	87,000
Niger	2,000	500	1,000	4,000,000	357	1,430,000	2,000,000	152	305,000	215,000	167	36,000	383,000	420	161,000
Nigeria	1,600,000	1,437	2,300,000	3,700,000	1,027	3,800,000	4,500,000	1,066	4,800,000	2,670,000	82	219,000	1,630,000	233	380,000
Senegal	110,000	1,136	125,000	978,000	671	657,000	128,000	765	98,000	358,000	125	45,000	287,000	358	103,000
Sierra Leone	14,000	857	12,000	30,000	866	26,000	42,000	571	24,000	58,000	86	5,000	69,000	246	17,000
Togo	340,000	1,155	393,000	140,000	535	75,000	190,000	663	126,000	42,000	119	5,000	43,000	232	10,000
1994															
Benin	481,000	1,023	492,000	37,000	680	25,000	145,000	778	113,000	143,000	110	16,000	125,000	130	16,000
Burkina Faso	218,000	1,604	350,000	1,312,000	634	831,000	1,549,000	796	1,232,000	360,000	110	40,000	690,000	175	121,000
Cameroon	223,000	2,018	450,000	50,000	1,000	50,000	480,000	729	350,000	550,000	136	75,000	245,000	500	123,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Chad	112,000	843	94,000	621,000	493	307,000	576,000	657	379,000	440,000	155	68,000	455,000	270	123,000
Côte d'Ivoire	685,000	755	517,000	120,000	679	81,000	52,000	599	31,000	290,000	137	40,000	131,000	165	22,000
The Gambia	11,000	1,262	13,000	50,000	1,061	53,000	8,000	1,056	9,000	48,000	120	6,000	40,000	175	7,000
Ghana	629,000	1,493	940,000	191,000	878	168,000	299,000	1,082	324,000	252,000	115	29,000	180,000	130	23,000
Guinea	88,000	999	88,000	7,000	727	5,000	6,000	636	4,000	115,000	100	12,000	250,000	185	46,000
Guinea Bissau	15,000	933	14,000	37,000	770	29,000	15,000	921	14,000	35,000	110	4,000	73,000	170	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	130	1,000
Mali	284,000	1,135	322,000	1,404,000	611	858,000	977,000	764	746,000	640,000	130	83,000	555,000	245	136,000
Mauritania	13,000	499	6,000	25,000	293	7,000	255,000	577	147,000	78,000	120	9,000	297,000	350	104,000
Niger	1,000	800	1,000	4,900,000	352	1,725,000	2,300,000	183	420,000	286,000	115	33,000	400,000	400	160,000
Nigeria	5,426,000	1,272	6,902,000	4,898,000	971	4,757,000	5,738,000	1,080	6,197,000	2,670,000	82	219,000	1,630,000	233	380,000
Senegal	107,000	1,013	108,000	936,000	585	548,000	142,000	931	132,000	365,000	125	46,000	287,000	360	103,000
Sierra Leone	10,000	896	9,000	31,000	849	26,000	29,000	843	24,000	58,000	90	5,000	69,000	250	17,000
Togo	324,000	833	270,000	120,000	375	45,000	155,000	549	85,000	42,000	125	5,000	43,000	225	10,000
1995															
Benin	481,000	1,023	492,000	37,000	680	25,000	145,000	778	113,000	143,000	110	16,000	125,000	130	16,000
Burkina Faso	218,000	1,604	350,000	1,312,000	634	831,000	1,549,000	796	1,232,000	360,000	110	40,000	690,000	175	121,000
Cameroon	300,000	2,180	654,000	90,000	1,111	100,000	530,000	804	426,000	560,000	134	75,000	250,000	500	125,000
Chad	112,000	843	94,000	621,000	493	307,000	576,000	657	379,000	440,000	155	68,000	455,000	270	123,000
Côte d'Ivoire	685,000	755	517,000	120,000	679	81,000	52,000	599	31,000	280,000	137	38,000	134,000	166	22,000
The Gambia	17,000	1,300	22,000	49,000	1,101	53,000	12,000	1,096	13,000	48,000	120	6,000	40,000	175	7,000
Ghana	670,000	1,555	1,042,000	225,000	892	201,000	360,000	1,085	390,000	252,000	115	29,000	180,000	130	23,000

Appendix 3 (cont'd)

	MZ AREA (ha)	MZ YLD (kg/ha)	MZ PROD (t)	ML AREA (ha)	ML YLD (kg/ha)	ML PROD (t)	SG AREA (ha)	SG YLD (kg/ha)	SG PROD (t)	MEAT (hd)	YL (kg/animal)	MEAT PROD (t)	MILK (hd)	YL (kg/animal)	MILK PROD (t)
Guinea	91,000	974	89,000	7,000	727	5,000	14,000	1,000	14,000	115,000	100	12,000	250,000	185	46,000
Guinea Bissau	15,000	1,003	15,000	38,000	911	35,000	17,000	927	16,000	35,000	110	4,000	73,000	170	12,000
Liberia	0	0	0	0	0	0	0	0	0	8,000	125	1,000	6,000	130	1,000
Mali	284,000	1,135	322,000	1,404,000	611	858,000	977,000	764	746,000	640,000	130	83,000	555,000	245	136,000
Mauritania	1,000	1,000	1,000	22,000	364	8,000	246,000	635	157,000	80,000	120	10,000	303,000	350	106,000
Niger	1,000	800	1,000	4,900,000	352	1,725,000	2,300,000	183	420,000	293,000	116	34,000	410,000	400	164,000
Nigeria	5,497,000	1,317	7,240,000	5,107,000	959	4,900,000	6,095,000	1,015	6,184,000	3,100,000	86	267,000	1,630,000	233	380,000
Senegal	98,000	1,088	107,000	891,000	748	667,000	148,000	858	127,000	368,000	125	46,000	287,000	360	103,000
Sierra Leone	8,000	939	8,000	30,000	793	24,000	26,000	848	22,000	58,000	90	5,000	69,000	250	17,000
Togo	350,000	846	296,000	120,000	375	45,000	155,000	549	85,000	42,000	125	5,000	43,000	225	10,000

MZ AREA = area planted to maize, ha
ML AREA = area planted to millet, ha
SG AREA = area planted to sorghum, ha
MEAT hd = cattle head
MILK hd = dairy herd

MZ YLD = average maize yield, kg/ha
ML YLD = average millet yield, kg/ha
SG YLD = average sorghum yield, kg/ha
YL = average meat per animal, kg/an
YL, average milk yield, kg/an

MZ PROD = maize production, t
ML PROD = millet production, t
SG PROD = sorghum production, t
MEAT PROD = meat production, t
MILK PROD = milk production, t

Source: FAO 1990–1998.

Appendix 4 Adoption of fodder bank technology by country and agro-ecological zone

(A) Humid zone

Year	Benin		Burkina Faso		Chad		Cameroon		Côte d'Ivoire		The Gambia		Ghana		Guinea	
	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha
1977																
1978																
1979																
1980																
1981																
1982																
1983																
1984																
1985													17	480		
1986							70	10								
1987							145	24								
1988							225	40								
1989							313	59								
1990							403	84					20	685		
1991							578	111								
1992							729	156								
1993							979	232								
1994							1280	313								
1995							1670	373								
1996							2120	423								
1997							2120	423					25	935		

Year	Guinea Buissau		Mauritania		Mali		Niger		Nigeria		Senegal		Togo	
	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha
1977														
1978														
1979														
1980														
1981														
1982													5	18
1983													23	40
1984									4	32			23	40
1985									7	56				
1986									10	74			23	40
1987									12	94				
1988									15	124				
1989									16	128				
1990									20	150				
1991									25	194				
1992									38	228			23	40
1993									38	228				
1994									38	228				
1995									38	228				
1996									38	228				
1997									38	228				

Note: Some of these adoption data were omitted from the impact analysis (see Chapter 5).

(B) Subhumid zone

Year	Benin		Burkina Faso		Chad		Cameroon		Côte d'Ivoire		The Gambia		Ghana		Guinea	
	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha
1977													22	660		
1978																
1979							1	10								
1980							1	13								
1981							1	13								
1982							6	15								
1983							6	15								
1984							6	15								
1985			30	45			7	16	42	210			21	1,310		
1986							7	16								
1987							7	16								
1988	20	10					7	16								
1989	200	100	900	1,350			9	19	50	290						
1990							9	19					36	1,890		
1991	500	250					9	19								
1992							9	19							1	5
1993	3,000	1,500					9	19			25	1			8	50
1994							9	19			75	1			21	145
1995							9	19	50	290	125	1			37	225
1996	10,000	5,000					9	19	106	850	325	1			57	345
1997							9	19	106	850	1,525	1,000	56	2540	82	495

Year	Guinea Buissau		Mauritania		Mali		Niger		Nigeria		Senegal		Togo	
	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha
1977					10	2								
1978														
1979														
1980					19	7								
1981					39	12								
1982					42	14								
1983					75	39			3	30				
1984					199	86			32	276			10	6
1985					382	137			52	430				
1986					500	208			70	591			43	27
1987					951	381			96	749				
1988									144	883				
1989									229	1,183				
1990									318	1,475				
1991					1,317	648			397	1,763				
1992	30	8							478	2,051			80	50
1993	30	8							521	2,217				
1994	38	10							534	2,283	23	9		
1995	45	10			1,421	700			548	2,302	28	11		
1996	61	11							576	2,439	35	14		
1997	73	12							589	2,467	37	15		

Note: Some of these adoption data were omitted from the impact analysis (see Chapter 5).

(C) Semi-arid zone

Year	Benin		Burkina Faso		Chad		Cameroon		Côte d' Ivoire		Gambia		Ghana		Guinea	
	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha	No.	ha
1977																
1978																
1979																
1980																
1981																
1982																
1983																
1984							1	1								
1985							1	1								
1986							1	1								
1987							4	2								
1988					11	8	4	2								
1989					23	17	4	2								
1990					54	41	4	2								
1991							4	2								
1992							4	2								
1993							4	2								
1994							4	2								
1995							4	2								
1996							4	2								
1997							4	2								

Year	Guinea Buissau		Mauritania		Mali		Niger		Nigeria		Senegal		Togo	
	No.	ha	No.	ha	No.	ha	No.	Ha	No.	ha	No.	ha	No.	ha
1977														
1978														
1979														
1980														
1981														
1982														
1983									12	10				
1984									152	41				
1985									355	73				
1986									535	149				
1987									798	195				
1988			600	150					995	346				
1989			1200	300					1273	593				
1990			1400	350					1969	891				
1991			2800	700			350	47	2806	960				
1992			3800	950					3125	1019				
1993			3900	975					3135	1065				
1994			3905	976			2800	373	3193	1113				
1995			3915	979					3358	1160				
1996			3935	984					3450	1196				
1997			3955	992					3539	1220				

Note: Some of these adoption data were omitted from the impact analysis (see Chapter 5).