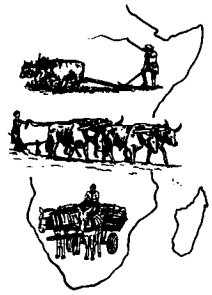
Improving animal traction technology



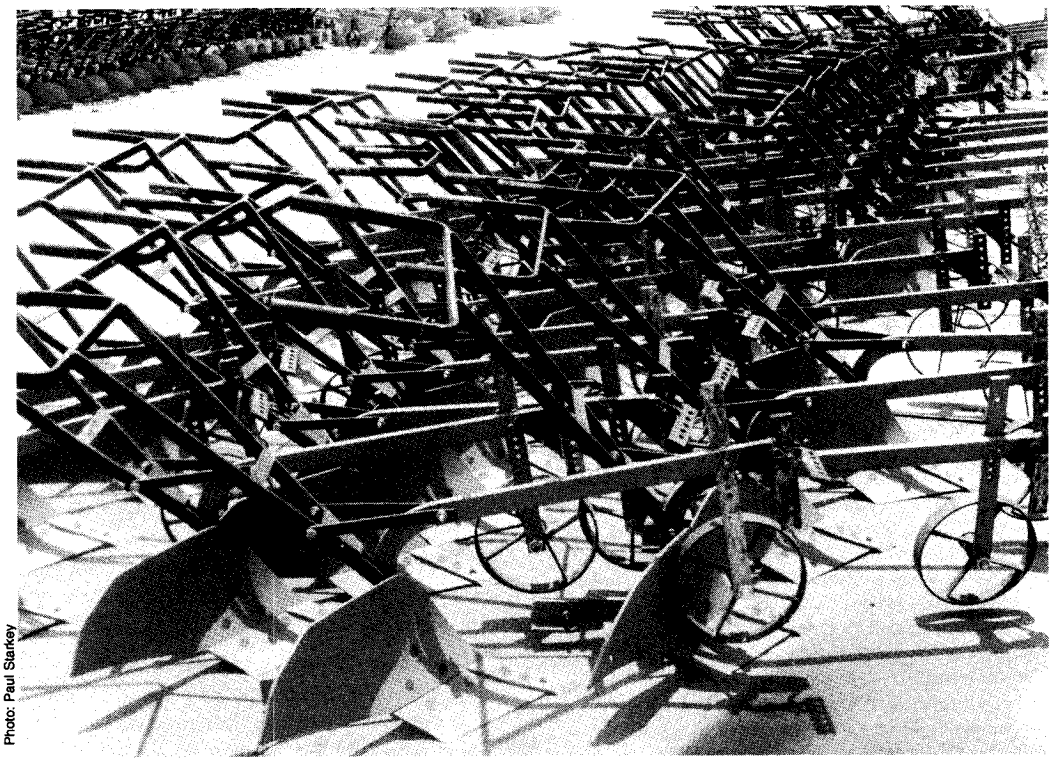


Photo: Paul Starkey

The supply and distribution of implements

Supply and distribution of implements for animal traction: an overview with region-specific scenarios

by

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Abstract

This paper reviews the region-specific needs for animal draft power implements, and the existing animal draft power supply and distribution systems, in West Africa and Zambia. The process of local development, manufacture and introduction of animal draft power in West Africa is highlighted, emphasising the need for local adaptation and diversification of the range of implements, in accordance with the type of draft animals available, the prevailing soil and agro-ecological conditions and the cropping and farming systems practised. The West African experience is considered highly relevant for Zambia (and other countries in eastern and southern Africa) where the lack of local adaptation and diversification of animal draft power equipment is a result of long-standing importation (mainly of plows, of various origins) and centralised (government/cooperative union) distribution.

A review of animal draft power implement supply and distribution scenarios illustrates the general failure of the centralised, top-down approaches followed by large-scale manufacturers and (parastatal) distribution agencies in both West Africa and Zambia. Present constraints on further development of animal draft power (particularly in Zambia) include poor profitability of small-scale farming, poor marketing and distribution and severe logistic and rural communication problems. The need for farmer-oriented, and thus area-specific, supply and distribution systems is stressed: these should include competitive local manufacture (including establishment of assembly workshops in the main animal draft power regions), linked with an effective private-sector marketing and distribution/after-sales service network in the rural areas (including involvement of rural blacksmiths).

Introduction

Animal draft power is recognised as the most viable technology for the development of the smallholder farm sector in most regions in Africa. In order to develop this technology successfully, a balance must be achieved between the farmers' needs (**demand**) and the **supply** of animal draft power equipment. This requires a **region-specific** approach which takes into account the diverse and changing agro-ecological and economic conditions.

Demand

Farmers' demand for animal draft power equipment reflects both the practical farm power requirements of the local environment, and the profitability of animal draft power farming.

In order to carry out the various farming operations using animal draft power, a range of implements is needed: the implements must be suitable for the types of draft animals available, the prevailing field and soil conditions and the farming and cropping systems practised. Successful introduction and use of animal draft power therefore requires:

- farmer awareness of existing and/or alternative animal draft power systems, implement designs and quality
- adequate communication with the supply side, in terms of effective feedback from the field on farmers' needs and on the acceptability of implements.

Applied research and development institutions, animal draft power extension services and area development programmes will all play important roles in meeting these requirements.

The profitability of animal draft power farming is mainly a function of economic and logistic factors which determine the number and range of the required animal draft power implements that can actually be marketed and bought. The prerequisites for profitability include:

- adequate agricultural product marketing and pricing policies (and credit facilities) which offer real incentives to produce food-crop surpluses and/or to incorporate cash crops into the cropping system
- timely availability of animal draft power equipment (and other production inputs) at affordable prices in the rural areas.

Supply

In the African context, local manufacture of animal draft power equipment is, to a large extent, based on

the selection and adaptation of designs and products originating from other regions with similar conditions. Adaptation of existing implements to meet the needs of local farmers requires adequate engineering knowledge and skills within the country. In particular, local manufacturers must be capable of undertaking design and construction adaptations and of initiating implement diversification. In some cases the establishment of local assembly or manufacturing facilities may require external assistance in the initial phase.

Local manufacture or assembly of animal draft power equipment must be competitive (implements must be of acceptable quality, and must be available when they are needed at prices which farmers can afford) and must be accompanied by adequate local supply and distribution systems and after-sales services, particularly for spare parts. Prerequisites for this include:

- government commitment and policy measures: tax and import duty system, foreign currency regulations in support of local manufacture
- a sound economic setting (adequate marketing and price policies) and stable markets (profitable small-scale farming).

Comparison of animal power demand in West Africa and Zambia

In many ways, the experience gained during 30 years of animal draft power development and related implement supply in West Africa appears relevant to the situation in Zambia (and other countries in eastern and southern Africa). Some of the similarities and differences in the conditions in which animal draft power is used in the two regions are outlined below.

Similarities

Small-scale farming in the areas of West Africa and Zambia that have 700–1200 mm of annual rainfall is characterised by highly variable environmental and soil conditions which require the supply of region-specific animal draft power equipment.

In both these 700–1200 mm rainfall areas, similar breeds and types of traditional draft cattle are used and cropping systems are dominated by upland cereals, such as maize, sorghum/millets, with groundnuts, wetland rice (in certain regions) and, to a varying degree, cash crops such as cotton.

Regional/integrated rural development programmes and societies play important catalytic or supporting roles in the development of animal draft power (particularly in new introduction areas with external assistance). A number of West African animal draft power regions benefit from pronounced support from cotton marketing agencies.

Differences

Zambia (with only 50–60% of its population living in the rural areas) can be characterised by its "empty countryside", with severe infrastructural, marketing, distribution, logistic and communication constraints. Comparable agro-ecological regions in West Africa (80–85% rural population) are more densely populated and have more roads, with cheap public/private transport services operating between the many villages.

In the drier areas of West Africa donkeys/horses are predominantly used, whereas the use of donkeys in similar dry areas in Zambia is only just emerging. In Zambia the use of two to three pairs of oxen pulling one plow is common, whereas in West Africa oxen are used only in single pairs.

In comparison with West African farm holdings, most Zambian rural areas appear to face more serious seasonal labour shortages as a result of smaller family sizes and of a larger proportion of households being female-headed.

With the present economic crisis, profitability of food crop production by small farmers in Zambia is under heavy pressure (low producer prices, difficult marketing, high inflation, limited credit availability). Zambia's animal draft power manufacturing and trading sector is facing serious raw material and hard currency constraints. Comparable agro-ecological regions in West Africa benefit in general from a more stable and favourable economic setting and a liberalised marketing and trading system (with, in some regions, cash crops such as cotton generating considerable revenues). Weekly markets exist in almost all villages in West Africa, and animal draft power is widely used for both on- and off-farm transport.

Animal draft power in West Africa

Equipment diversity in relation to animals used (with reference to Senegal)

In Senegal, the use of animal traction for field operations was introduced in the Groundnut Basin (see Figure 1a) as early as the 1930s. In this 500–800 mm rainfall area, where minimum tillage is the traditional practice, the use of imported one-row seeders, drawn by horses or donkeys, allowed timely and quick planting of groundnuts and traditional cereals.

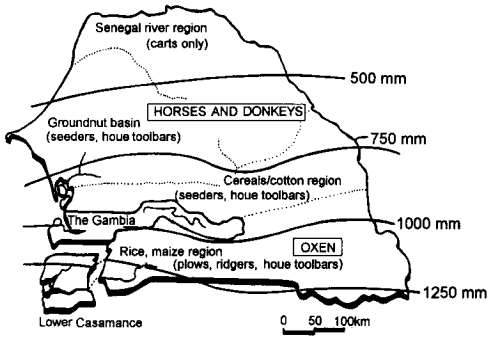


Figure 1a: Agricultural regions, annual rainfall zones and animal draft power systems in Senegal

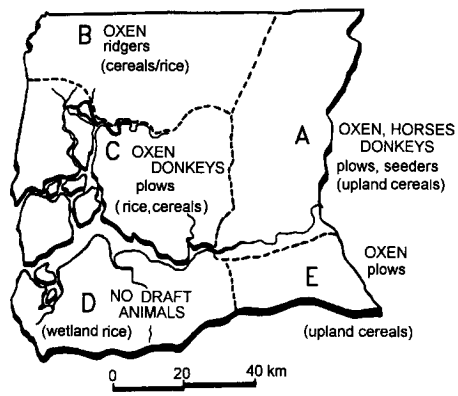
In the 1960s a massive rural development programme was implemented in this region. Foreign financial and technical assistance was provided for research and development of animal draft power equipment, for training and extension and for supply/distribution of agricultural inputs. In addition, seasonal and medium-term credit systems were set up, and local manufacture of implements was started with the establishment of the Siscoma factory in 1963.

This "crash" programme resulted in the local manufacture and introduction of large numbers of implements—20 000 to 30 000 units/year, enough for almost the entire horse/donkey population (Bordet et al, 1988). The *Super-Eco* one-row seeders, supplemented by light toolbars (*Houe Occidentale* and the heavier, more versatile *Houe Sine*) fitted with cultivator tines, weeding and groundnut-lifting devices proved to be perfectly adapted to the draft animals available.

In spite of considerable research and development efforts in the 1960s and 1970s, which resulted in a wide range and variety of implements, including those suitable for use with oxen, the introduction of animal traction in the more humid southern regions of Senegal proceeded at a much slower pace. Reasons for this included availability and costs of the oxen as well as animal husbandry and health considerations.

With the increased draft power of the oxen, plows and/or ridgers are used to an increasing extent in these 800–1200 mm rainfall areas, either as single-purpose implements or as part of the *Sine* and *Arara* toolbars.

In the 1960s a large variety of multipurpose implements were developed and manufactured in Senegal (Bordet et al, 1988).



	Percentage of farmers owning		
Agricultural zone	*Oxen*	*Horses*	*Donkeys*
A	68	18	8
B	17	–	2
C	10	–	9
D	1	–	–
E	12	–	–

Figure 1b: Area-specific animal draft power systems in Lower Casamance, Senegal (Source: Ndiamé, 1988)

The more complete, heavier and expensive wheeled toolcarriers (*Polyculteur* and *Tropiculteur*) and the Ariana type toolframes (basic frame supported by small wheels) did not receive spontaneous or widespread farmer acceptance. Although these implements are of high quality and are versatile and easy to use, their introduction remained limited to specific areas and intensive extension programmes only. This was due to:

- high investment costs
- multi-row cultivation techniques not being easily mastered by farmers (or animals)
- the requirement for properly cleared fields and strong animals
- in practice, incompatible timing of the use of different components (eg, plowing and ridging are overlapping operations).

The lighter and cheaper *Houe Sine* toolbars ("multiculteurs") with their range of cultivating, weeding, ridging and groundnut-lifting devices were, however, widely accepted in different West African regions because they were better adapted to less optimal field conditions, and suitable for a wider range of draft animals.

The example of the Lower Casamance region in southern Senegal (Figure 1b) shows that, even within a small region, introduction and use of animal power varies enormously, being dictated by

Table 1a: Typical animal draft power use in Lower Casamance, Senegal

	Cattle	*Horse/donkey*
Average yearly use (days)	32	22
Average yearly use (hours)	154	62
Percentage of time spent on:		
Ridging	32%	0%
Plowing	21%	0%
Seeding	21%	64%
Weeding	0%	23%
Transport	0%	13%
Renting out	26%	0%

Table 1b: Additional uses of experienced animals (after 3 years) in Lower Casamance

Animal type	*Young animals*	*Experienced animals*
Cattle	plowing/seeding	also ridging
Horse/donkey	mainly transport	also seeding/weeding

Source: Sonko (1985)

type and availability of draft animals and cropping and farming systems practised.

Table 1 illustrates that the types of field operations carried out in this region vary according to:

- the draft animals available: primary tillage operations, such as plowing or ridging, are done by oxen, and seeding and weeding operations by horses/donkeys
- the experience/age of the animals: row cultivation (seeding, ridging and weeding) requires trained animals.

As well as field operations, horses and donkeys (and to a lesser extent oxen) are widely used for on- and off-farm transport all over Senegal (see Figure 2). Locally manufactured simple high-platform carts, based on imported conventional roller bearing/axle assemblies, are used in large numbers.

Figure 2: Evolution of the use of animal draft power implements in Senegal (Harvard and Faye, 1988)

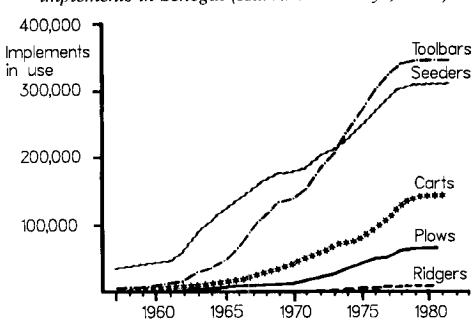


Figure 2 also illustrates that the termination of the massive rural development programmes around 1980 (resulting in suspension of the parastatal supply and credit structure and closing of the Siscoma factory), had an important impact on the further expansion of animal draft power in Senegal.

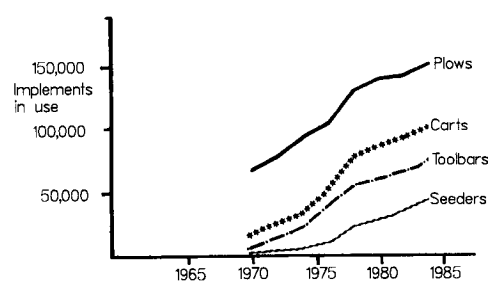
Towards the end of the 1980s, the use of animal draft power in Senegal stabilised at the level of some 200 000 horses, 200 000 donkeys and 140 000 oxen (Havard and Faye, 1988).

Diversity of equipment in relation to farming systems (with reference to Mali)

The pattern of the introduction of animal draft power in Mali was different from that in Senegal (see Figures 2 and 3). One reason for this is the difference in availability of draft animals: because there is a long-standing tradition of cattle holding in Mali, oxen are predominantly used for farm operations there. By 1957, 40 000 work oxen were already being used in Mali, compared with only 2000 in Senegal (Bordet et al, 1988). Use of donkeys in Mali is mainly limited to transport and to seeding/weeding operations in the groundnut region.

Another reason is that important integrated rural development programmes have been implemented in the different agro-ecological regions of Mali (see Figure 4a). With foreign (French and later multi-donor) assistance, two rural development societies played, and still play, an important role in the development of region-specific animal draft power-based farming-systems in Mali. One is the Office du Niger which, since 1957 (when tractorised tillage ceased), has introduced oxen for plowing and harrowing in a 50 000 ha area of wetland rice production. The other is CMDT (Compagnie Malienne pour le Développement des Textiles), the cotton development authority in southern Mali, which supports the development of cotton-based

Figure 3: Evolution of use of animal draft power implements in Mali (Source: Zerbo and Kantao, 1988)



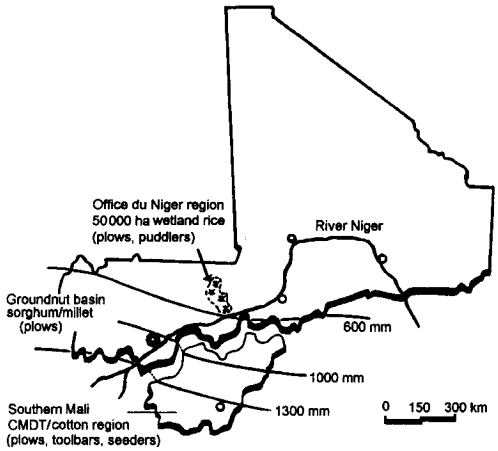


Figure 4a: Agricultural regions and animal draft power introduction in Mali

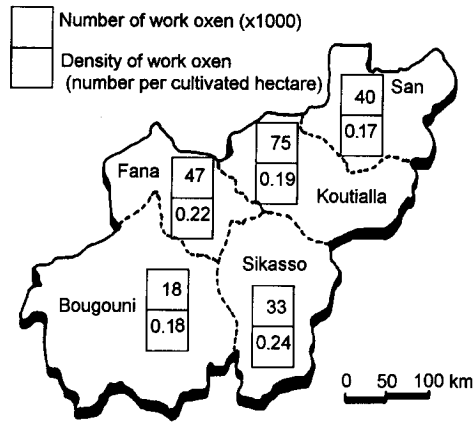


Figure 4b: Animal draft power in southern Mali

farming systems. The cotton marketing structure of CMDT has an important influence on the profitability of animal draft power based smallholder farming. By providing support for, research, training and extension programmes, input supply and distribution systems, including seasonal and medium-term credit for production inputs (such as animal draft power equipment), rural blacksmith programmes (training and implementation), marketing and processing systems, and regional assembly workshops (since 1986), these autonomous parastatal societies achieved the introduction of a range of region-specific animal draft power implements.

Categories and sources of animal power equipment

The supply of animal draft power implements was initially based on importation of different makes of plow from France. After the establishment of the parastatal Smecma factory in Bamako in 1974, one make of plow (the relatively lightweight *Bajac TM* plow, originally designed for use in the uplands) continued to dominate the market, supported by government directives for standardisation (Bordet et al, 1988). Until 1985 this same plow model was also most common in the heavy clay rice-growing regions. Following the example of Senegal, *Super-Eco* seeders and *Sine* toolbars (with cultivator, weeding and ridging devices) were subsequently manufactured for distribution in the southern region.

Starting in 1986 local manufacture and assembly of animal draft power equipment was to an increasing extent shifted to the main agricultural regions. Autonomous workshops were established by the Office du Niger and the CMDT, in order to more adequately cater for the specific needs of the farmers in these regions. This has resulted in new designs of plows and harrows, better adapted to the heavier soils in the rice-growing area of the Office du Niger. More recently, in answer to the large-scale adoption of rice transplanting practices, animal-drawn puddlers and levelling boards for wetland tillage have also been developed and manufactured locally. Another aim of the workshops was to assist in the further development of rural blacksmiths in these regions. The blacksmiths participate in spare-part supply and distribution, offer repair services to the farmers and are involved in village level local manufacturing initiatives.

Large numbers of carts have also been introduced in all areas of Mali. Mainly designed to be pulled by donkeys, they are simple platform carts based on conventional roller bearing/axle assemblies. They are manufactured locally, not only by Smecma, but also, to an increasing extent, by rural and urban workshops in the regions.

Importance of cash crops for animal draft power

Experience with the introduction of animal draft power in Senegal, Mali and other countries in West Africa demonstrates the importance of cash crops in achieving a profitable animal draft power based farming system. Integrated rural development programmes and societies operating in such regions play an essential catalytic and supporting role through:

- marketing and price guarantees by the concerned development societies and marketing and trading partners
- infrastructural support and services, including training, extension and the supply and

distribution of various essential production inputs (seed, fertiliser, etc)

- regular supply (recently based on on-the-spot manufacture and assembly) and distribution of animal draft power implements (with or without medium-term credit), including after-sales service provisions (spare-part supply, rural blacksmith programmes).

Figure 4b shows that the density of animal draft power use varies among the different districts in southern Mali. In this region cotton cultivation increased from 40 000 ha in 1958 to 140 000 ha in 1986, average cotton yields being 200 and 1200 kg/ha respectively (Bordet et al, 1988).

The percentage of farms that have adopted animal power for their field operations varies from roughly 80% ("nearing saturation") in the more advanced areas, such as parts of Koutilla and Sikasso (Sangaré et al, 1988), to between 33 and 57% in the more recently supported Bougouni region.

Undeniably, the availability of medium-term credit for purchasing work oxen and implements plays an essential catalytic role, particularly in new animal draft power development areas. However, farmer initiatives and cash purchases still remain the most important method of acquiring oxen and implements, also in the traditional CMDT supported regions.

Table 2 shows that, for an "old" CMDT area in Sikasso district, most of the "traditional" implements (plows, harrows and carts) have been acquired by cash purchase. Credit support proved especially important for the "second phase" diversification of animal draft power, with about 50% of the toolbars and seeders being obtained on credit (Whitney, 1981).

Similar observations can be made for Bougouni region, where support has been provided more recently by CMDT. In three years of support so far, only 11% of the farms have had access to credit:

Table 2: Method of acquisition of animal draft power implements (case study of Bambadougou villages, Sikasso, 1978)

Implement	*Cash purchase*	*Government credit*
Plows	80%	20%
Toolbar (ridger/weeder)	50%	50%
Harrow	100%	0%
One-row seeder	43%	57%
Ox cart	63%	37%
General average	65%	35%

96% of the plows in use have been purchased on a cash basis, but about 20% of the work oxen and toolbars in use were more recently obtained on credit.

In general, cultivation of a cash crop, such as cotton, requires more attention and is more labour intensive than the growing of traditional cereal crops (millet, sorghum and maize). Incorporation of cotton in a cropping pattern in this region therefore provides an additional incentive to diversify and intensify the use of animal draft power on a farm, in order to be able to extend the cultivated area: as well as plowing and ridging, oxen are used more for weeding and seeding operations.

Table 3 illustrates this more intensive and diversified use of animal draft power implements in the case of cotton growing.

Implement diversification according to soil conditions, farm size and cropping systems

Plowing versus reduced tillage practices

In many regions in West Africa, animal draft power based tillage systems (and related implements) are to a large extent determined by the prevailing soil and climatological conditions.

The customary zero and minimum tillage practices applied in the 700–1000 mm rainfall regions (such as in Senegal, with direct seeding and direct ridging of the lighter soils) reflect the prime importance of **timely** and quick interventions at the start of the short rainy season. The more time-consuming full-field plowing is hardly practised at all, in spite of extensive research and extension efforts in these regions (and in spite of proof that better water conservation and deeper rooting of the crops leads to increased yields). For the same reasons of timeliness and speed of crop establishment, direct or split ridging is the most common primary tillage technique in the main animal draft power region of Togo, as shown in Table 4 (Sabi, 1990)

Table 3: Animal draft power use in relation to crops cultivated, CMDT region, Mali

	Percentage of farmers using implements		
Implement	*Cotton*	*Millet/ sorghum*	*Maize*
Plows	89	50	35
Seeders	50	18	16
Toolbar (weeding)	86	33	27
Toolbar (ridging)	58	17	19

Table 4: Typical animal draft power operations in Togo in 1987

	Savanna Region	*Central Region*
Average farm size (ha)	8	34
Area of cash crops	30%	23–34%
Principal crops (ha)		
Maize	–	1.65
Cotton	1.0	0.60
Sorghum/millet	5.0	0.50
Groundnut	1.5	–
Field operations (% of farmers)		
Plowing	3	96
Ridging	97	4
Weeding	67	30

Source: Sabi (1990)

The same applies to many other 700–1200 mm rainfall areas in West Africa (including parts of Mali) where, as well as ridgers, standard plows are also used to split old ridges or to form back furrows (leaving 50% of the land untouched). In Nigeria the *Emcot* ridger has been widely accepted by farmers since the 1940s because of its simple and durable construction and its multipurpose use for direct ridging, split-ridging, re-ridging, weeding and even groundnut-lifting (Gwani, 1990).

More time-consuming full-field plowing, enabling complete inversion of the arable layer, appears only justified, from the farmers' point of view, in heavier soils and higher rainfall areas because of the need to bury abundant weed infestations: a well designed plow is, without doubt, the most effective implement for controlling weed growth.

Animal draft power supplementing family labour

It is widely accepted that the introduction of animal draft power enables farmers to extend their cultivated area. Generally, adoption of animal draft power follows a step-by-step approach, whereby the need for a more diversified range of animal draft power equipment seems directly linked with the amount of family labour available on the farm. Animal draft power is merely supplementing the available human labour force, in the first instance by alleviating labour/time constraints for the primary tillage operations. Extension of the "plowed" area, however, will soon be limited by labour constraints for the subsequent weeding and other crop husbandry operations. In a second phase, the need for a more diversified and intensive use of the available draft animals will grow with a gradual adoption of seeding, ridging and/or weeding implements.

Experience demonstrates that farmers are seldom able to acquire the whole package of animal draft power implements in one go (even if adequate credit is available), so credit schemes should consider gradual, step-by-step introduction as the most viable approach.

The interaction between larger family sizes and more intensive and diversified use of animal draft power with a related range of implements is clearly demonstrated by a case study in southern Mali (Whitney, 1981). Table 5 illustrates that the introduction of a more or less diversified range of animal draft power implements is merely supplementing the existing labour force. The use of plows (80% purchased on a cash basis) for primary tillage increased not only the cultivated area per farm but also the area per active worker available. However, further increase in the cultivated area (including the incorporation of more labour-intensive cash crops in the cropping pattern) appears possible only if the use of a more diversified package of animal draft power implements (average 50% purchased on a credit basis) can be matched by an increased availability of family labour.

A similar relationship between the size and wealth of a farm and the number and range of animal draft power implements used (and area of cash crops

Table 5: Animal draft power equipment in relation to available family labour and cultivated area (case study of Bambadougou villages, Sikasso, 1978)

Categories of farmers	*Cultivated area per family (ha)*	*Active workers per family (persons)*	*Area per active worker (ha/person)*
Non-equipped farmers	2.8	5.4	0.51
Farmers owning one plow	4.9	7.2	0.78
Farmers owning complete package[1]	13.0	16.5	0.73
Average	5.8	9.6	0.64

[1] *Package includes plow, toolbar, seeder, harrow and ox cart*

Table 6: Average cultivated area of crops on large and medium farms in Gladié village, southern Mali

Categories of farmers and animal power use	*Average cultivated area per farm (ha)*			
	Cotton	*Millet/maize*	*Sorghum*	***Total***
Large farms using 5 pairs of oxen with 2 plows, 1 toolbar, 1–3 one-row seeders, 1–2 harrows and 1 ox cart	9.0	7.7	5.7	**22.4**
Medium farms using 1–2 pairs oxen with 1 plow and 1 toolbar, no seeder, no harrow and no ox cart	2.9	2.3	9.0	**14.2**

Table 7: Cropping pattern in relation to farm size and animal draft power equipment available (case study of Bambadougou villages, Mali)

Categories of farmers	*Family food*[1] *(ha/family)*	*Cash crops*[2] *(ha/family)*	*Personal*[3] *(ha/family)*	***Total (ha)***
Non-equipped	2.14 (77%)	0.22 (8%)	0.42 (15%)	**2.78**
Plow only	3.69 (75%)	0.44 (9%)	0.78 (15%)	**4.91**
Well equipped	8.63 (66%)	1.78 (14%)	2.62 (20%)	**13.03**
Average	4.12 (71%)	0.65 (11%)	1.04 (18%)	**5.81**

[1] *Millet/sorghum, maize and rice*
[2] *Cotton, sesame, sweet potatoes and tree crops*
[3] *Women's rice fields and vegetable gardens*

cultivated) was demonstrated by another case study in southern Mali (see Table 6).

These and other studies reveal that an increase in cultivated area cannot simply be considered as the effect of the introduction of animal draft power as such. Instead they indicate that the need for (and the ability to correctly manage) additional ranges of animal draft power implements is to a large extent determined by traditional differences in general "wealth" among farmers within a particular area. "Wealth" is here expressed in terms of number of cattle owned, access to more and better permanent land and the size of the family, particularly number of women and older children present.

Effect of animal draft power on cropping systems

Table 7 illustrates, for the same categories of farmers in southern Mali, that those with larger and better-equipped farms are able to attach relatively more importance to cash crops. The more intensive use of draft animals with a more diversified range of implements helps to alleviate the peak labour bottlenecks in the weeding season, allowing the women to extend their personal rice area and vegetable gardens (Whitney, 1981).

The same study reveals that there is a marked impact of the more diversified use of animal draft power on the applied tillage and cropping systems and field size. Table 8 shows that:

- farmers equipped with animal draft power cultivate larger fields and more fields; they are able to carry out the field operations with greater speed and efficiency
- farmers who only own plows continue to practise the traditional intercropping systems (millet/sorghum intercropped with maize, beans, groundnuts) in which the cereals are planted on the ridges made by the plow (cotton and rice being cultivated in pure stands)
- farmers who also own seeders and toolbars practise more monocropping (even of the traditional millet/sorghum crop) because they own weeding/ridging implements.

In general, the well-equipped farmers benefit also from better timeliness of cultivation (planting and

Table 8: Effects of animal draft power equipment use on cropping pattern and field size (case study of Bambadougou villages, Mali)

Categories	*Number of fields per farm*	*Average field size (ha)*	*Percentage pure stand all crops*	*Percentage pure stand of millet and sorghum*
Non-equipped	4.8	0.58	51	26
Plow only	6.6	0.74	57	20
Well-equipped	14.5	0.90	84	67

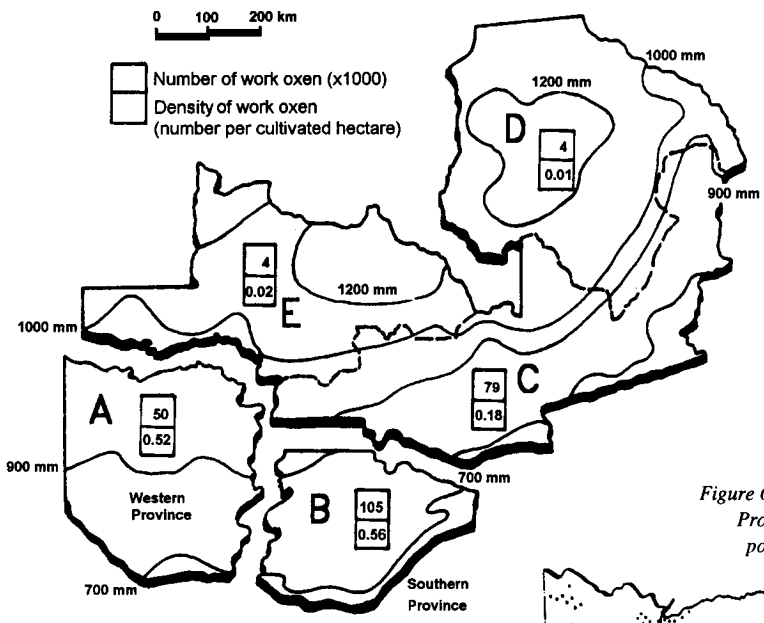


Figure 5: Zambia showing rainfall pattern, numbers of work oxen and density of work oxen

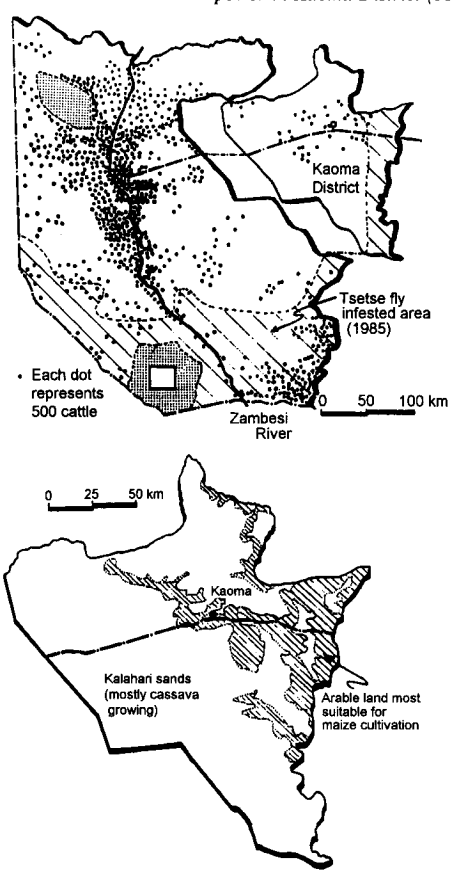


Figure 6: Cattle distribution in Western Province, Zambia (top) and animal power in Kaoma District (bottom)

weeding) and easier transport by carts of their farm inputs (including manure) and produce.

Animal draft power introduction in Zambia: current trends and needs

Regional introduction of animal draft power

The use of animal draft power in Zambia has always been (and still is) largely confined to those regions having a long-standing tradition of cattle holding, in particular the Western and Southern Provinces (see Figure 5). These two provinces have the highest densities of work oxen per cultivated hectare (MoA, 1985; Starkey, Dibbits and Mwenya, 1991), although within them the distribution of work oxen is very uneven.

Distribution of work oxen is largely determined by the traditional availability of cattle and region-specific animal health constraints. Figure 6 illustrates the low density of work oxen in the relatively new settlement areas of Kaoma District in Western Province (0.13 per hectare, compared with 0.52 per hectare for the whole of the province). Considering its high potential for increased food crop production (and export to the urban regions), supply and distribution of both work animals and implements has a particularly high priority in this district.

This uneven distribution and ownership of cattle resulted in an important need for ox hiring in most regions of Zambia, 20–30% of farmers relying on

	Kaoma District	*Western Province*
Cultivated area (ha)	22 700	97 000
Trained oxen	2 900	50 000
Trained oxen per ha	0.13	0.52

hiring of oxen for, often delayed, plowing (Tembo and Rajeswaran, 1989).

Table 9 illustrates that, in Kabwe region, farmers relying on ox hiring are in a much weaker position than ox owners, in terms of both cultivated area and available cattle and labour force (Baker and White, 1983).

In most other provinces of Zambia there is little or no tradition of cattle keeping. Introduction of animal draft power is thus a slow and difficult process which requires considerable investment and development efforts in the areas of animal husbandry and health, general extension and training, marketing and distribution and credit.

As in West Africa, regional integrated rural development programmes (with foreign financial and technical assistance) have to play an important initiating role in the development of animal draft power in new introduction regions of Zambia. Compared to West Africa, however, the development of animal draft power (and of smallholder farming in general) in Zambia appears severely constrained by a number of socio-economic and logistic conditions (particularly at the present time).

First, farming is not very profitable: producer prices for maize and other food crops are low, and in most regions there is no real cash crop. Figure 7 illustrates the high relative investment costs of work oxen and implements in Zambia (expressed in kg maize equivalent) compared with some other African countries.

Second, high inflation and price/marketing policies make it impossible to implement realistic credit schemes.

Third, low rural population densities result in seasonal labour shortages in the rural areas (characterised by a relatively high percentage of female-headed households).

Fourth, poor rural communications in the "empty" countryside result in logistic and economic constraints in terms of marketing and distribution of production inputs (including animal draft power equipment) and of provision of adequate after-sales

Table 9: Case study of ox hirers and ox owners in Kabwe region in 1981

	Ox hirers	*Ox owners*
Active workers per household (aged 15–55 years)	2.9	3.9
Average cultivated area (ha)	2.7	3.7
Average number of cattle	1.6	17.0

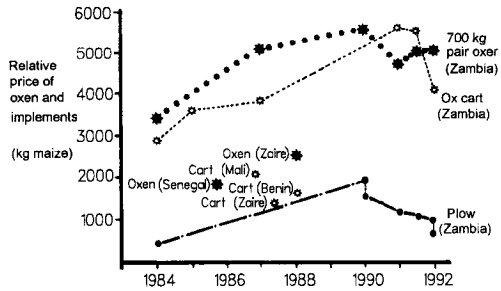


Figure 7: Relative animal draft power investment costs in Zambia, with some comparisons from other countries (Comparison sources: Kabeya, 1990; Kokoye, 1990)

service support (including supply constraints of rural workshops and blacksmiths).

Sources and diversity of animal draft power equipment

Compared to the situation in most West African regions, the introduction of animal draft power equipment in Zambia can be characterised by a lack of diversification of animal draft power tillage practices (and related implements). Essentially one type of plow is being used all over Zambia, and introduction of ridgers and cultivators has been limited. The use of ox carts for transport is also poorly developed.

This lack of diversity has arisen as the result of long-standing importation (even after the establishment of the first local manufacturer in 1978) of batches of implements of various origins, supplied and distributed through government and parastatal trading and distribution agencies (see Figure 8).

In the central planning, "top-down" approach followed, little attention is given to adequately assessing region-specific requirements of the farmers, nor are private-sector trading and manufacturing initiatives being promoted in the different regions in order to develop equipment (adapt imported implements) and to establish a proper distribution and after-sales service network.

In Zambia, as in West Africa, a certain degree of diversification in the use of animal draft power (and related equipment) appears called for, taking into account the diverse soil conditions and different farming systems practised throughout the country.

Primary tillage operations

In many regions of Zambia conventional full-field plowing is, without doubt, the most appropriate technique for controlling the abundant weed growth

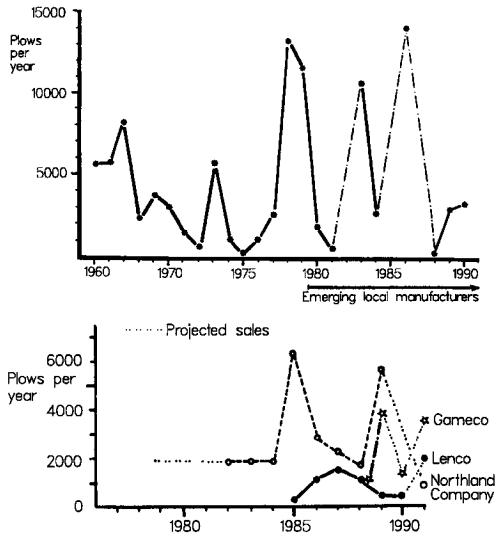


Figure 8: Annual plow inports (top) and local plow production and sales (bottom) in Zambia

at the start of the rainy season. It is questionable whether one single plow design is equally appropriate for all the different conditions of use throughout the country: considering the enormous variety in soil type (from light/sandy soils to heavy and often not properly cleared soils) and draft power availability (from one to three pairs of oxen used in plowing), there appears to be room for several different plow designs in Zambia. On the other hand, the need for better timeliness and speed of crop establishment, especially in the drier regions which have lighter soils, may, as in similar agro-climatological regions in West Africa, provide a real incentive for farmers to investigate the use of alternative tillage practices, such as direct ridging and/or split ridging techniques, which are better adapted to the conditions and hence less time-consuming.

Other animal draft power field operations and rural transport

In most rural regions in Zambia, there appears to be an important need to supplement the limited family labour available, particularly for weeding. Table 9 shows that family sizes in Kabwe region are very small—only three or four active workers per household. An animal draft power survey in Southern Province (Tembo and Rajeswaran, 1989) revealed an important variation in family size and in the number of active workers available on the farm. Families have, on average, seven workers, of which at least two-thirds are female; only a few younger men are available.

Under these circumstances a serious labour shortage occurs during the peak weeding season, and so there is an important need for weeding/ridging implements to help to alleviate this bottleneck. Similar needs are also evident in other regions of Zambia, such as the new settlement areas in Kaoma District. In the past, however, only a limited number of weeding and ridging implements have been imported or manufactured locally. Moreover, most cultivators and ridgers offered to the farmers in the past were heavy and expensive (especially when compared to the designs common in West Africa). In addition, some of these implements, depending on their origin, show more or less serious design shortcomings and construction compromises.

Where transport is concerned, there is an obvious need (and market) for locally made ox carts, particularly considering the recently more liberalised marketing, trading and local processing initiatives in the rural areas. Some alternative axle/bearing and wheel designs may continue to be of relevance for small-scale manufacture of ox carts in specific areas in Zambia (in relation to technical assistance and manufacturing skill available). On the whole there appears to be a big demand for conventional axle/roller bearing assemblies and pneumatic tyres, to be fitted locally with wooden bodies. Farmers' preferences in this direction are evident (as they are in the rest of Africa), and the unavoidable tyre punctures are not considered a major constraint.

Animal draft power supply and distribution: West Africa and Zambia

Relevance of West African experience

As far as the development, manufacture, supply and introduction of adapted animal draft power equipment is concerned, many West African regions have a lead of some 15 years of relevant experience over Zambia. Already in the 1950s and 1960s important animal draft power research, development and extension efforts in Senegal resulted in a wide range of region-specific implement designs. Over the years, small-scale farmers and manufacturers in other West African regions have subsequently chosen, adopted and fully accepted some of the equipment designs proposed. For comparable agro-ecological regions in Zambia, local adaptation/manufacture of relevant West African designs may constitute a valuable starting point to effectively initiate a more diversified use of animal draft power.

In West Africa, large-scale local manufacture by central (parastatal) companies started as early as

1963 (Senegal) and 1974 (Mali). Raw materials and implement components were supplied from France, with a varying but often low locally added value (eg, Smecma in Mali). Because of declining markets and a distinct over-capacity of manufacturing facilities established in the region on the whole, these centralised manufacturers started to face serious financial problems in the 1980s, resulting in suspension of production. This situation was the result of several factors:

- the "saturation effect" after the initial "crash" programmes of large-scale introduction in the 1970s
- the breaking-down of the (parastatal) supply, distribution and credit system
- increased competition from more effective and better placed regional/rural workshops, including blacksmiths' manufacturing initiatives.

In other West African countries (such as Burkina Faso, Niger and Togo) smaller (both private and parastatal) workshops have been established closer to the main animal draft power regions. These workshops took advantage of earlier experience of implement development and manufacture from Senegal by selecting and adapting existing designs to suit local conditions of use. In line with government policies to implement rural development "from the bottom up" and to promote private sector initiatives (instead of previous central planning and "top-down" approaches), regional assembly and manufacturing workshops were established in the 1980s in the heart of the main agricultural regions in Mali. These autonomous regional workshops are in the position to assure a timely supply and distribution of a range of implements specifically adapted to the regions concerned, involving and supporting rural blacksmith workshops.

Along with local manufacture, blacksmith training and support programmes have been implemented since the 1970s in most West African countries. Relatively dense networks of rural blacksmiths (in Mali: associations) are to an increasing extent able to serve farmers' needs in terms of implement repair and manufacture and supply of spare parts. In more advanced regions, blacksmiths' workshops are able to supply local farmers with complete (simple) implements; the quality is moderate to poor, but the prices are distinctly lower.

Scenario A: Supply relying on importation

Recent experience in Zambia represents a supply scenario biased towards imports. Following a "top-down", central planning approach involving mainly parastatal agencies and international tenders, bulk supplies of implements of different origins and varying designs and quality are obtained. This is illustrated schematically in Figure 9.

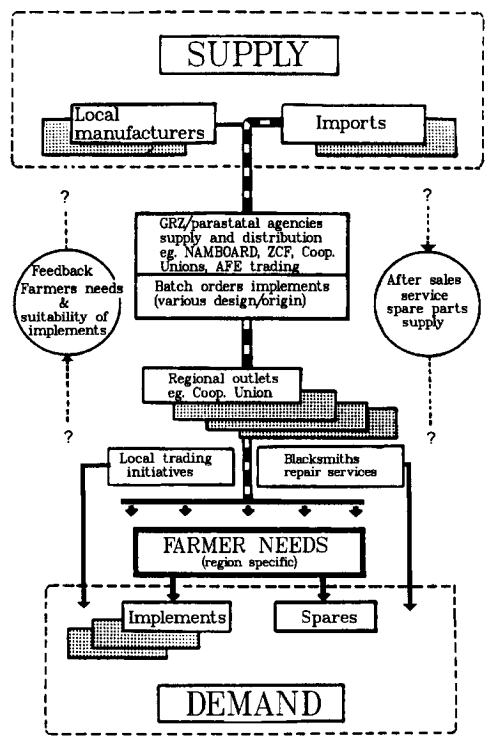
Constraints to relying on imports to satisfy demand for animal draft power implements arise from the risks that:

- implements supplied to farmers will be, at best, poorly adapted to local conditions, and farmers will have no choice of implements
- few efforts are made to take account of region-specific farmers' needs or to diversify the use of animal draft power
- limited (or no) attention is given to the need to develop an adequate after-sales service organisation (poor standardisation of production and neglected spare-part supply/distribution).

Scenario B: Centralised local manufacture

In a number of African countries, such as Mali, Senegal and Zambia, centralised production is (or has been) realised by just one (often parastatal) manufacturer. In such monopoly situations, an essentially "top down" approach is being followed

Figure 9: Schematic representation of recent supply and distribution in Zambia



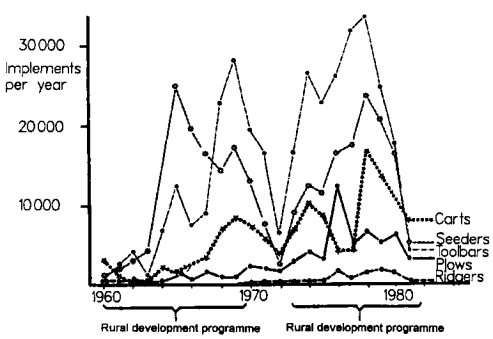
as far as the supply and distribution of often a limited range of implements is concerned.

In retrospect, it can be observed that the central production facilities that were established were often too large: for example, in Senegal, and to a lesser extent in Mali, factory capacities were based on the initial (artificially) high production rates, which were aimed at exports to other countries in the region as well as at domestic consumption. This resulted in limited diversification and flexibility of production. It also resulted in heavy dependence on sometimes inadequately functioning (parastatal) trading and distribution agencies, and hence reliance on the economic survival of such agencies, with limited possibility to fall back on private sector marketing and distribution systems if parastatal animal draft power supply/credit programmes should be reduced or suspended. Figure 10 illustrates the highly variable manufacture and supply of animal draft power implements by Siscoma in Senegal, with the non-sustainable high production figures in the 1970s.

The disadvantages of relying on a single local manufacturer of animal draft power implements are that:

- little, if any, attention is given to developing or adapting implement design in accordance with diverse region-specific needs (limited choice)
- there is limited incentive to diversify the product range, and a tendency toward design and quality compromises in case of monopoly situations (poor standardisation)
- there is limited possibility and incentive to develop an effective distribution and after-sales service network.

Figure 10: Annual introductions of animal draft power implements in Senegal, showing effects of two rural development programmes (after Havard and Faye, 1988)



Where local manufacture is realised by a number of medium- to small-scale central manufacturers, both private and parastatal (as is the present tendency in Zambia), an element of competition is introduced, which allows the alleviation of some of the above constraints. In order to develop its market, each manufacturer will be forced to invest in agricultural engineering and design know-how, maintain and improve design and quality standards, and act upon actual farmers' needs, thus introducing a range of implements, and an after-sales service and spare-part supply and distribution network into the rural areas.

This does not solve all of the problems, however, because it will still be difficult to adjust manufacture to the diverse, region-specific farmers' needs, in terms of types and diversification of implements and spare parts; this difficulty is exacerbated by poor communication with, and feedback from, the regions. There will still be a need to invest in the establishment of an adequate (private sector) animal draft power marketing and distribution system in the regions, possibly involving assembly workshops and consequently subsidiaries in the main regions.

Scenario C: Decentralised manufacture

In many African countries (such as Burkina Faso, Mali and Togo) the region-specific needs of the rural sector would be best served by decentralised manufacture/assembly of implements. Regional workshops would ensure a more timely supply and distribution of a well-adapted range of implements and would facilitate the organisation of an effective after-sales service and spare-parts distribution network in which rural blacksmiths, for example, could participate (see Figure 11).

Basically equipped regional workshops could operate in liaison with (as subsidiaries of) a central manufacturer, which would supply raw materials and key components, and carry out special machining and heat treatment operations.

Alternatively, regional workshops could operate independently to manufacture or assemble a region-specific range of implements. Because the start-up of such workshops would require external assistance, an autonomous regional integrated development programme could be involved to help in providing investment capital, raw materials and management capacity. In time, however, once a regional workshop has assured its autonomous status with adequate capital resources, and established links with its own commercial suppliers of materials and components, external assistance could gradually be phased out, and decentralised manufacture or assembly could become a sustainable activity.

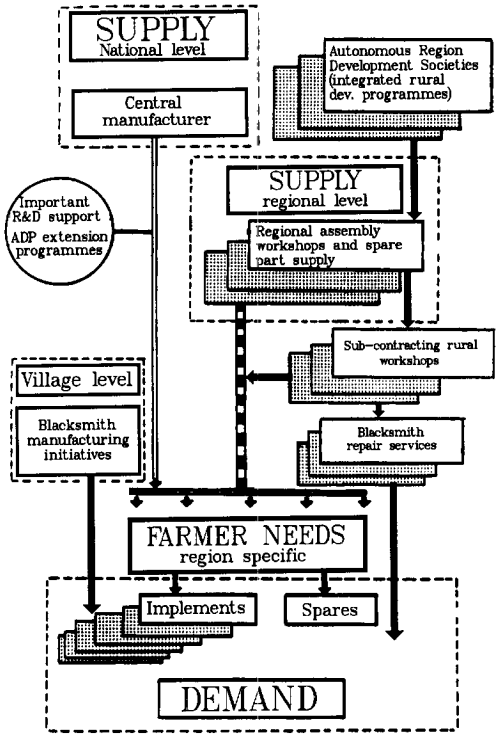


Figure 11: Schematic representation of a decentralised system of supply and distribution of animal draft power implements based on West African experiences

Lessons from the different scenarios

Some positive points and limitations of the three animal draft power supply scenarios that have been outlined are summarised in Table 10.

In practice, centrally planned, top-down implement supply scenarios (types A and B) that relied heavily on government or parastatal manufacturing, trading or distribution institutions have suffered from institutional weaknesses. Various constraints (economic, logistic or operational) have tended to result in partial or complete suspension of the animal draft implement supply and distribution system in a country. There have been examples of this in Mali, Senegal and Zambia. Furthermore, experience has shown that establishment of centralised large-scale implement manufacturing facilities has often been based on unrealistic local demand forecasts and export potential. Diminishing markets and vanishing exports, together with competition from more flexible or better placed smaller workshops, have resulted in suspension of a number of such large-scale production units, such as Siscoma in Senegal.

As far as the quality and local adaptation of animal draft power equipment is concerned, a monopoly situation with centralised manufacture and supply may result in design and construction decisions and compromises which are not in the interest of the actual users. Relatively small-scale, more flexible private sector manufacture and distribution facilities may be better able to serve the rural community needs. Government involvement (and animal draft power policy measures) should aim to create the conditions required for such farmer-oriented private sector initiatives. Experience from West Africa suggests that external financial support and technical cooperation may be required. This is likely to be most important in the initial phases of animal power development, both at the level of the manufacturers (transfer of design and manufacturing skills) and in the rural areas (support to rural development programmes with animal draft power components).

Table 10: Positive and negative aspects of the three implement supply scenarios

	A *Importation*	*B* *Central workshops*	*C* *Decentralised workshops*
Communication with rural sector			
Feedback on farmers' needs and implement acceptability	–	–/+	+
Farmers' choice of type of implement (diversification potential)	–	–/+	+
Spare-part supply service	–	–/+	+
Supply and distribution			
Possibility to adapt design according to regions	–	–/+	+
Local components/added value	–	+	+
Effective supply/production planning (reacting to seasonal demand)	–	–/+	+
Timely distribution to the rural sector	–	–/+	+
Possibility of effective after-sales network for spare parts	–	–/+	+
Liaison with and support to rural blacksmiths (repair services and sub-contracting manufacture/assembly)	–	–/+	+

Prospects for Zambia

The parastatal animal draft power implement supply and distribution system in Zambia recently came near to breakdown. This, and the national reorientation toward a liberalised marketing system with private sector involvement, may lead to a more effective farmer-oriented approach to local manufacture, marketing and distribution of adapted implements and spare parts (see Figure 12).

The recent establishment of some small-scale assembly and manufacturing facilities may, through competition, result in a more adapted range of higher quality implements being marketed in the rural regions. This may lead to increased involvement of small assembly workshops in the main rural regions. Ideally the system will evolve to reflect the actual demand, choice and preferences of farmers, and provide an effective after-sales service and spare-part supply organisation.

A crucial prerequisite is the revival of the economy in Zambia in general, and an increased profitability of animal draft power farming in particular.

Zambia suffers from difficult communications with the rather isolated and "empty" rural regions and this has resulted in poor feedback. In view of the high investment costs required to establish a farmer-oriented marketing and distribution system and spare part supply, rural development programmes had important liaison and supporting roles, especially in regions where animal power is being introduced. Both in new and more traditional animal traction areas, animal draft power research and extension institutions (such the Magoye–Palabana on-farm testing programme) may help to bridge the gap between the supply side and the users. They may do this by creating and improving farmers' awareness of both existing and recently adapted animal draft power technologies through on-farm trials and demonstrations. This should help assure adequate feedback, from the different regions to the supply system, concerning the needs of farmers and the acceptability of implements.

Implementation constraints

Local manufacturers of a wide range of adapted animal draft power equipment in Zambia require greater support (this has already been suggested by recent changes in tax and import duty regulations). The problems of raw material supply and foreign currency constraints need to be addressed to enable the private sector to invest in the required marketing and after-sales service system.

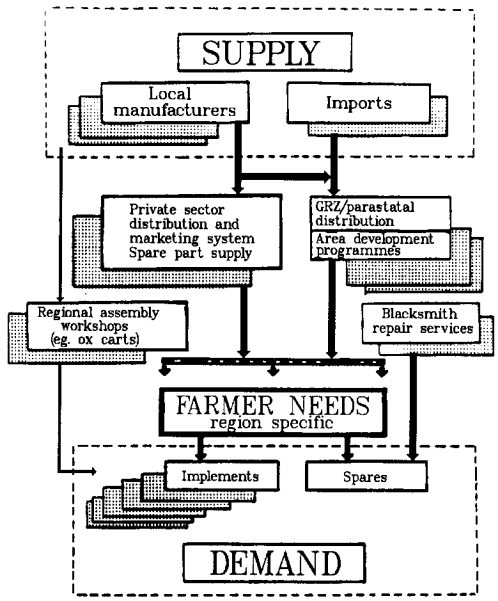


Figure 12: A possible scenario for animal draft power implement supply and distribution in Zambia

The profitability of smallholder animal draft power farming is under heavy pressure and access to credit is almost nonexistent. Nevertheless, recent developments indicate that there is an important demand for animal power equipment. There is a real interest in ox carts, ridging/weeding implements and spare parts in general. On-farm animal power trials and demonstrations of different tillage and weeding systems have provided clear indications that:

- farmers have poor awareness of existing and new implement designs and qualities
- once farmers are offered a choice of implements, their "tolerance" of design/ construction shortcomings will rapidly change into a more critical selection of implements adapted to the local requirements
- implements and spare parts must be available for sale in rural areas: in particular, adoption of weeding/ridging implements does not depend only on economic or credit factors, but is mainly dictated by whether or not distribution and sales outlets are available close to farmers.

In the past manufacturers paid little attention to initiating private-sector distribution/marketing of implements and spares through retail stores and rural blacksmiths. With the exception of parts of Eastern Province (where blacksmith support programmes were in operation), the involvement of blacksmiths in the local manufacture of animal

Table 11: A comparison of southern Mali and the Western and Southern Provinces of Zambia

	Southern Mali	*Western Province, Zambia*	*Southern Province, Zambia*
Total area (ha)	10 000 000	13 000 000	8 500 000
Cultivated area (ha)	1 087 000	97 000	190 000
Percentage cultivated	11	0.7	2.2
Number of inhabitants	2 300 000	607 000	n/a
Number of inhabitants per km^2	25	5	n/a
Number of inhabitants per cultivated ha	2	6	n/a
Number of villages	4 000	n/a	n/a
Implement distribution points	130	6 district cooperatives	6 district cooperatives and some retail stores
Manufacturing	1 provincial workshop 25 assembly workshops	None	None
Implement repair services by rural blacksmiths	2500 blacksmiths including 130 well-equipped and 70 fully equipped with welding facilities	Few	Few

power spares and the repair of implements is poorly developed in Zambia.

Many rural areas are "littered" with plows in need of spare parts. This is a result of the long-standing importation of various designs of plows requiring different spares, together with the lack of spares distribution to the regions and limited means of rural blacksmiths. Some sources have estimated that only 60% of introduced plows are actually in use.

Regional marketing and logistical constraints

The urgently-needed private animal power marketing and distribution system will face important constraints for its development.

Communications in the rural areas are much worse than those in similar agro-ecological zones in West Africa. Establishment of sales outlets in the main rural areas (through hardware stores, blacksmiths or other regional workshops) will require logistic and financial support from the manufacturers.

Table 11 illustrates the enormous rural communication differences existing between southern Mali and the traditional animal draft power regions in Zambia (Southern and Western Provinces).

The "emptiness" and poor communication of the Zambian countryside is even more clearly shown in Figure 13, which depicts the situation in the new animal power introduction areas in Zambia and Mali.

Figure 13:Comparison of Bougouni District (Mali) and Kaoma District (Zambia) showing roads and infrastructure

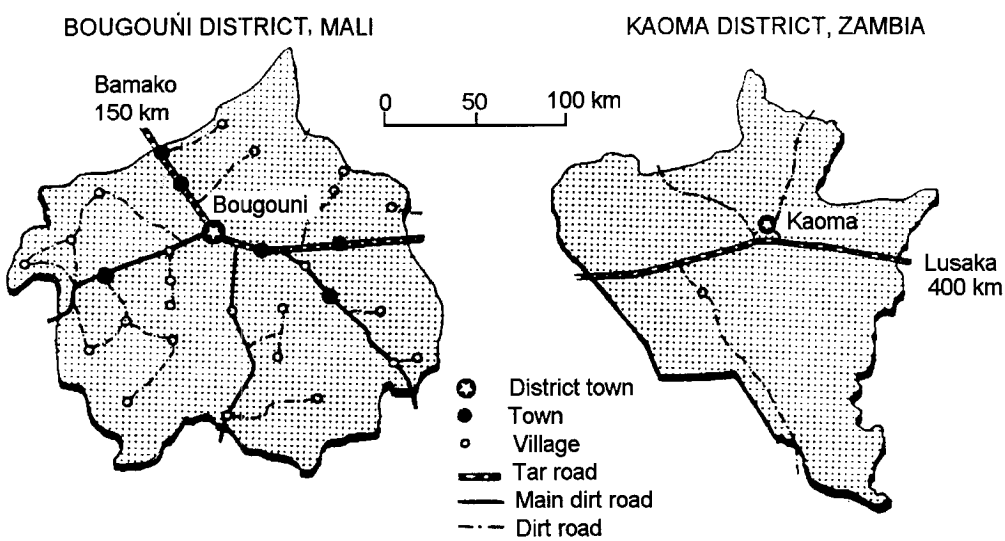


Table 12: Summary of reported surveys relating to rural blacksmiths in West Africa and Zambia

	Mali		*Senegal*		*Togo*	*Zambia*
	Southern Mali	*Office du Niger*	*Nioro and Fatick*	*Lower Casamance*	*North Central*	*Southern Province*
Total number of blacksmiths	2500	150	207	85	93	320
Number of well-equipped blacksmiths	130	20	–	–	–	–
Number of fully-equipped blacksmiths	70	8	–	–	–	–
Cultivated area (000s ha)	1087	50	232	–	–	190
Cultivated area per blacksmith (ha)	400	300	1100	–	–	600
Number of farm holdings (000s)	125	10	37	–	–	97
Number of farm holdings per blacksmith	50	67	180	–	–	300
Number of work animals (000s)	212	20	–	–	14	96
Pairs of animals per blacksmith	42	67	–	–	78	150
Number of villages	4000	150	810	60	–	–
Number of blacksmiths per village	0.6	1.0	0.3	1.4	–	–
Total area (000s km^2)	100	–	5	7	–	85
Area per blacksmith (km^2)	40	–	25	85	–	265

Zambia has a very low rural population density, combined with a low and highly dispersed land-use pattern. Consequently there are few villages, poor connections, no public or private transport inside the rural areas, and no weekly markets. In order to obtain their supplies, farmers and blacksmiths alike must make enormous efforts to reach the district towns, and even then have no guarantee that implements, spares or raw materials are available.

Rural blacksmith constraints

Table 12 gives a summary of the blacksmith situation in some surveyed areas in Mali, Senegal, Togo and Zambia. In Mali and Senegal, blacksmiths are able to service farmers within their own villages or in the immediate vicinity. Traditionally, blacksmiths are influential and may have high social status. Depending on the region, an average blacksmith has reasonable access to scrap material (eg, spring steel from cars and trucks) from the nearby towns and larger villages. In most Zambian regions, however, blacksmiths appear very isolated, both from their widely dispersed potential customers and from their supply possibilities. Experience in various regions in Zambia shows that rural blacksmith training and equipment support programmes are severely restrained by problems of obtaining raw materials and spare parts, as even scrap material is rare in remote rural areas.

Thus efforts to establish private sector sales outlets combined with basic assembly and blacksmith repair services in rural areas will require the active support of implement manufacturers. Following West African experiences, such pilot private-sector rural workshop initiatives may lead to the sustainable development of rural blacksmiths in areas of high market potential. For example, in the Southern Province alone, a large proportion of some 25 000 unused plows could be usefully overhauled once spare parts and repair services became available.

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