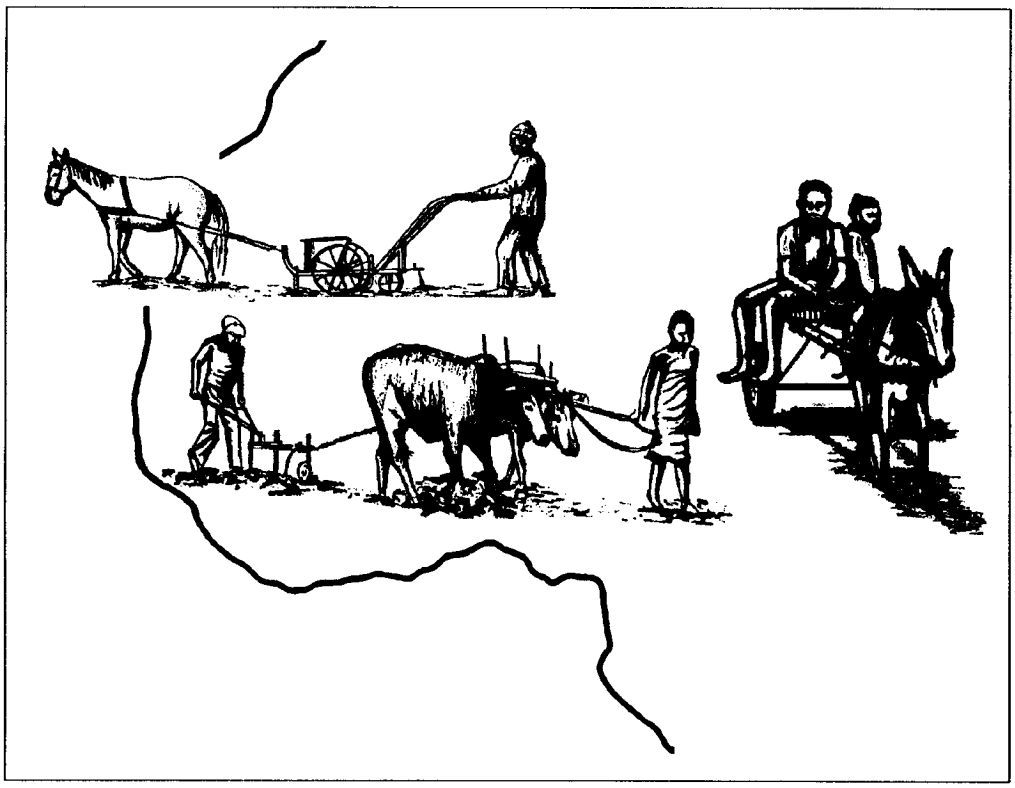
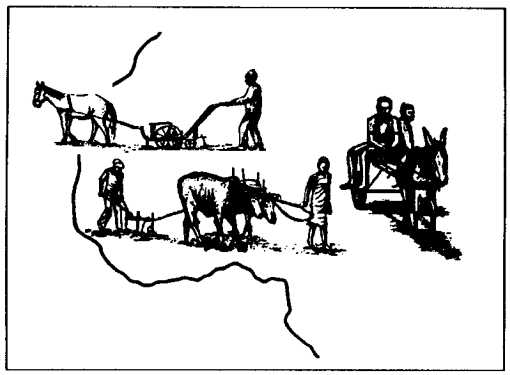
Animal Traction for Agricultural Development



Part 2.

Papers prepared for the Workshop

Title photograph (opposite)
Animal power for production: weeding cowpeas with a single N'Dama ox during trials at Njala University College, Sierra Leone
(Photo: Paul Starkey)



Keynote paper and overviews

Animal traction experiences in West Africa and elsewhere

Animal traction for agricultural development in West Africa: production, impact, profitability and constraints

Keynote paper

by

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Abstract

This paper gives a broad introduction to "animal traction for agricultural development" and the four workshop subthemes: production, impact, profitability and constraints. Much reference is made to information within previous network publications.

Animal traction can increase crop production through farm extensification and improved timeliness of plowing, seeding and weeding. Food production may increase despite emphasis on cash crops. Dual-purpose food-fodder crops are widely grown and groundnut hay is increasingly conserved. Various strategies are employed to capitalize on weight gains of draft cattle. With good management, female draft animals have high total production.

Animal traction adoption increases risk but reduces drudgery. Socio-economic costs and benefits vary between ages and genders. Both costs and benefits are shared through hire or loan arrangements. Animal traction is commonly found in areas with increased intensity of farming where there is deforestation, permanent monocropping, reduced species diversity and increased erosion. However there is **not** *a cause-effect relationship between animal traction and environmental degradation. Animal traction encourages crop-livestock integration. Animal-drawn carts provide new marketing opportunities and facilitate the movement of goods, people, produce, water, crop residues and manures. All draft species are expanding their ranges southward. Oxen remain the dominant draft animals but donkeys and cows are increasingly employed.*

The profitability and sustainability of animal traction depends on support services, including credit, implement supply and repair and animal health requirements. The informal private sector may provide support services once animal traction is established. Cotton companies have encouraged rapid adoption by providing long-term credit and a market outlet.

Constraints to animal traction may include lack of appropriate implements, limited capital and credit, insufficient animals, animal health problems, inadequate animal nutrition (quantity and/or quality), uncleared fields, farmer traditions, lack of technical knowledge, poor infrastructure and limited marketing possibilities. Most constraints can be overcome when other conditions are favourable and knowledge spreads quickly through informal channels. Human labour can constrain crop production and animal traction relieves bottlenecks by switching labour between seasons and household members, increasing or decreasing total requirements. National development policies and interventions by aid agencies may stimulate animal traction but sometimes constrain it.

There are numerous interactions between subthemes including profitability-production, profitability-impact and transport-manurefodder-production-profitability. The profitabilityconstraints interaction is crucial since solutions to constraints may appear when profits are high.

Introduction

The overall theme of the workshop and this paper will be "Animal traction for agricultural development". The intention is to give a broadly-based introduction to the workshop theme and the subthemes in a way which will stimulate thoughts and discussion. This introductory approach will involve presenting many different examples so that each will have to be covered superficially. There is neither the time nor the intention to give a detailed consideration to any one of the subthemes. Opportunities for such detailed analyses will arise during the thematic presentations and the small-group discussions. Therefore this presentation is designed to give an overview of the workshop theme, with strong emphasis on experience that has been reported in the Network publications of the past three years.

The four broad and interrelated workshop subthemes were chosen by the Network Steering Committee to give the workshop presentations and small-group discussions a clear focus. This focusing of discussions was one of the recommendations of the previous animal traction workshop on "Animal power in farming systems", held in Sierra Leone in 1986. However the Committee recognized that the workshop themes would have to be broad, for since its inception, the Network has been based on interaction between professionals working in a wide range of different jobs and disciplines. Many other networks in the region are orientated to specific disciplines (such as the Association Euro-Africaine des Centres de Mécanisation Agricole, ACEMA, agricultural engineering network based in Cameroon) or to specific research themes (such as the West African Farming Systems Research Network, WAFSRN). The West Africa Animal Traction Network has been much more broadly-based than these, involving many different disciplines including specialists in agricultural engineering, animal health and husbandry, agronomy, agroforestry, economics, sociology, extension and other relevant fields. The Network has not been limited to the interests of researchers nor has it been limited to the needs of development projects; the Network has tried to assist the processes of agricultural development by bringing together many professionals working in research, education, development, planning, evaluation, extension, training and technical cooperation.

For these reasons the subthemes are extremely broad in their scope, and their potential ramifications, but nevertheless they should assist us to orientate our detailed discussions. The four subthemes are:

Animal power for **production**,
The **impact** of animal traction,
The **profitability** of animal traction,
Constraints to the use of animal traction.

One important objective of our discussions is simply the exchange of information among ourselves; it is likely that the benefits of this alone would justify all the time and money spent in getting us all here. Nevertheless it will be even more beneficial to ourselves, and also to our colleagues who are not here, if we can, by the end of the workshop, summarize our analyses of these themes and our conclusions in a form that can be published.

Animal power for production

Animal traction and crop yields

Animal traction may assist farmers to increase the total production of their crops. One of the clearest ways in which this is achieved is through increases in area cultivated. There is very often a correlation between farm size and the ownership of draft animals, although this does not *necessarily* mean that the animals are the *cause* of the large areas of cultivation; it may be that the farmers that have big farms are the ones wealthy enough to use draft animals, so that draft animals may be the *result* of large farms. This latter hypothesis linking animal traction to land- and resource-rich farmers was supported by data collected in Sierra Leone (Gboku, 1988) but not in Burkina Faso

(McIntire, 1983). Surveys that record farm areas before and after the adoption of draft animals tend to indicate that where land is available, farmers will cultivate more land when they have draft animals, so that total yield per farm increases (Barrett *et al.*, 1982; Allagnat and Koroma, 1984; Panin, 1986; Francis, 1988; Westneat, Klutse and Amegbeto, 1988). In some cases there may be a drop in yields per unit area, as farmers tend to farm more extensively rather than intensively (Francis, 1988).

Animal traction is often associated with higher crop yields than those obtained by hoe-farming (Sargent, Lichte, Matlon and Bloom, 1981). However this may not necessarily be a direct effect of the tillage for the yield increase may be due to factors associated with, but not caused by, the working animals. For example farmers that have adopted work oxen may be more likely to use fertilizers than other farmers. Panin (1986) found that a significant increase in total crop yield of maize, millet, groundnuts and beans was associated with ridge formation using oxen. Timeliness of plowing, seeding and weeding may well improve with animal traction, and lead to yield increases. Weed control may be improved by plowing and mechanical weeding (Starkey, 1981), which may have a positive effect on yields. On-station research has led to the development of comprehensive technological packages, using oxen as power sources, which, if adopted, could provide significant benefits in terms of improved yields (Bansal, Klaij and Serafini, 1988; Jutzi, Anderson and Astatke, 1988).

Farmers generally **optimize** rather than **maximize** their cropping systems, and may prefer **guaranteed** medium yields to potentially high, but unreliable yields. Optimizing strategies affect all aspects of animal traction, including seeder technology. Well-regulated animal-drawn seeders may be able to plant at optimum depths, so producing higher yields; on the other hand poorly regulated seeders may lead to very uneven results, and lower yields. Hand planting may lead to great variation in planting depth; this is unlikely to result in high yields, but total crop failure is also unlikely. In Southern Mali, some farmers who own draft animals and seeders still seed some of their crops by hand, using long ropes to mark the lines: these hand-planted areas require greater human labour to seed, but are easier to weed, since the lines are always straight (Starkey, 1988d).

Crop yields may be affected by special techniques such as tied ridging. Joining ridges to form a grid of mounds and hollows can assist in soil and water conservation particularly in those semi-arid regions that have 400-700 mm of annual rainfall. Large yield effects attributable to tied-ridging (made with hoes or animal-drawn implements) have been demonstrated on research stations. Several designs of animal-drawn ridge-tiers have been developed and tested in Nigeria in the 1960s (Stokes, 1963: ITDG, undated) and The Gambia in the 1970s (Matthews and Pullen, 1974). One recent prototype ridge-tier developed by ICRISAT researchers is based on a ridger with a large eccentric ground wheel that changes the working depth cyclically and so creates very gradual ties; the other developed by researchers from IITA and SAFGRAD has four blades arranged at right angles, and the operator trips the blade to allow it to rotate by 90°, so depositing the soil and forming a ridge (Wright and Rodriguez, 1986). To date the uptake of animal-drawn ridge-tiers has been negligible, and so production effects (if any) of such implements at village level cannot be reliably estimated.

In much of West Africa, weeding is a major constraint to agricultural production and line-planting followed by early or regular inter-row weeding with draft animals may improve yield per unit of labour and unit of area. The timing and positioning of fertilizer application can also be crucial, and at the last animal traction networkshop details were provided of a system being recommended for animal traction users in Togo (Lekezime, 1988).

Production of different crops

Animal traction may lead to changes in the crop mix, and therefore may have differential effects on crop production. Animal traction has often been promoted in West Africa for monocropping, in areas where inter-cropping was traditional. It has been suggested that animal traction leads to increased production of cash crops, such as cotton, to the detriment of food crops such as maize. However some surveys have not found marked differences in crop mix associated with animal traction (Barrett *et al.*, 1982; McIntire, 1983; Panin, 1986; Francis, 1988). Increased production of cash crops does not necessarily imply lower production of food crops. In the cotton zones in West Africa, where animal traction has been successfully promoted by cotton companies, food grain production has increased. It is thought that grain production benefits not only from animal power for cultivation, but also from the residual effects of fertilizer applied to cotton crops (Deveze and Levaray, 1988). Nevertheless should a major change in crop mix be associated with animal traction, this could well affect food production and the local economy, with significantly different affects on the various members of farm households.

Fodder production and conservation

Draft animals are often in poor condition at the end of the dry season, and many extension programmes have recommended that farmers grow and conserve fodder for their draft animals. On-station trials have demonstrated the potential for growing forage legumes and pasture grasses, but, to date, the production of single-purpose fodder crops at farm-level in West Africa has been minimal. In southern Mali, small quantities of forage cowpeas have been grown, because this was made a condition of credit allocation (Sangaré, Ladrette, Mungroop and Berthé, 1988). Even in this case there has been a tendency to make this a dual-purpose crop, with a small harvest for human consumption (Starkey, 1988d).

In contrast to the situation with single-purpose fodders, dual-purpose food-fodder crops are widely grown, and the conservation of groundnut hay and cowpea hay has increased markedly in recent years. In Senegal, it is common to see large quantities of groundnut hay being transported on lorries for sale to people operating horse carts in the towns. The stover from maize, sorghum and millet is also increasingly stocked, but not to the same extent as leguminous crops (Reddy, 1988).

In some cases it is argued that the limiting factor is not the production of the fodder, but its conservation. Successful production of cut hay is very difficult in lowland tropical areas, and leaving standing hay or forage legumes in a "fodder bank" involves considerable risk of loss to other animals or fire. Small-scale silage production has not proved popular, partly because it is labour-intensive during the crop-growing season. The gathering of residues is generally labour-intensive at a less critical time, after the harvest, and requires no significant investment prior to this time. However if there has been investment in an animal-drawn cart, this greatly increases the ease with which bulky residues can be collected and stored.

Alley farming has been proposed as a means of combining the cultivation of forage trees with the growing of food crops. Trials in the humid zone of Nigeria involving such agroforestry and the feeding of small ruminants have demonstrated the feasibility of the system. In this case simple crop production in association with leguminous trees appeared more profitable than mixed farming (Sumberg, McIntire, Okali and Atta-Krah, 1987). It seems that it has yet to be demonstrated that small farmers can profitably use draft animals within integrated alley farming systems.

Meat production

Draft cattle increase in weight during their working lives and this represents significant meat production. The use of work oxen reduces the common practice of slaughtering young male animals when only one or two

years old and therefore leads to larger carcasses. In one illustration of the potential effect of this at national level, it was estimated that should one quarter of male animals be used as work oxen, production of beef in Sierra Leone could increase by 10% (Starkey, 1981). Lhoste (1987) discussed some of the different strategies that farmers have adopted to benefit from the gain. As animals increase most in weight during the early years of work, overall weight gains are generally maximised if animals are replaced after a short number of seasons. Rapid turnover is the strategy employed in some villages in northern Nigeria, where young bulls are bought from reproductive herds, worked for one season, fattened and then sold. On the other hand maximum weights of individual animals are achieved only after several seasons of work, and keeping animals for this long also allows farmers to benefit from having the same well-trained animals for many years. Some farmers in the Guinea savanna zone of Nigeria adopt this strategy (Otchere, Ahmed, Olorunju and Kallah, 1988) as do farmers in Lower Casamance, Senegal (Ndiamé, 1988a and 1988b). If draft animals are kept for many years, they become old and start to lose weight. Nevertheless some farmers in Guinea employ this strategy, arguing that after working together for several seasons their animals had become their friends, and it would be unthinkable to sacrifice such friendship merely for meat production (Bangura, Allagnat and Starkey, 1983).

If reproductive cows are used for traction, animal production levels can be high as the animals produce work, milk, calves and eventually meat. Successful cow traction requires a high level of management to ensure that the cows stay in good condition, work at the right time and also rear healthy calves (Mathers *et al.*, 1985). In Sine Saloum, Senegal, about 25% of the farmers now use draft cows (Lhoste, 1987) and cows are also being increasingly used in Cameroon (SODECOTON, 1986).

The impact of animal traction

Quality of life

Animal traction may well have a direct impact on the quality of life, by reducing drudgery. Working with draft animals as they cultivate, transport goods, grind or draw water may be tiring, but it is seldom as bad as the manual alternative. Many farmers would also add that their animals provide them with a valuable form of friendship that improves their life. This benefit is seldom discussed in West Africa, but it can be best appreciated when an apparently unsentimental farmer shows signs of regret or even grief when a well-used draft animal is sold or dies.

Impact on farming systems

Animal traction is associated with the tendency to move from bush-fallow cultivation, involving mixed cropping in partially-cleared areas still containing stumps, to permanent systems, in which single crops are grown in cleared fields. It has already been noted that animal traction may lead to extensification, with larger farm areas being less intensively managed. Although it has been suggested that changes in overall crop mix may be small, farmers may well put an emphasis on those crops most likely to yield cash revenues.

One of the more notable ways animal traction affects farming systems is through the integration of crop and livestock enterprises. The traditional separation of livestock rearing and crop production found in some African countries can become socially divisive and environmentally unsound, as population and land pressures increase. Animal traction allows nutrients to be recycled and soil fertility to be maintained through the use of animal dung, green manure and composting techniques. It is also claimed that farmers learn important animal husbandry techniques when they start working closely with draft animals. It may well be that the attitudes and skills learned in this way may be applied to other livestock enter-

prises, with benefits for the animals, farmers and rural economy.

Impact on risk

In early stages of adoption, animal traction increases risk. The risk of animal mortality is particularly important for farmers who were not animal owners, and who therefore purchased animals using savings or credit. Such people are often unused to animal husbandry and yet have committed themselves to a major investment. Animal mortality rates in some areas of introduction have been high, with figures of 18%, 25%, 25%, 40% and 40% respectively reported for particular schemes in Cameroon, Burkina Faso, Sierra Leone, Malawi and Mali (Wagner and Munzinger, 1982; Bangura, 1988; Imboden, Starkey and Goe, 1983; Starkey, 1985b; Reddy, 1988). In some cases the mortality risk has been exacerbated by development projects using animals not adapted to the local conditions. Even in areas where draft animals are in regular use, wastage rates of 3-10% can be experienced through disease, accidents (e.g. broken limbs, eye damage, poison, bloat, snakes, lightning) or theft. Farmers sometimes try to reduce risk through their choice of animal: in tsetse-infested areas trypanotolerant cattle are often chosen. Despite low power output, small-sized animals may sometimes be preferred, since they are individually cheap and so of limited capital risk (Starkey, 1985c). In The Gambia donkeys have been seen to have a much lower risk of theft than cattle (donkey meat has no value there), even though the risk of mortality is greater. In western Sudan, promotion of the use of camels for draft purposes was suspended after the risk of theft became unacceptable, and attention turned to using draft cattle and donkeys. Some credit schemes (including some in Burkina Faso and Togo) have had animal insurance built into the cost of credit, but verification of insurance claims has often proved difficult.

In a recent study of animal-drawn wheeled toolcarriers, the importance of risk in implement design was discussed (Starkey, 1988b). Wheeled toolcarriers have a range of attachments that allow them to be used as plows, harrows, seeders, cultivators and carts. In such multi-purpose implements, in which many functions are ascribed to one common part, a single breakage of a critical part (or even a puncture in the case of some toolcarriers) can prevent all functions from being fulfilled until the repair is made. Furthermore the relative complexity of toolcarriers, and the need to change between functions, makes breakages more likely than would be the case with single-purpose implements. A range of single-purpose implements involves lower risk since the breakage of any one tool should not prevent the other implements from being used.

Impact of farmer preferences

In common with most aspects of life, animal traction both benefits from, and suffers from, longstanding traditional preferences and the vagaries of more rapidly changing "fashions". Animals often have prestige status unrelated to their working abilities, so that one sickly horse may have higher social status than a pair of strong oxen. In some countries and communities the colours of animals and implements may be very important, influencing decisions relating to adoption, even though it is unlikely that these factors would influence performance. Such preferences that appear illogical *may* have a technical justification that is not immediately apparent to an outsider. Nevertheless farmer prejudice can be as important as farmer judgement, when it comes to selecting animals, implements, harnesses or management regimes. In such circumstances any reduction in possible technical efficiency may have to be set against the pleasure associated with the choice, since "fashion" may sometimes be viewed as a social benefit of animal traction.

Impact on different ages and genders

The social costs and benefits of animal traction vary considerably between people of dif-

ferent ages and genders in farm households. Men and children usually train the animals, work with them and herd them. These people have the initial problems associated with first use of animals and area expansion, but may later benefit from easier and more fulfilling work. In some communities men consider it appropriate to cultivate land for the crops usually grown by women: in others they do not. Women and children often have the task of weeding and harvesting, and their work may be increased if cultivated areas are expanded. Children often tend draft animals and because of this their educational prospects can suffer, either due to limited school attendance or due to fatigue when school is combined with looking after animals. In one small survey in Sierra Leone, it was found that children of draft animal owners were less likely to attend primary school (Allagnat and Koroma, 1984). On the other hand the general correlation between draft animals and wealth might make it easier for animal-owners to afford secondary school fees.

In West Africa most of the direct economic costs and benefits of animal traction (relevant capital and recurrent expenditure, the cost of credit and the income from hiring and harvests) are controlled by males. There are certainly examples of women owning draft animals and being given credit through banks or projects. Participants at the last workshop visited one group of women in Sierra Leone who own oxen (Starkey and Ndiamé, 1988), but these are exceptions to the general picture. When women have access to the use of draft animals it is often through informal exchange or hire arrangements (Gboku, 1988). All farmers (men or women) who hire in draft animals inevitably suffer the uncertainty of dependency, but there appears little evidence to suggest that this dependency is any worse than other systems of obtaining external assistance (such as hiring labour teams). If women themselves adopt draft animals their economic dependency on men may be greatly diminished: and if women start to use animals for transport, whole new areas for marketing, trade and hire may be opened up.

The adoption of animal traction (as with most investments in agricultural development) tends to increase income differences between farmers within villages. However the benefits of animal traction are often shared through hire or loan arrangements: depending on village relationships these can range from close cooperation to financial exploitation, although the scope for exploitation is severely limited by the low resources of small farmers and the availability of alternative human power. The hiring-in farmers are unlikely to benefit from the draft animals at the optimal time (for then they will be working on the owner's land) but also they do not have to bear the management costs and risks of owning the animals.

In some parts of West Africa, animal traction has been introduced through communal ownership, often encouraged by governments or aid agencies. Participants at the last workshop visited some such schemes in Sierra Leone (Starkey and Ndiamé, 1988). While there have been examples of successful village associations for animal traction, many have experienced major social and organizational problems associated with conflicting interests for access during the crucial working hours and responsibility for maintaining the animals at other times (Kanu, 1988). With individual ownership it is clear who is responsible for both the costs and the benefits of animal management. One of the costs is grazing supervision, and if this is not carried out with dedication the animal may suffer from insufficient food, accident or theft: alternatively growing crops can be eaten, causing much social conflict and expense. In one survey in Sierra Leone a quarter of farmers reported that they had to pay out significant sums in compensation as a result of the alleged misbehaviour of their work oxen (Corbel, 1988).

Impact of animal transport

The use of animals for transport provides numerous opportunities for social and economic benefits including:

- reduced drudgery for personal transport;
- enhanced possibilities for collecting and distributing harvests, water, building materials, timber, farm implements and other goods;
- increased marketing opportunities for farm produce;
- greater ease of utilizing crop residues, composts and manures.

About 300,000 animal-drawn carts are employed in West Africa, and in some countries, including Senegal and Mali, the number of carts in use has increased greatly in recent years (Havard and Faye, 1988; Zerbo and Kantao, 1988). The importance of carts to the agricultural sector is much greater than absolute numbers imply since carts (unlike plows) are used throughout the year.

Around towns animal-drawn vehicles can supplement farm income or even provide a full-time livelihood. An interesting example comes from Malawi where one farmer who adopted work oxen for cultivation subsequently purchased a cart and started hiring it out: this was so profitable that he concentrated on being a transporter, using hired manual labour on his farm rather than his work oxen. Similar examples can be seen in West African countries: animals used for peri-urban transport are often high-value animals, such as horses. Local marketing arrangements for feeds such as groundnut hay have spontaneously developed in countries such as Senegal, The Gambia and Mali and farmers often sell conserved feed to transport entrepreneurs rather than feeding it all to their own draft animals.

The pattern of adoption of cart technology in Africa as a whole is very uneven. In Sahelian countries, relatively high-cost steel-framed carts fitted with roller-bearings and pneumatic tyres have proved very popular. Attempts to develop cheaper carts in southern and eastern Africa have seldom been very successful. In Ethiopia, a country with numerous draft and pack animals, there are very few carts in the rural areas. In Madagascar on the other hand, there are few pack animals but professionally-operated wooden carts with large, wooden spoked wheels play an important role in the rural economy, and well-used cart tracks scar the highlands.

While carts are relatively complex and expensive, simple wooden sledges can be made by selecting a naturally occurring fork of a tree or by joining two wooden beams in the form of a V. Such sledges are seldom seen in West Africa, but they are used in several areas of eastern and southern Africa and Madagascar. They have the advantages of being cheap and simple to make and maintain and they can be used on tracks unsuitable for carts. However they tend to accelerate erosion by leaving rutted tracks, often only passable by other sledges, which become water courses during heavy rains. In some countries, including Lesotho and Zimbabwe, the dangers caused to the environment by sledges has led them to be officially discouraged and even banned.

Camels are used for packing in the countries bordering the Sahara but other pack animals such as donkeys, horses or cattle are not common in West Africa, except where they are used by traditional pastoralists and transhumant groups. Spencer (1988) argued that pack transport should have a high chance of success in West African farming systems, since investment in equipment is minimal. However there has been very little recent adoption of this form of transport in West Africa, and the situation remains very different from Ethiopia, where pack donkeys, horses and mules are widely employed.

Impact on the environment

Animal traction is associated with increased farming intensity, deforestation and permanent cultivation, although animal traction is not the cause of this process. One World

Bank study considered that population pressure in Africa was causing farming systems to gradually evolve from shifting forest-fallow cultivation to annual cropping in destumped fields (Pingali *et al.*, 1987). Animal traction was considered a part of this progression. Farmers destump their land for plowing when farming with short bush-fallows starts to give low returns. At this point, it is argued, the cost of land preparation and weed control using traditional techniques becomes excessive.

Permanent cultivation in the absence of soil conservation techniques and the replacement of nutrients can lead to increased erosion. In this way, animal traction may be associated with increased erosion, but not in a cause-and-effect relationship: poor farming practices can lead to erosion whether human, animals or tractors are used. In southern Mali some heavily-eroded fields have never been cultivated with draft animals, but because the majority of the land is now tilled with oxen, most erosion is on animal-tilled fields.

Permanent cropping and monocropping lead to reduced ecological diversity, and fewer species of native plants and animals, whether they be trees, shrubs, medicinal plants, wild mammals or insects. This depletion of the environment and reduced ecological stability is also associated with the adoption of animal traction technology, but again the association is not cause-and-effect, but linked effects of intensified agriculture. Increases in the local population of large animals can lead to pasture degradation, and one of the reasons for retaining animals may be for work. Where watering places are few, such as in areas of the Sahel, in Botswana and in southern Mozambique, regular trampling along paths in the vicinity of water holes can cause serious erosion problems. Again the association with animal traction is indirect, and there is no suggestion that animal traction *per se* causes pasture degradation and erosion.

Impact on animal populations

Oxen (castrated bulls) remain the dominant draft animals in West Africa. This is not surprising since cattle have a very wide geographic range, cattle herds invariably produce more males than are needed for reproduction and oxen are excellent draft animals. When relatively small numbers of draft animals are used in an area and where heavy draft work is required oxen seem to be the obvious choice of draft animal, and few farmers seriously consider other options. In some areas such as Northern Nigeria uncastrated males (bulls) are used for work (Otchere *et al.*, 1988). In Sine Saloum in Senegal cows (females) are increasingly being worked, and Reh and Horst (1982) reported that N'Dama cows used for draft purposes actually had higher reproductive characteristics than similar cows kept in traditional herds. This was attributed to the fact that the better husbandry associated with draft animals, more than compensated for the stresses imposed by the work. Elsewhere in the world, female animals are often used where a high proportion of all large animals are worked and where it takes significant human or feed resources to maintain an animal during the year (Mathers *et al.*, 1985). In Bangladesh about 30% of the draft animals are females (Mettrick and James, 1981). In Egypt, with a long tradition of animal traction, most draft animals are working cows, serviced by artificial insemination. In Indonesia, where farming is often extremely intensive, the great majority of working animals, whether cattle or buffaloes are females.

In general the oxen used in West Africa are those found locally, although the stratified nature of cattle production means that cattle in local markets may well have come from herds in more northerly range lands. In countries where work oxen come from small local herds, some unintentional negative selection for size may be taking place. The "best" males that seem large and strong are selected for work, and so are castrated and are therefore unable to breed. Thus the breeding bulls may be

genetically inferior in terms of body size and conformation, giving rise to worries over the "shrinking Mashona beast" in Zimbabwe (Tembo and Elliot, 1987). Similar trends associated with castration for work have been observed in the Philippines and Indonesia, but this is less likely to occur in Sahelian countries where the large reproductive herds are not controlled by crop farmers.

Horses have a very limited geographical range in Africa and they are not very hardy. They are often expensive, as a result of their high prestige value, their suitability for transport and their relatively low reproductive efficiency and survival rate. They are thus seldom used for agriculture in West Africa, with the very notable exception of west-central Senegal where they are widely used to pull cultivation tines, seeders, weeders and groundnut lifters. Participants at this workshop will be able to observe many horses at work during the field visits.

Donkeys have a slightly greater range than horses, and generally have better rates of reproduction and survival. They are well-suited for pack transport and for pulling carts in relatively flat areas: however they do not have great tractive power, and so their use for pulling plows is very limited. Nevertheless with the development of implements and techniques for low-draft tine cultivation, together with changing ecological conditions, donkeys are increasingly employed for cultivation in West Africa.

Camels are used mainly as pack animals in the countries bordering the Sahara desert. Small numbers are also used for land cultivation in semi-arid areas in Mali, Burkina Faso, Niger and Nigeria. It appears that the use of camels for land preparation in West Africa is increasing, although absolute numbers in use are still low (Blench, 1987; Arrachart, 1988).

In recent years, the geographical ranges of working camels, horses, donkeys, zebus and taurines have been expanding southward in West Africa. This appears to be due to the changing climate, and the reduction of the tsetse fly challenge. Many farmers in southern Senegal, The Gambia, southern Mali and western Burkina Faso, who until a few years ago used only taurine cattle, have recently changed to the large Zebu animals for plowing. Many have also switched from ox-carts to donkey carts. These changes do not seem to have been attributable to extension policies, but rather to the increased chances of survival of zebus and donkeys in places where mortality rates for such species used to be unacceptably high.

Attempts to introduce exotic species or breeds for draft work in West Africa have, as yet, had negligible impact (Starkey, 1985a). In Senegal, a recent programme has started to assess the use of draft buffaloes in the north of the country (Roosenberg, 1988). Draft buffaloes are also being tested in Tanzania. Past schemes to use buffaloes in sub-Saharan Africa have been disappointing (Cockrill, 1977). In terms of animal traction impact, no buffalo scheme is likely to have a significant influence on animal populations during the present century. This is not a question of being either optimistic or pessimistic about current initiatives, for it is much too early to know whether buffaloes can survive, work and reproduce under village conditions in Senegal and Tanzania, and whether they will prove to be socially acceptable and economically appropriate. Whatever the success of the pilot schemes, the sheer practicalities of buffalo reproduction would mean that it would take many, many years to build the numbers of working buffaloes into the hundreds, let alone the thousands.

Impact of alternative applications

There are several alternative applications of animal power which may have significant impact at a local level. These include animal-powered mills, animal-powered water-raising systems and the use of draft animals for timber extraction. None of these technologies is widely used in West Africa. At the last

workshop participants saw some prototype mills and gears in use by an institution in Sierra Leone (Koroma and Boie, 1988) and during the current workshop some participants will see further prototype systems in use in villages in Senegal. Participants will be able to judge for themselves what impact these installations are having on the quality of life of the villagers. They will also be able to consider whether the animal-powered mills and pumps are technically and economically sustainable and what might be the constraints to the much wider adoption of this technology.

Profitability of animal traction

Economic assessments

It has often proved difficult to assess the economic impact of animal traction at village level. Some people (including Starkey, 1981) have produced economic models based on economic and labour data derived from on-station studies. The relevance of such data can be questioned, since animal size, condition and training, implement adjustment, soil conditions and operator motivation on research stations can be very different from those prevailing in nearby villages. Even if data from village studies are used, they are not necessarily reliable, since this depends on the method of collection. Farmers may intentionally or unintentionally over- or underestimate figures and enumerators have been known to filter farmer responses or even make up answers.

Animal traction cannot easily be assessed in isolation from the rest of the farm or village economy, and some form of standard units are required. The use of monetary units appears unwise when inflation is rife, currencies are unstable, much of small-farm economy is based on non-monetary transactions or when there are dual legal and black-market economies. For example at the last workshop detailed information was provided on the economics of using animal traction in Sierra Leone (Corbel, 1988; Bell and Kemp, 1988). It is only two years since that workshop, but a combination of local inflation, shortages of foreign exchange and black-marketeering during this period have greatly diminished the relevance of all the figures in these papers that were expressed in Leones, the local currency. The use of other units such as grain-equivalents (Jahnke, 1982) necessitates so many assumptions that reality becomes easily lost.

To ensure observed trends are not spurious, economic information has to be collected over a period of time, preferably several seasons. Clearly there is no such thing as an "average" year, and disruptions due to exceptional rain, drought, pests, epidemics, elections and bereavements are part of "normal" village life, however "exceptional" they may seem. However with large variations in social, economic and environmental conditions between farmers and years, together with gradual economic evolution, changing project/government interventions and other confounding factors, it becomes extremely difficult to produce accurate economic models of animal traction use on a small farm.

There have been examples of apparently "unprofitable" technologies spreading and "profitable" technologies being rejected: the difference in "profitability" being mainly a function of the assumptions made by economists. Reddy (1988) discussed several shortcomings of animal traction economic models in the Sahel, arguing that economists had overestimated the opportunity cost of human labour for herding. It is difficult to ascribe opportunity costs to the labour required by, or saved with, animal traction, particularly when it causes shifts in the time and category of labour. Quite small amounts of time saved by adults during crucial labour-bottleneck cultivation periods may have to be "paid for" by much longer periods of child labour, most of which will be required during slacker periods of the year. Reddy also noted economists had tended to underestimate the severity of initial cash-flow problems.

Starkey (1988b) noted that many economic models were produced to illustrate the profitability of adopting animal-drawn wheeled toolcarriers, but they convinced donor agencies rather than farmers. It seems increasingly realised that in the recent past there has often existed a large discrepancy between the economic perceptions of farmers and those of conventional project economists (Sargent *et al.*, 1981; Reddy, 1988; Bordet, Lhoste, Le Moigne and Le Thiec, 1988; Starkey, 1988b).

Sources of profit

A major contribution to the profitability of animal traction comes from the final sale of draft animals which normally increase in weight during their working lives. As noted when discussing production, different strategies have been adopted to capitalize on the gain. Profits are generally maximised if there is a rapid turnover, but involves greater training or lower training standards. The more sentimental farmers keep their animals until they are old, allowing social benefits to override economic considerations. Cow traction systems can be very profitable. Reproductively active working cows require higher management and more food but the production of valuable calves, and possibly some milk offtake, more than compensates for this. (Starkey, 1981; Lhoste, 1987; Bangura *et al.*, 1983; Mathers *et al.*, 1985).

Credit and back up services

The profitability and sustainability of animal traction at farm level depends on the availability of a variety of backup services, such as credit, implement supply and repair, animal health requisites. In West Africa, these have often been provided by government funded institutions, projects and extension services. However some or all of these services can be provided by the private sector. In some countries, formal commercial enterprises such as private workshops, drug and chemical companies and commercial banks have been involved in supplying services. More commonly the informal commercial sector has been involved, with the services of traditional or modern blacksmiths, cart makers and repairers, itinerant spare-part traders, animal herbalists, local money lenders and so forth.

Both formal and informal enterprises depend on adequate markets for their services, and are unlikely to be active at low levels of animal traction adoption. As adoption increases, so services are supplied, making further adoption easier. A visit to a local market in Sine Saloun, Senegal, or southern Mali clearly illustrates how private traders make it easy for farmers to purchase implement spares, once the market has been established. This has implications for policy makers, for in areas of new adoption it may be sensible to concentrate resources in order to establish a critical mass of animal traction users in an area so that local private-sector support services can be viable.

Marketing organizations, including cotton companies, have been largely responsible for the rapid adoption of animal traction observed in southern Mali and northern Côte d'Ivoire. They have generally provided credit as well as a vital market outlet. Credit is particularly important since animal traction is a long-term investment that has to be afforded in the short term. Several studies, including that of Barrett *et al.*, 1982, have illustrated that there may be negative cash flows during the initial years of adoption, and without favourable credit, such economic hurdles may be insurmountable. New markets may also facilitate animal traction adoption. In Nigeria the pattern of adoption has been heavily influenced by the presence of roads, and the marketing opportunities they represent (Blench, 1987).

Constraints to animal traction

Implements

Lack of appropriate implements can be an important constraint to the use of animal traction and farmers have sometimes found it

difficult or impossible to obtain *suitable* equipment (Harouna and Imboden, 1988; Gifford, 1988). In most West African countries there are factories or workshops capable of producing steel plows, cultivators and other animal-drawn implements. Indeed since most workshops are theoretically capable of producing more implements than the national demand warrants, there is an overall regional overcapacity for the production of animal-drawn implements. This overcapacity is seldom obvious as most workshops are heavily constrained by limited capital availability, unreliable infrastructure (electricity, fuel etc.) or lack of raw materials. COBEMAG (Coopérative Béninoise de Matériel Agricole) in Benin, Rolako Centre in Sierra Leone, SMECMA (Société Malienne d'Etude et de Construction de Matériel Agricole) in Mali and USOA(Usine des Outillages Agricoles) in Guinea are just some examples of workshops constrained in this way. Poor marketing channels exacerbate the situation, so that farmers may complain of lack of implement supply at the same time as workshops complain of lack of market demand. In some cases the problem is due to implement quality rather than quantity: farmers are only offered equipment of poor standard or inappropriate design and consequently do not purchase them. For example, farmers in Tanzania wanted to purchase conventional mouldboard plows, but the local factory at Mbeya only produced unpopular, wooden-beamed plows: the farmers considered lack of implements was a constraint, while the factory pointed to unsold stocks.

Lack of spare parts can also be a constraint, although it is seldom a critical one. At this moment there are many implements in the region lying unused, waiting for a new share, wheel or tine. However perhaps more remarkable are the numbers of implements still in operation after many years, despite lack of spare parts. At the last workshop, participants visited farmers in Sierra Leone who had kept their implements in use for over thirty years without access to manufactured spare parts (Starkey, 1981; Starkey and Ndiamé, 1988).

Poor implement adjustment causes unnecessary work for animals and farmers in many countries in West Africa. The lack of knowledge or inadequate training responsible for poor use of implements reduces the overall efficiency of animal traction use. While this is clearly important, it is unlikely to be a primary constraint to animal traction, although in extreme cases the difficulties experienced can lead to the abandonment of this technology.

Harnessing

Several people have suggested that harnessing is a major constraint (Smith, 1981; Vietmeyer, 1982; Micuta, 1985). Different people have strongly advocated the use of head/horn yokes, withers/shoulders yokes, collars, breastbands, single yokes or double yokes (Gryseels *et al.*, 1984; Micuta, 1985; Ramaswamy, 1985; Dibbits, 1986; Conroy, 1988). In each case it has been argued that other systems are inefficient. Some participants at this workshop are strongly in favour of one particular harnessing system, and there may be some valuable opportunities to consider harnessing issues in the workshop discussion groups.

In West Africa the present adoption position is quite clear, oxen are yoked with double withers yokes or double head yokes (the latter mainly in the more humid zones where humpless, taurine cattle are common) and donkeys and horses are harnessed with breastbands. Collars and single yokes are rare or absent. It could be argued that harnessing is not a primary constraint, since the existing yoking systems (when used correctly) do allow animal traction to be used for agricultural development. Nevertheless it could be a secondary constraint and animal traction might be made more efficient, and/or more comfortable for both animals and farmers if harnessing were "improved", either by different designs or by better attachment of existing designs.

Human labour

Human labour can be a critical constraint in farming, and animal traction may ease or exacerbate this. The labour bottleneck of cultivation may be lessened if draft animals are used, although the overall effect may be labour-switching rather than labour-saving. For example, draft animals may save adult males valuable time at critical cultivation periods, but this may have to be "paid for" by children supervising the draft animals as they graze throughout the year. Farm households that do not have sufficient labour to manage draft animals throughout the year may be unable to adopt animal traction (Westneat, Klutse and Amegbeto, 1988a and 1988b). Stumping fields to allow the use of animal-drawn plows itself requires much labour, and in some areas this may be a critical constraint to adoption (Reynolds, 1988).

It can be surprising to see how many people are involved in plowing in West Africa. Two to four people are often employed: one (usually an adult or strong youth) handling the plow, one guiding the animals, and one or two (often children) encouraging or beating the animals. In Ethiopia and most Asian countries it is rare to see more than one person working with a team of animals. It is interesting to try to identify specific reasons for this, rather than merely ascribing it to generations of experience. For example, where one person is used to control the animals, implements often have long-poles, and this may give the person plowing greater control over the animals than when a traction chain is employed. It is not suggested that this simple fact explains all the differences in labour use, but it may be one contributing factor. Another explanation was given by a farmer in The Gambia: if animals are well-trained they are easily stolen, but if they are kept relatively wild, people will be scared to steal them. Thus work oxen are kept wild, and three to four people are needed during the short plowing season. Donkeys on the other hand are well-trained because no one steals donkeys, as their meat has no value. In areas where this argument holds little sway, it may simply be that it is not worth farmers investing their time in training when animals are used for such a small time during the year. Where animals are regularly used for transport, training standards are high, and it is common for only one person to supervise an ox-cart.

Capital and credit

It is well known that lack of capital or credit can be a critical constraint to agricultural development, and the adoption of animal traction can be highly dependent on the availability of these resources. The market cost of oxen, cultivation implements and carts in West Africa is high relative to average farm incomes. In areas of low animal traction adoption, few crop farmers have both sufficient savings and also the confidence in animal traction to purchase animals and implements without assistance. In such cases the provision of credit has often led to rapid adoption, as occurred following credit schemes provided by cotton development or marketing companies in Mali, Togo, Benin, Cameroun and Côte d'Ivoire. In such cases there were packages of inputs besides credit, but the loans were considered to be particularly crucial. When there were major changes to the system for providing credit to small farmers in Senegal in the early 1980s, the market for new animal-drawn implements almost completely disappeared, and the SISCOMA (Société Industrielle Sénégalaise de Constructions Mécaniques et de Matériels Agricoles) implement factory went bankrupt (Havard and Faye, 1988).

Environment and infrastructure

In forest areas, the presence of trees and stumps constitute a major constraint to animal traction. However this constraint gradually "disappears" as population and land pressures increase and as the time required for land preparation and weeding under forest-fallow cultivations systems increases. A

stage is reached where farmers find it more worthwhile to remove the stumps and start plowing with oxen, than to continue with short-fallow rotations using hand labour (Pingali *et al.*, 1987). Similarly increases in farm prices or access to new markets may make it worthwhile for farmers to overcome the environmental constraints. At the last workshop in Sierra Leone, participants who visited villages considered poor infrastructure to be a major problem and concluded that repairs to bridges, the opening of new roads and the development of the crop marketing system would help overcome the existing constraints to animal traction (Starkey and Ndiamé, 1988).

In forest areas, animal disease, notably trypanosomiasis, may act as a constraint to the use of draft animals. In more arid areas, the provision of water can be a constraint, and animals may have to walk long distances to watersources. High temperatures and large quantities of direct solar radiation may exacerbate water shortage, and cause animals to stop work as their body temperatures rise.

Many environmental constraints are genuine, but can be overcome if other conditions are favourable. For example people wanting to show that animal traction is not universally applicable may refer to mountainous areas of Africa and state that animal traction could *never* be appropriate there. While their conclusion may indeed be correct, this would be due to a wide range of socio-economic, edaphic and infrastructural reasons, and not simply the topography. In Nepal and Indonesia, draft oxen are integral components of the farming systems in very mountainous areas, and they successfully plow tiny terraces on steep slopes (Starkey and Apetofia, 1986). Even the constraints of mountains can be overcome if the returns are adequate.

Animals

The limited availability of animals can be a serious constraint to the employment of draft animal power in some areas. In the humid and sub-humid zones of West and central Africa, there are very few cattle, and projects in southwestern Burkina Faso, Liberia, the south of Mali, southern Sierra Leone, central Togo and eastern Zaïre have all reported animal supply as a serious constraint (Apetofia, 1988). Elsewhere civil unrest or wars can restrict animal availability, and reports from southern Mozambique and central Angola have indicated that farmers already using work oxen are having difficulty in purchasing replacement animals.

The problem of animal health is often linked to that of availability. Some very high mortality rates (10-25% in bad seasons) have been recorded for draft animals in areas of Burkina Faso, Cameroun, Malawi, Nigeria and Sierra Leone. Such mortality has often occurred when animals were not readily available locally so that they were brought in from surrounding areas. In one study of the "plow line" in Nigeria, attempts were made to identify the main reasons why draft cattle were used to the north of this line, but not to the south. Although no single reason stood out as paramount, poor animal health was certainly a major constraint in the transitional zone (Blench, 1987).

The range of horses and donkeys in West Africa is severely limited by disease constraints, and they seldom thrive in the zones infested with tsetse fly. The range of Zebu cattle extends further, but in zones heavily infested with tsetse fly, Zebu cattle succumb to trypanosomiasis and other diseases, and the only the trypanotolerant taurine cattle seem to thrive. There have been suggestions that trypanotolerance may break down if animals are worked, but trials carried out in Liberia (and reported at the last networkshop) demonstrated the N'Dama's ability to thrive in areas of tsetse challenge despite a regime of work (Ravindran, 1988). The success of N'Dama cattle as working animals in The Gambia, Guinea, Sierra Leone and elsewhere also suggests that tsetse challenge may not be a crucial constraint.

Nutrition

Inadequate animal nutrition is often cited as a major constraint to the use of animal traction (Le Thiec, 1988; Sangaré *et al.*, 1988; Otchere *et al.*, 1988). Animals are expected to cultivate fields at the beginning of the rainy season. This is the very time of the year when they are in poorest condition, following the inevitable weight losses of the dry season. The seriousness of the constraint is seen most dramatically in drought years, when large numbers of animals may die of starvation. Nevertheless recent research has confirmed the observation that even when they are in poor condition and losing weight, animals can continue to work quite satisfactorily (Abiye Astatke, Reed and Butterworth, 1986). Furthermore it has been observed that farmers may know how to improve the condition of their animals, but choose not to. For example, farmers in Ethiopia may sell hay for money, even when their own animals are in poor condition (Goe, 1987). Similarly farmers in The Gambia and Senegal may sell groundnut hay to commercial transporters, rather than feeding it all to their own animals. These observations suggest that even though nutrition is a constraint, it is not always a limiting factor. It may be that overall farm profitability is limiting, and this discourages farmers from investing in the nutritional status of their working animals. In almost all extension manuals it is recommended that farmers should feed supplements to their animals prior to, and during, working periods. This is seldom done in West Africa, although the feeding of groundnut hay is increasing (Otchere *et al.*, 1988; Sangaré *et al.*, 1988; Reddy, 1988). In some areas of Zimbabwe farmers feed their animals groundnut hay, maize bran and even maize flour prior to the working period: it is not clear whether this reflects an efficient extension programme, high grazing pressure, or high returns from early plowing.

It seems there is uncertainty as to the extent to which poor animal nutrition is a direct constraint. There is also controversy as to the best strategies for making optimal use of available feed resources during the farming year, and the value of strategic supplementation. However there is certainly no doubt that there is much room for improvement in the quantity and/or quality of feedstuffs generally made available to draft animals, through grazing, browsing, forage conservation or supplementation. Low-cost methods to improve nutrition, such as the improved stockage of crop residues, seem most likely to be adopted (Reddy, 1988).

Social constraints

In areas where animal traction is still a highly innovative technology, it is common to hear someone argue that the technology is appropriate to one tribal group, but not another. Thus one farmer watching a plowing competition in Sierra Leone explained how amazed he was to hear plowmen giving orders to animals in the local tribal language: he had naturally assumed the oxen would only have understood Fulani, the language of the local cattle herders. This illustrates the type of sociological or psychological constraint that may have to be overcome if animal traction is to diffuse into an area. Nevertheless, while social traditions are obviously important, many examples from different parts of Africa show how quickly animal traction can spread, if it is found to be profitable. For example, in Zaïre two cooperating projects had broadly similar problems of farmers being totally unfamiliar with cattle husbandry and draft animal technology. Progress in both projects was slow until farmers in one area started to benefit from increasing maize prices as traders carried grain to a growing town. In the villages with access to greater market opportunities animal traction adoption was higher. There was no suggestion that the social (or technical) constraints were any less, but in the area of higher economic profitability the constraints were more rapidly overcome (Starkey, 1984).

Apart from social traditions, farmers may simply be unaware of animal traction options.

For example, it has been claimed that farmers in The Gambia and southern Sierra Leone may be unaware of technology that is suitable for employing oxen in rice swamps (Jarju, Sarr and Marong, 1988; Leaman, 1988). Nevertheless knowledge can spread very quickly, within areas where animal traction technology is technically and economically appropriate. An interesting example of this comes from The Gambia, where prior to 1955 there was virtually no use of draft animals for crop cultivation. Through a very structured extension programme based on ox-training centres, animal traction was successfully introduced into most Gambian villages between 1955 and 1975. However while the extension services were promoting the use of yoked pairs of oxen, an alternative, and technically very different, draft animal technology based on single-harnessed donkeys was diffusing informally from Senegal. By 1988 more donkeys than oxen were being used in The Gambia, as farmers adopted scarifying tines and seeders (with low-power requirements) rather than the ridgers and plows first promoted by the extension services. Thus through the two processes of formal extension and informal diffusion, major changes in farming technology were rapidly adopted, as animal traction became a normal part of farming systems in The Gambia in the period of about one generation (Starkey, 1988c).

Theft of animals, or fear of this, can effect animal traction users, and this has been cited as a social constraint in parts of The Gambia, Nigeria, Sierra Leone and Sudan. In The Gambia, one reason given for using donkeys rather than oxen was reduced risk of theft with donkeys. In some countries draft animals give prestige to their owners, but they may also cause jealousy and friction within communities. In extreme cases this may lead to the loss of animals through theft, poison or "witchcraft". In more minor cases, ox-owners may have to pay compensation for genuine or alleged damage to crops, buildings or people (Corbel, 1988). In some countries horses are prestigious, oxen are intermediate and owners of donkeys may be laughed at (although such traditions may rapidly change where their technical benefits are demonstrated). Farmers' distinct preferences for particular animals, harnessing systems, implements type and colours and cultivation practices may be founded in longstanding technical assessments, or they may simply represent a form of "fashion". In either case sensitivity is required when dealing with such social "constraints", however ephemeral they may appear.

National policies

National development policies can represent either an impetus to animal traction, or they can act as a major constraint: interventions at national level can greatly influence decisions at farm-level. In extreme cases animal traction is actively discouraged by governments. This is the case in present-day Egypt, where the policy is that the forage consumed by working animals could be better used for milk production. More often animal traction has merely been neglected. In several African countries, tractorization policies were actively pursued in the 1960s and 1970s and by providing heavily subsidized tractor-hire services, governments made it economically undesirable to use draft animals. Participants at the last workshop visited the Rolako Ox Centre in Sierra Leone. This had been established with Chinese assistance, as a Ministry of Agriculture mechanization centre. From the outset animal traction was a part of the programme, but it was neglected as long as there were subsidized tractors and power tillers available. Only when the tractors had finally broken down did farmers and ministry officials become interested in the animal traction option.

Although there have been major advances in the "image" of animal traction in Africa in recent years, some senior officials and politicians still tend to think of it as an outmoded, old-fashioned technology, or as one Sierra Leonean put it "a U-turn back to the stone age"

(Starkey, 1986). Thus animal traction has sometimes been neglected in the allocation of resources for the provision of national services such as credit, extension, research and training. Occasionally national policies may make it very difficult for the private sector to provide support for animal traction. For example customs tariffs may be applied to raw steel, while manufactured agricultural implements can be imported duty-free. This has put local manufacturers at a competitive disadvantage compared with importers, making it difficult for local workshops to manufacture implements and develop systems of rapid farmer-producer feedback.

Aid policies

Aid donors and international institutions are naturally very sensitive to any suggestion that their policies can sometimes act as constraints to development. Nevertheless donor-funded activities can adversely affect the development of animal traction, and it has even been suggested that one of the biggest constraints to the success of one donor-assisted programme is another donor-assisted programme! For example just as animal traction is developing in an area, with farmers hiring out their animals to their neighbours, another donor may provide tractors to allow a subsidized tractor-hire scheme to start, so reducing the attraction of animal traction. Similarly, implement workshops established by one donor may find their market has been flooded by imported implements provided by another donor. Now it can be argued that such problems are really the fault of the host governments, who have to approve all donor-supported interventions. This is true, but all those involved in development planning know how much influence and pressure is exerted by donors. Coordination between different aid agencies within countries is important, and the situation does seem to be improving.

Donors generally tie their expenditure to products made in the donor country so British-funded projects generally make use of British ox plows, Dutch-funded projects use Dutch plows, French-funded projects use French implements, EEC-funded projects tend to use implements made in the EEC and FAO-funded projects usually supply Italian plows, whenever Italian funds are used. Such arrangements are not necessarily bad, but farmers are seldom consulted about it.

Donors naturally have a strong sense of self-interest, that is not merely linked to product purchases. One reason why animal traction has been neglected, is that donors have often been promoting their own makes of tractors. One reason why animal traction is now being supported is that animal traction is photogenic, and looks well in publicity brochures. Donors are very keen to report the "success" of their programmes, and publicise the value of the "improved technology" that their funding has created, be it implements, harnessing systems or sustainable farming systems. To illustrate just how far such publicity (and sometimes propaganda) can go, one can look at the thirty-year history of animal-drawn wheeled toolcarriers, implements that were "perfected yet rejected". It seems that everyone in the world who was aware of these implements thought they were successful and had been widely adopted by farmers somewhere, even though this had never been the case (Starkey, 1988b).

When donors provide funds they often dictate how they can be spent. The organizers of the workshop experienced this. One donor wanted this workshop to accept a disproportionately high number of people from "its own" projects. Another wanted to make its funding conditional on that donor having the right to approve all workshop communications and proceedings. (Fortunately both donors accepted that since the Network is an independent West African organization, with multi-donor support, such conditions were inappropriate). In order to obtain sponsorship to participate at this workshop, affiliation to a donor-assisted project often proved more important than professional merits and needs.

Expatriates working in donor-assisted projects in Africa found it very easy to attend the workshop, followed by the direct counterparts of expatriates. Other African staff working in donor-assisted projects, and those working in ministries or universities in Africa and elsewhere found it much more difficult, but thanks to multi-donor support, all suitable participants were sponsored.

Clearly we must not bite the hand that feeds us. This workshop and the information exchange of the animal traction network would not be possible without donor support, and we are very grateful to them. Various donors, aid agencies and international institutions have been invaluable in their support for animal traction in Africa. Nevertheless our gratitude should not censor our debate or blind us to problems where they exist. Where the policies and activities of aid agencies are detrimental to the development of animal traction, this should be openly discussed.

Interactions between subthemes

One of the clear points to emerge from this introduction to the four subthemes is how much interaction there is between them. High economic profitability may encourage additional production while high production may increase overall profits. Similarly interactions occur with low profits and low production. High or low animal traction profitability may be reflected in environmental impact, further investment in the technology or to changes in the general social and economic costs and benefits to different members of the farm households. Higher standards of living may lead to greater educational prospects for children, leading in turn to less available labour on the farm with possible consequences for draft animal herding and farm production (Phillip, Abalu and Ingawa, 1988).

Perhaps the most interesting interaction is that between profitability and constraints. Clearly constraints limit profits, but of equal importance is the observation that constraints may cease to be constraints if the system is basically profitable. Social traditions that inhibit animal traction adoption seem to be rapidly overcome if the system is profitable. Farmers can start to feed their animals well if they think it is economically justified (as it often is when animals are used for transport). The problem of tyre punctures is a genuine constraint to animal-drawn carts, but one that can be overcome: it is clear that punctures ***can*** be repaired in villages if it is economically (a bush taxi) or socially (a prestige mobylette) necessary. Farmers (or traders) may travel long distances to obtain suitable animals, drugs, implements or spare parts if it seems worth their while; if not, they will sit back and cite the lack of these as major constraints. This links in with one of the conclusions of the first West Africa Animal Traction Networkshop in Togo in 1985: where the technology is profitable, many "essential services" can be provided by the farmers themselves and the formal or informal private sectors. Projects may help to establish or speed up local processes and help remove constraints, but if the fundamental precondition of basic socio-economic profitability is not met, the impact of projects will be limited (Poats *et al.*, 1985).

Another interesting interaction that has been stressed is that between transport, production, manure use, fodder conservation and overall profitability. If farm incomes or credit facilities allow the purchase of a cart, it becomes much easier for farmers to collect and stock animal fodder and to make use of manures. This should improve animal condition and animal training (possibly enhancing operational timeliness), increase production and increase farm incomes.

Role of the workshop

People may recall that the principal objective of this workshop is "to bring together a wide range of people of various disciplines who are involved in work relating to the introduction, diversification or intensification of the use of animal power in West Africa in order to stimulate the exchange of information and ex-

periences". We have already succeeded in bringing different people together, and circulating the papers they have prepared. These contain many and varied experiences. What is now needed is some detailed discussion of these experiences and rigorous analyses. We would like to find what are the commonalities and what are the exceptions. In this way we hope to learn both general and specific lessons that should improve the value of all our work in the coming years.

The workshop will give all participants the opportunity to give networking announcements or capsule reports to stimulate information exchange, but the number of plenary presentations of papers on the workshop themes will be very limited. This is in order that we can hear something of the animal traction experiences in Senegal and then travel to villages in small groups for discussions with farmers. Much of the subsequent discussion and analysis will take place in small groups. At the last workshop in Sierra Leone the discussions with farmers and in small groups were considered the most valuable aspect of the workshop, and it is hoped that this workshop will also provide a setting for intense, profound and profitable discussions.

A major objective of this workshop is to discuss and plan the future organization and activities network. The network needs to be formally established. We need to specify what is actually wanted of the network. It is also necessary to plan what can realistically be achieved, given the available resources of individual people's time and the expected support of various organizations and donors. Following this workshop, network development will depend on specific actions rather than rhetoric and well-meaning resolutions. If the network is to develop, it will be because of our own efforts, in which case we will be supported by others. If the people at this workshop do not take any initiative, no one else is likely to.

Conclusion

This presentation has attempted to introduce some of the themes that will be the subject of our discussions during the coming days. There will be many other important topics to add to the ones briefly mentioned here. This workshop presents a unique opportunity for honest exchange of actual experiences, good and bad, "successes" and "failures", between workshop participants themselves and between participants and some of the farmers of Senegal. It also allows us to critically but constructively assess well-proven and innovative ideas and techniques being employed or proposed in Senegal and in the other countries represented here. However the workshop is merely a temporary framework, and whether the long-term objectives are fulfilled will depend on the ability of us, the participants, to make maximal use of this opportunity. We have all made a considerable effort to come here together, let us now work together to ensure that, through this workshop, we make a significant contribution to the use of animal traction for agricultural development in West Africa, and elsewhere.

Résumé

Cette communication est une introduction générale à la traction animale au service du développement agricole, et à quatre thèmes du séminaire : production, impact, rentabilité et contraintes. De nombreuses références renvoient le lecteur à des publications ultérieures du Réseau. La traction animale peut augmenter la production agricole par extension des surfaces cultivées, amélioration du calendrier cultural et des temps de travaux (labour, semis, désherbage). Les productions vivrières peuvent être augmentées même si les cultures de rente demeurent l'activité prioritaire. Les cultures associant une plante fourragère sont très répandues et la paille d'arachide est de plus en plus conservée. La présence d'un marché de la viande introduit de nouvelles opportunités commerciales et influence les méthodes de gestion de la carrière des animaux de trait. Une bonne gestion permet d'intégrer les animaux de trait femelles à toutes les activités de produc-

tion. L'adoption de la traction animale augmente le niveau de risque, mais réduit la pénibilité des travaux. Les avantages et les coûts socio-économiques de la traction animale varient en fonction de l'âge et du sexe des membres de l'unité de production. Le prêt et la location des équipements contribuent à distribuer les avantages et les coûts de la traction animale entre les membres de la communauté. La traction animale est fréquemment rencontrée dans des environnements d'intensification des cultures, de déforestation, de monoculture permanente, de réduction de la diversité des espèces, et d'une certaine augmentation de l'érosion. Néanmoins, il n'y a pas de relation de cause à effet entre l'utilisation de la traction animale et la dégradation de l'environnement. La culture attelée stimule l'intégration agriculture-élevage. Les charrettes attelées favorisent de nouvelles initiatives commerciales et la circulation des marchandises, personnes, produits, eau, résidus de récoltes, engrais divers. Les boeufs de trait prédominent, mais les ânes et les vaches sont de plus en plus employés. Toutes les espèces d'animaux de trait ont tendance à s'étendre géographiquement vers le sud.

Le maintien et la profitabilité de la traction animale dépendent des programmes de crédit, de l'approvisionnement en équipements, des services de réparation et des services de soins vétérinaires. Une fois la traction animale établie, ces services de soutien peuvent être pris en charge par le secteur privé. Les programmes de crédit à long terme et les filières commerciales des sociétés cotonnières ont favorisé l'adoption rapide de la culture attelée. Les contraintes au développement de la traction animale peuvent inclure : manque d'équipements adaptés, problèmes de santé des animaux, malnutrition des animaux (quantité et/ou qualité), défrichage et essouchage des champs, pratiques paysannes traditionnelles, manque de connaissances techniques, faiblesse des infrastructures, débouchés commerciaux limités. La plupart des contraintes peuvent être résolues si les autres conditions au développement sont satisfaites et si les connnaissances techniques circulent rapidement. La main-d'oeuvre peut constituer une contrainte dans certaines situations. La traction animale élimine les goulots d'étranglement en redistribuant les travaux entre les saisons et les membres de l'unité de production, diminuant ou augmentant les besoins globaux. Les stratégies de développement nationales et les interventions des organismes de développement peuvent contribuer au développement de la traction animale, mais elles peuvent aussi constituer une contrainte. Les interactions entre les différents thèmes du séminaire sont nombreuses. Elles incluent rentabilité-production, profitabilitéimpact, transport-engrais-fourrage-production-profitabilité. L'interaction entre rentabilité et contraintes est primordiale, le niveau de profit constituant un excellent indicateur de résolution des contraintes.

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