

The introduction, intensification and diversification of the use of animal power in West African farming systems: implications at farm level

Keynote address by

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Abstract

In Ethiopia and North Africa, draft animals have been used for centuries, sustained by traditional services. In much of sub-Saharan Africa, systematic attempts to introduce animal traction to increase export crops started between 1905 and 1945. Almost all countries in Africa are now actively encouraging the use of animal power.

In Africa about 10 to 17 million draft animals are employed. Estimates are given of the numbers in use in different countries. In West Africa about one million draft cattle and 800,000 donkeys and horses are used for work. Most of these are found in the Sahelian and savannah zones, with the highest concentrations in central Senegal and central and southern Mali. In Africa, primary soil cultivation accounts for 90% of animal power usage. Less than 5% of farmers who plow with animals use seeders or weeding tines. Carts are used all year so their importance is greater than their numbers imply.

Single discipline, component, on-station research has generated technically excellent, expensive solutions to non-limiting factors. Examples include wheeled toolcarriers and large draft animals, which are unaffordable and unadapted to farm conditions. Research programmes should consult farmers from the outset, concentrate on limiting factors, and maintain economic and environmental realism.

In The Gambia an extension programme, based on training centres, started in 1955 and by 1975 it had brought work oxen into most villages. Between 1965 and 1985, donkeys became increasingly important. Donkeys are inexpensive and un-

likely to be stolen. The rapid adoption of donkeys involved major changes in harnessing, equipment and cropping systems and these were achieved through farmer innovation, and not government intervention.

When animal traction is introduced, equipment should be selected that is simple, affordable, available and easily maintained. Animals should be well adapted to the environment and capable of existing on available resources. Animal traction involves investment in time and money and exposes farmers to increased risks. The social and economic costs and benefits of animal traction vary between gender and age groups and develop over a period of years. Where animal traction is clearly profitable, social constraints and unfamiliarity can be rapidly overcome.

Intensifying animal power can involve using draft animals for more cultivation operations or for transport. A wide range of implements is available. An association between the adoption of carts and the conservation of crop residues has been seen in several countries. Diversified uses include animal-powered systems for water raising and milling, water harvesting and the construction of ponds or terraces. These operations often require social cohesion.

Introduction and workshop orientation

The objective of this paper is to provide an overview of animal traction in West Africa, and also to introduce some of the workshop themes. The overall workshop theme of "the introduction, intensification and diversification of the

use of animal power in West African farming systems" was chosen by the Networkshop Committee at its combined meeting and study tour that took place in Senegal and The Gambia in November 1985. The committee decided that deliberations during this workshop will focus on the farm level implications of animal traction. The village discussions with farmers that are planned for the field visit should assist this orientation.

Four closely interrelated subthemes have been selected to help stimulate discussions: animal power equipment at the farm level; animal utilization and management at farm level; economic implications of animal power at the small farm level; and social implications of animal power at the farm level. At first it might seem that these topics, each closely associated with a single discipline, might discourage the holistic approach that is normally encouraged by those with a farming systems perspective. In fact it is intended that the small groups visiting the villages and discussing the workshop theme will be multidisciplinary. During the course of the workshop all participants should have an opportunity to consider, in greater or less detail, all the subthemes. For example it is anticipated that, in addition to their discussions in their own fields, the economists and sociologists will look at the problems of equipment and animal health, and also that the agricultural engineers and veterinarians will consider the economic and social implications of animal traction technology.

It is hoped that as the workshop develops, networking will be seen as a valid methodological component of research and development programmes. Networking through document exchange, study visits and workshops allows people to broaden their horizons, become more aware of the options, and build on each other's experiences. Study visits can benefit both sending and recipient organizations by stimulating, in a non-threatening way, self-assessment by both projects. Some of the benefits of study tours and workshops can be successfully com-

bined through network monitoring tours. Examples of these are the crop-livestock systems tours of the Asian Rice Farming System Network, coordinated by the International Rice Research Institute, IRRI. These have involved international groups of research workers travelling extensively for two weeks to farm sites in several locations in two countries, and combining discussions of the farming systems observed with presentations of the work being undertaken by the participants in their own countries (IRRI, 1985; Starkey and Apetofia, 1986).

The Farming Systems Support Project (FSSP) has, in the last 18 months, attempted to improve contacts between those working on animal traction in West Africa, and many of the ideas and examples cited in this paper can be traced back to previous networking activities in the region. For example, this paper will draw on three animal traction network publications produced in the last year: the proceedings of the animal traction workshop in Togo (FSSP Network Report 1, edited by S. Poats *et al.*, 1986), Networking Paper No. 14 (Starkey, 1986) which provided an overview of animal traction in Africa and the report of the visit of animal traction specialists in West Africa to Nepal and Indonesia (Network Report 3 by P. Starkey and K. Apetofia, 1986). The paper also benefits from the ideas and information exchanged during the network meetings in Togo and Senegambia.

Other organizations have also been promoting information exchange; for example, the Mano River Union has financed visits between animal traction programmes in Sierra Leone, Guinea and Liberia. Participants at this workshop are being funded by a wide range of organizations. It is hoped that the workshop will stimulate similar examples of cooperation between animal traction programmes in the region.

This workshop will be orientated to village level and the individual farmers. It is understood that such farmers are highly dependent on decisions taken by governments, projects, credit organizations and other institutions at a national level.

While it would certainly be most useful to exchange experiences concerning the organization and operation of development projects, national services and large-scale manufacturers, this is not the objective of the present workshop. It is hoped that, by focusing on the village level, implications for national organizations will become clear through identification of key constraints. However detailed discussion of national strategies may well have to wait for a subsequent workshop.

Overview of animal traction in Africa

The great diversity of Africa, geographically, ecologically, socially, economically and politically, makes meaningful generalization very difficult. Even within countries, there can be a great range of conditions, making global statements concerning animal traction in just one country fraught with problems. Yet there is a need to draw together experience from widely different farming systems. Thus while the danger of generalization and simplification is acknowledged from the outset, it is hoped that this will be offset by the enhanced understanding that can come from an overview.

An historical perspective

It is helpful to briefly contemplate the history of draft animal power in Africa, as this assists an understanding of some of the present constraints. The development of draft animal power in Africa has been considered in several reviews, including those of ILCA (1981), Munzinger (1982), Bigot (1985), Starkey (1986) and Pingali, Bigot and Binswanger (1987). In Ethiopia, the Nile Valley and North Africa, draft animals have been very widely used for centuries, and in many ways the well proven systems of utilization found today differ little from those used long ago. In these countries the plows, or ards, are made by the farmers themselves or by village artisans and they can be maintained in the villages. Apart from exceptional needs resulting from droughts or resettlement,

government services are not normally required to sustain animal traction technology. The training of animals is carried out by farmers, and transactions relating to implement and animal ownership involve mainly traditional sources of capital and credit. The use of animals for pack transport is also very common in Ethiopia and northern Africa. In several other parts of Africa, including Mali and Somalia, different cultures have traditionally used animals for carrying people or goods. However in most sub-Saharan African countries the use of draft animal power for crop cultivation is less than a century old.

In the nineteenth century, animal traction was widespread throughout Europe, and as missionaries, traders, colonizing forces and settlers came to Africa they brought with them the draft animal technology with which they were familiar. Animal-drawn carts generally came first, and these were used around many of the trading ports in the nineteenth century. In a few cases including Botswana, Kenya, Madagascar and South Africa plows were introduced before the beginning of the present century. In Madagascar and Botswana, the use of plows diffused rapidly, and plowing with animals rapidly became a standard practice for many of the smallholder farmers in these countries (Pingali *et al.*, 1987).

In most sub-Saharan countries, the first systematic attempts at the introduction of animal traction for crop production took place between 1905 and 1945. In the majority of cases the objective was to increase the production of export crops. In many parts of Francophone West Africa, including Burkina Faso, Cameroun, Guinea, Côte d'Ivoire, Mali and Senegal, private companies provided all the training, extension, credit and equipment necessary to allow very rapid rates of adoption of draft animals for cotton and groundnut production (Sargent, Lichte, Matlon and Bloom, 1981). For example, in Guinea, animal traction was first systematically introduced for crop production in 1919, in the flat savannah area of Haute Guinée to the

northeast of the country. The colonial administration and the French cotton company CFDT (Compagnie Française pour le Développement des Fibres Textiles) wished to increase the export of cotton. As a result of the extension efforts, the number of Guinean farmers using work oxen increased rapidly from 24 in 1919 to 790 in 1924. By 1928 over 4000 farmers were using oxen, with a total of 24,000 ha being plowed with animals (H. Verheaghe, personal communication). Today about 100,000 draft oxen are used in Guinea. Similar rapid and very localized expansion was seen in parts of Kenya, Uganda and Tanzania, also associated with cotton production (Kinsey, 1984; Pingali *et al.*, 1987).

Thus by the time of the second world war, animal traction was well established in several southern African countries, and was used in very specific and limited areas in most savannah regions of Africa. At this time most of Africa was under European administration, and it is important to understand the dramatic changes that were occurring in European agriculture at this time. The psychological effect of these changes directly or indirectly influenced policies in Africa for the subsequent three decades, including the period immediately following the emergence of new, independent states. In Great Britain, there were 11 million draft horses in use in 1910, but as tractor power developed this fell to 650,000 in 1940 and 370,000 in 1965. In France in 1940, there were 2 million draft cattle and 1.8 million work horses, but by 1965 this had dropped to 100,000 working cattle and 730,000 draft horses (Binswanger, 1984). Clearly, in European agriculture, animal traction was becoming a rapidly outmoded technology, and the universities and agricultural colleges naturally emphasized the new forms of mechanization and neglected animal traction. This had two major consequences. Firstly during the 1950s, 1960s and 1970s there were numerous attempts to introduce tractorization schemes in Africa, often with disastrous economic and ecological consequences. Secondly, a whole generation of African educators and

decision-makers had been trained in an environment (whether in Africa or Europe) in which it was generally assumed that animal traction was old-fashioned and of purely historical interest. Thus, in the pre- and post-independence periods, very many national policy decisions in agriculture were taken by people who considered any promotion of animal traction would be a U-turn back to the stone age (Argus, 1979). (This delightful phrase comes from an article written by a university lecturer who was criticizing attempts to introduce draft animals on the farms of Njala University College in Sierra Leone).

By the 1970s, most countries had recorded failures in over-ambitious tractorization schemes (Pingali *et al.*, 1987). Fuel crises were followed by chronic foreign exchange problems. Agricultural planners and donor agencies realized that the majority of the farmers in Africa still used hand cultivation techniques, and in most countries there grew a new interest in stimulating the development of animal traction. Interest of national authorities was complemented by donor support so that multilateral and bilateral aid projects proliferated (Sargent *et al.*, 1981). During the 1960s and early 1970s, few governments kept statistics relating to animal traction, and many writers and development workers claimed draft animal power was a badly neglected subject (Smith, 1981; Vietmeyer, 1982; FAO, 1982; Munzinger, 1982). Nevertheless attitudes were rapidly changing, so that by 1986 in almost all countries in Africa animal traction was being actively encouraged by government departments, parastatal organizations, major aid projects and non-governmental agencies (Starkey, 1985; Starkey and Goe, 1985; Starkey, 1988). Thus, if viewed from a continental perspective, relatively large amounts of public sector funds (African, international and bilateral) are now being channelled into the active promotion of animal traction, and related research and development activities. In a few countries, draft animal power is also being promoted by private manufacturing and commodity trading companies.

Since there is now a significant interest in animal traction, it is important to ensure that those resources being allocated to draft animal power are efficiently utilized.

A geographical and numerical perspective

North and Northeast Africa

While in the whole world there may be as many as 400 million draft animals (Ramaswamy, 1981), in Africa the total figure is only in the order of 10 to 17 million (ILCA, 1981; Anderson, 1984). Of these around 6 million are found in Ethiopia, where almost all the farmers in the highlands use draft oxen (Anderson, 1983; Gryseels, 1983). In Morocco, over one million animals are employed including oxen, donkeys, mules, horses and camels. In Egypt, about one million cattle and water buffaloes are used for work. Elsewhere in North Africa animal traction is also widespread in the small-farm sector, although the number of animals employed is smaller.

West Africa

In West Africa, there are three broad zones in which draft animals are used. In the north of the Sahel, where rain is less than 600 mm per year and arable farming is limited, most of the animals employed for work are donkeys, horses and camels, all mainly used for transport. Further south is an ecological belt running from central Senegal to Chad including northern Nigeria and northern Cameroun, where zebu breeds of cattle are widely used for crop cultivation. South of this zone, trypanosomiasis is a major constraint. Thus in The Gambia, southern Senegal, southern Mali, southwestern Burkina Faso and the northern parts of Guinea, Sierra Leone, Côte d'Ivoire, Ghana, Togo and Benin, where work animals are used, they are generally small, trypanotolerant taurine cattle. Equines are seldom used in these Guinea savannah areas and purebred zebus are rare. In the more humid zone, a belt stretching some

400 km inland from the southwestern and southern coastline, there are very few cattle of any breed and no equines.

In Mauritania, crop cultivation with animal traction is uncommon and probably only 4000 zebu oxen are employed. However donkeys, horses and camels are widely used for transportation. In Senegal over 30% of farmers use draft animals for cultivation, including about 200,000 horses, 130,000 donkeys and 100,000 cattle (Harvard, 1985). In The Gambia about two thirds of the farmers use animal power, and employ 30,000 donkeys and 18,000 N'Dama taurines (Starkey, 1986). In Guinea about 100,000 N'Dama are used for work (Bigot, 1983). Between 30,000 and 40,000 taurines and taurine-zebu crosses are employed in each of Côte d'Ivoire, Ghana and Benin (Bigot, 1983; Smid, 1982; Manigui and Medenou, 1986). In Togo about 7000 taurine and taurine-zebu cattle are employed, while in Sierra Leone about 1000 N'Dama oxen are used (Starkey and Apetofia, 1986; Starkey and Kanu, 1986). In Mali, about 50% of the farmers use animal traction, employing a total of about 400,000 draft animals: 200,000 cattle (taurines, zebus and crossbreds), 150,000 donkeys and 40,000 horses (DMA, 1986). In Burkina Faso 140,000 draft animals are employed by 10-15% of the farmers. About 80,000 cattle are used for cultivation, particularly in the southwest of the country, while the majority of the 60,000 donkeys and horses are used for transport in the central areas (Imboden *et al.*, 1983). In Niger about 16,000 zebu cattle are employed, together with 10,000 donkeys, while in Chad the figures are much higher, with 130,000 zebu cattle and over 50,000 donkeys. In northern parts of Nigeria 200,000 zebu cattle are used for work while the comparable figure for Cameroun is 55,000 (SODECOTON, 1986). In the central and southern parts of both these countries, the use of draft animals is rare.

Thus in the whole of West Africa about one million draft cattle and 800,000 donkeys and horses are used for work, in addition to a much

smaller number of camels. The great majority of the working animals are found in the Sahel and savannah zones, with very small numbers in the arid and humid zones. Overall, perhaps 10-20% of farmers in West Africa use draft animal power, with the highest concentrations in the cotton- and groundnut-growing areas of central Senegal, central and southern Mali, and the southern parts of Burkina Faso, Niger and Chad together with the northerly parts of Côte d'Ivoire, Ghana, Benin, Nigeria and Cameroun. All countries in the sub-region have research and development activities relating to animal traction.

Central Africa

In the forest zone of central Africa, there are very low cattle populations, and even fewer equines. Projects promoting the use of draft animals in northwest Cameroun and Zaire have experienced high cattle mortality, but have persisted due to the sustained interest of farmers and development agencies (Wagner and Munzinger, 1982; Starkey, 1984a). In most countries in the sub-region, both governments and non-governmental organizations are carrying out studies on the potential for draft animal power, and a few private agricultural companies are using work oxen. However, at present well under 1% of farmers use this technology.

East Africa

Animal traction is used in all countries of East Africa, but there are great differences between and within countries in the extent of its use. For example in Kenya, an overall figure of 12% of all farmers using a total of 700,000 working animals, mainly zebu oxen, derives from some areas, such as Machakos, where 80% of farmers use draft animals, and from other areas, such as the Maasai rangeland, where no cattle are used for cultivation (Starkey and Goe, 1984). In Tanzania around 600,000 East African Zebus are used for work, and cultivate about 15% of the cropped area (Kjaerby, 1983). In Uganda, about 600,000 draft oxen are used, particularly in the cotton-growing areas in the south. In

many parts of the East African sub-region, agricultural research stations, universities and agricultural projects are currently undertaking research and development studies relating to animal traction.

Southern Africa

Draft animals are used in all countries in southern Africa, and in Botswana 80% of farmers work with animals, using a total of 350,000 cattle and 140,000 donkeys. Cattle often plow in mixed teams of 6-12 oxen, bulls and females (Farrington and Riches, 1984; Starkey and Goe, 1984). In Malawi, about 70,000 work oxen are used, with adoption ranging from 60% in some areas in the north to less than 5% in the south (Starkey, 1985). About 500,000 oxen are used in Zimbabwe, where 15-20% of smallholders use animal power, and 180,000 are used in Zambia, mainly in the central and southern areas (Shumba, 1983; MAWD, 1985). In Mozambique, about 100,000 draft animals are employed, mainly in the south of the country, while in Madagascar, 330,000 draft oxen are used (Lexa, 1985; Tran van Nhieu, 1982). In central Angola, about 350,000 draft oxen are employed. Work oxen have been quite widely used for crop cultivation in Swaziland and Lesotho for many years, and in Lesotho donkeys and horses are commonly used for transport. Throughout the independent countries of southern Africa, and in Madagascar, development projects are currently promoting the use of draft animals, and several research studies are being undertaken.

From these generalized figures, it is clear that while there are differences between the present extent of draft animal power utilization in the different sub-regions and countries, there are also some important similarities. With the notable exceptions of Ethiopia and Botswana (and perhaps some central African countries), there are wide variations within each country as to the extent of adoption. While overall national figures are commonly in the order of 10-25%, these disguise large within-country variations,

with localized adoption rates as high as 80% being offset by other areas where fewer than 5% of farmers use animal power. In almost all countries, animal traction has been proven to be viable in certain (often undefined) circumstances, and therefore in each country innovative farmers could travel to see draft animals in use and could obtain basic advice and equipment. In almost all countries, there are full-time professional staff of ministries, projects, research stations and educational institutions that are currently devoting a great deal of time to development activities aimed at improving the use of draft animal power.

The range of operations

Having considered the numbers of draft animals in use in Africa, it is important to understand the extent to which they are used. Primary soil cultivation accounts for probably 90% of animal power usage, with probably three million maresha ards in use in Ethiopia, and a similar number of steel mouldboard plows in use elsewhere in sub-Saharan Africa. The majority of plowing is for dryland crops, notably maize, sorghum, groundnuts, cotton and teff. In Madagascar, parts of West Africa and in small irrigation schemes elsewhere, oxen are used for plowing and puddling rice swamps. In a few places in Africa, including northern Nigeria, ridgers are used instead of mouldboard plows. Senegal is unusual in that about 150,000 seeders and 70,000 groundnut lifters are in use (Harvard, 1985), but elsewhere numbers of seeders and groundnut lifters are very small. Throughout Africa, harrows may be used, but there may be ten plows for each harrow in use. While weeding implements are available in most countries, it is likely that less than 5% of farmers who plow with animals use weeding tines. While fewer than 10% of animal power users have carts, these may well be in use throughout the year, and so their importance may be greater than absolute numbers imply. In Ethiopia the use of animals for threshing by trampling is common, but this involves little time and no equipment. In some parts of the

Sahel and Botswana, animals are used to raise water from wells, and in a few countries in Africa oxen and mules are used in timber extraction. In Northeast Africa, animals are used for grinding and oil extraction, using traditional wooden mills.

It should be remembered that the majority of crop farmers in Africa still use manual labour for their farming. However it is clear that animal traction is becoming increasingly important in most sub-Saharan countries. At present most draft cattle are only used for plowing, an operation frequently restricted to one cropping period each year. As the ownership of draft animals necessitates investment in time and resources throughout the year, the lack of regular employment has major implications both for overall farm profitability and the standard of training of the animals.

Animal traction component research

Single discipline studies

Many countries now have multidisciplinary farming systems research teams, but in most countries such team work is a quite recent phenomenon. Historically, and this includes the time up to the early 1980s, most research relating to animal traction was carried out by single disciplines working in isolation. For example, in most countries those responsible for research on agricultural engineering and those responsible for research on animal nutrition and breeding worked in separate organizations, ministries or divisions, with few linkages or contacts between the professional staff. In such circumstances, it was common to find the agricultural engineers designing and re-designing plows and implements, while the livestock specialists concentrated on producing feed supplements or the genetic improvement of potential draft animals through breeding. Staff of both divisions strove to achieve excellence in their fields, and the results were often implements and animals of superb quality. However, all too

often, the research had little impact on the farmer, as it did not address the critical limiting factors, and did not take into account the fact that the farmers could not afford the cost of such high quality products.

Wheeled toolcarriers

Perhaps the best example of component research leading to unaffordable solutions is the wheeled toolcarrier, which has been developed and refined for three decades. Despite widespread and continued promotion by different development agencies in many countries in Africa, it has not yet been proven by farmer adoption. In The Gambia, several hundred wheeled toolcarriers were imported, before it was found to be too expensive and insufficiently manoeuvrable (Mettrick, 1978). Different designs were tried in Botswana, and after the initial optimistic suggestions that they would prove invaluable (Gibbon, Harvey and Hubbard, 1974; Mochudi, 1975), they were quietly rejected by farmers (EFSAIP, 1981). In Senegal, wheeled toolcarriers have been commercially available to farmers for many years, but due to lack of demand, regular production has now ceased, and only small numbers are made to meet the requirements of research stations. In the past ten years, about 1000 wheeled toolcarriers, some ready-manufactured and some in the form of raw materials, were imported into Mozambique, but not used by farmers to any significant extent. Elsewhere in Africa, for example Ethiopia, Kenya, Malawi, Mali, Nigeria, Tanzania, Zimbabwe, wheeled toolcarriers have been evaluated and modified on research stations, but have not been recommended for farmer use. Altogether more than 5000 wheeled toolcarriers have been made in Africa or imported, but the number ever used by farmers as multipurpose implements for several seasons has been negligible. A similar combination of on-station success and on-farm rejection has been observed in India and Latin America (Starkey, 1987).

The problems of wheeled toolcarriers at farm level are seldom discussed in the literature, so that many people are under the impression that the technology has been widely adopted by farmers. There have been a few technical problems, and some designs have needed much modification, but most of the difficulties have been due to the differences between the conditions under which the equipment was developed, and the realities of the farms. For example farmers have often complained of the weight of the toolcarriers, which had been developed and tested using station-maintained animals that have been far bigger and stronger than village animals. Similarly farmers have complained of problems of manoeuvring wheeled toolcarriers around stumps, whereas these and other obstructions seldom exist on research stations. In many countries the wheeled toolcarriers have been rejected on the grounds of convenience or of economics. Some farmers who have been lent them for evaluation have been happy to keep them, but not to pay the real cost of the toolcarriers. Few farmers have used wheeled toolcarriers as multipurpose implements for long. After initial testing, most farmers have used them only in a single mode (plowing, cultivating or, most often, transport). Farmers have pointed out that it is preferable to own a simple cart and a simple plow than one combined implement. This is more flexible, more convenient and it reduces risk. Much time (and money) could have been saved had researchers spent more time discussing with farmers the technical and economic realities of their farming systems, rather than concentrating on the undoubted successes achieved on the research stations (Starkey, 1988).

Improved draft breeds

There are strong parallels between the development of wheeled toolcarriers and the development of improved draft animals. Both have tended to be the domain of a single discipline, both have been centred on research stations, and both have had strong donor support. In both cases, the goal has been excellence, rather

than adaptability and affordability. In several countries, including Côte d'Ivoire, Kenya, Madagascar, Malawi and Senegal, breeding programmes have produced crossbred animals that are clearly stronger than indigenous breeds, (Letenneur, 1978; Tran van Nhieu, 1982, Tessema and Emojong, 1984). However the crossbreds have inevitably required more maintenance feeding (Anderson, 1983; Tessema and Emojong, 1984), they have often been disease-susceptible (Letenneur, 1978), and have been more expensive (Tran van Nhieu, 1982). Discussions with farmers indicate that while strength may be desirable, vital characteristics of draft animals include the requirement to be relatively inexpensive, readily available and easily changeable, and animals must be able to survive using available and affordable feed resources and animal health services (Starkey, 1985). Thus, while farmers are often happy to benefit from the output of subsidized breeding programmes, such schemes are unlikely to be viable in the long term. This was seen in Senegal where little now remains of the draft animal breeding programme of the late nineteen sixties (Hamon, 1970).

The examples cited have involved agricultural engineers and animal scientists. However many comparable examples of component research giving rise to relatively expensive solutions to non-limiting factors could be cited in other disciplines, for example relating to the development of nutritionally excellent but highly expensive feed supplements, and even technically sound but excessively time-consuming training courses.

Lessons from previous methodologies

The most important lessons from these examples are that farmers should be consulted from the outset, that studies should be prioritized to address the key limiting factors, and that economic criteria must not be forgotten. It is also important that research should be carried out under conditions representative of the local farming systems. The multidisciplinary ap-

proach should include a careful assessment of the priorities for the farmer, and care should be taken that research subjects reflect the key constraints of the farmers, rather than simply the interests of the researchers. A strong element of economic realism should be integral within any research team, so that time is not wasted on developing technically excellent, but clearly unaffordable solutions. The methodology should be flexible and open-ended, being designed to seek solutions, rather than prove points. The studies should be highly developmento-rientated, with any data collection being merely a means to an end, rather than an end in itself, and measurements or assessments should clearly reflect those parameters important to the farmer. Wherever possible, research should be carried out on representative local farms, using resources that are available to, and affordable by, the farmer. Finally, research should be undertaken in close liaison with similar programmes elsewhere, to ensure that researchers do not duplicate studies unnecessarily, and that they build on each other's experience.

Animal traction in The Gambia

Introduction of draft oxen

In many West African countries at the present time, projects are attempting to introduce animal traction into different farming systems with very different success rates. The Gambia is a small country that has not had any long history of using draft animal power, and yet today over 60% of rural households use animals for work. It is therefore interesting to see how such innovative changes have come about, and what the implications may be for the introduction and the diversification of animal power in other countries in the region.

The first recorded systematic attempt at promoting working animals in The Gambia appears to have taken place in 1947, when a small

number of ex-servicemen were assisted to purchase oxen and steel plows. However the major extension thrust started in 1955, with the establishment by the Department of Agriculture of the first ox-plowing schools. These schools initially trained both young men and oxen for long periods of six to nine months, during which time accommodation and board were provided, and a small allowance paid. By 1965 there were 24 schools (subsequently known as Mixed Farming Centres) with 377 trainees. The period of training was gradually reduced, so that in 1965 it involved two months at the centre, the cultivation season on farm, with supervisory visits, and regular refresher training at the centre. Cattle had to be provided by the family or sponsors of the trainee but for the first season robust Emcot ridging plows were lent to the trainee. Small financial incentives were given to the trainees and trainers to encourage widespread use of the animals during the first season, and short-term credit was made available for purchase of seeds and fertilizer. Trainees, or their sponsoring farmers, were expected to purchase their own ridger by cash payment after the training period.

The initial impact of the ox-plowing schools was encouraging and the numbers of work oxen in use increased rapidly. Prior to 1955 very few farmers in The Gambia used draft animals. However the ox-plowing schools and extension programme during the period 1955 to 1970 brought animal traction into the majority of villages in the country. By 1975 about one third of farming families were using draft animal power and such a major change in just twenty years represents a small agricultural revolution. The importance of the formal extension programme was highlighted during a recent visit to The Gambia when farmers in fifteen villages all asserted that animal traction had started in their villages 17 to 20 years before as a direct result of the Department of Agriculture programme, and that prior to this extension programme no one in their families had ever tried to use work animals.

Diversification and donkeys

From 1955 to 1976 training had been based at Mixed Farming Centres and involved only N'Dama work oxen. In 1977 it was decided to start a programme of village-based farmer training, in order to reach more farmers. At the same time it was decided to allow extension staff to assist in the training of donkeys and horses. In contrast to the initial, highly innovative decision of the Department of Agriculture to promote oxenization, the decision to train donkeys and horses was an example of the extension staff responding to the farmers' own innovation. Up to this time all government reports had referred to oxenization and ox-drawn implements. Donkeys and horses had not been used or trained at Mixed Farming Centres, and animal traction research involved only N'Dama oxen. However farmers, on their own initiative, had been increasingly using donkeys and horses for work, often obtaining the animals and harnessing from private traders in Senegal.

The 1974 the Agricultural Census put the number of oxen or bulls in use at 44,000 and the donkeys and horses at 10,000 and 5000 respectively. Thus already by 1974, 25% of compounds were using donkey power, primarily for seeding. In one area there were more donkeys in use than oxen. The numbers of donkeys in use have risen very rapidly, and there are now estimated to be 30,000 donkeys working in The Gambia while the number of oxen has dropped to about 18,000. Figures for 1983 put the national figures at 38% of compounds using oxen, 44% using donkeys and 13% using horses (these figures are not exclusive and some farmers will be in more than one category). Thus during the period 1965 to 1985, donkeys changed from being of minor importance to their present status of the dominant draft animal of The Gambia. This rapid change, almost another farming revolution, appears to have come about almost entirely through farmer innovation rather than extension effort, and illustrates clearly how quickly a technology can

spread without government intervention if farmers see it to be profitable.

Reasons for preferring donkeys

The increasing popularity of donkeys was largely due to their low cost. The meat of donkeys is not eaten in The Gambia and surplus donkeys from Senegal could be bought for US\$15-25. On the other hand oxen, which are valuable for their meat, cost US\$100-170. However it was not simply cost that caused the change, for some farmers who owned cattle started using donkeys in preference to their oxen. One major reason for the use of donkeys is related to the perceived requirement for several people to work with oxen, while frequently only one person is used to control a donkey. Some farmers appeared unaware that it is possible for oxen to be worked with one person, as is normal in Ethiopia and Asia. For others, the risk of theft prevented them investing more of their time in training, since well-trained, docile oxen are much easier to steal than poorly trained, wilder animals. Donkeys are not very attractive to thieves since they are of low value and cannot be easily transported and sold in the form of fresh meat. This means a farmer can allow a well-trained and docile donkey to wander unsupervised in the dry season without the nagging fear of theft.

This example shows that The Gambia has experienced two dramatic changes in its farming systems in less than thirty years. Firstly through a highly structured extension programme based on formal training centres, the extension service brought what previously was almost an unknown technology into the majority of the villages in The Gambia. This suggests that lack of knowledge of innovative technologies, or lack of confidence to try them, can indeed be limiting factors, and that catalytic programmes to introduce draft animal technology can sometimes be both appropriate and highly effective.

Implications of the farmer innovation

The rapid spread of donkey technology throughout The Gambia, prior to any official encouragement or endorsement by the extension services, illustrates how very quickly knowledge can diffuse through informal channels. This spread involved not just a change in animal, but a change in cultivation system: a change from heavy draft plowing and ridging with oxen, to tine cultivation or direct planting with donkey-drawn seeders. In many cases this involved obtaining new equipment and spare parts from neighbouring Senegal, and often innovative equipment modifications were undertaken in the villages. The change from paired oxen to single donkeys involved a change from simple wooden yokes to more complicated rubber or leather harnesses and different hitching systems. Yet these dramatic changes did not involve government services but were based mainly on traditional means of obtaining knowledge, training, advice and credit.

It could be argued that the example of The Gambia is not typical, since it is a small country, and farmers were influenced by developments in neighbouring Senegal. However the case of animal traction technology crossing national frontiers is by no means unique in West Africa. Emtcot ridging plows from Nigeria have spread into neighbouring Niger, Benin, Togo and northern Ghana through private traders, and plows from Guinea have been brought into Sierra Leone. In many countries animal traction has been sustained entirely by private training, equipment and financial services. Conversely there have been many expensive projects that have actively tried to promote animal traction, with disappointing results.

Economic and social considerations (costs and risks) are crucial to the adoption of technology. In The Gambia, farmers have adopted a novel, exotic species of animal with a high mortality rate which was cheaper than the indigenous cattle. Elsewhere donor-assisted projects have often tried to promote the use of new breeds

that have been disease susceptible and more expensive than local breeds, and this has not generally been successful. In The Gambia, a new harnessing system using a single animal spread rapidly, despite the fact that it was slightly more expensive and complicated than the wooden yoke, and this may be because it allowed the use of the cheaper animals that required less training and supervision. Elsewhere new yoking systems have not been rapidly adopted, because they have often not been associated with clear benefits. In The Gambia the farmers rejected the government-subsidized wheeled toolcarriers that were complicated, heavy and very expensive. Nevertheless they have also shown themselves willing to invest their private resources in other technology, such as the Super Eco Seeder, that also seems quite complicated and expensive, but which is seen by the farmers as very appropriate.

The introduction of animal traction

Equipment

In general, equipment should be selected that is simple, affordable, readily available and can be easily maintained. The word selected, rather than developed, is used since there already exists a vast number of equipment designs. Innovative farmers and village artisans are generally very astute at selecting the most appropriate equipment to their needs from a range of options. They can often fine-tune the equipment to their particular conditions by various modifications to the existing design.

Animals

When animal traction is introduced, it is particularly important that the animals used should be well adapted to the environment and capable of existing on the resources available to the farmer. Many introduction programmes have been severely set back by high mortality rates in the early years. Animals should be af-

fordable and available in sufficient quantity that a farmer can obtain replacements easily. In most cases this will mean that indigenous breeds are used. There are far too many suggestions by external consultants that large or exotic breeds should be used by programmes attempting to introduce animal traction into an area. Such animals would almost certainly be less hardy than local animals, require greater resources and a higher degree of management, and be difficult to obtain in the short term. When a new technology is combined with a new animal, there is a strong risk that the appropriate technology would be rejected because of problems with the inappropriate animals.

Economic issues: risk and credit

Introducing animal traction is likely to involve farmers in considerable investment in their time and resources, and expose them to significantly increased risk. It may be desirable to provide some form of insurance against the risk of losing an animal, and some credit schemes, such as those operating in Burkina Faso, include an insurance element within the loan terms. In the first year, there are unlikely to be rapid returns from adopting animal traction, and the benefits may only develop over a period of five to seven years (Barratt *et al.*, 1982). It is unlikely that loans based on standard commercial credit conditions for interest rates and repayment periods will be appropriate to programmes introducing animal traction. If credit is given, it should be based on realistic and not optimistic forecasts of farm profitability over the years, and should not assume that farmers will immediately make full use of the technology. Animal-powered farming systems require considerable effort in stumping, and it is unlikely that farmers will have the resources, time or confidence to rapidly destump their land. Thus animal traction use is likely to be progressively increased over several years. This is not simply a question of stumping, it is a question of risk. Farmers are likely to be changing from traditional mixed cropping systems that require little investment and provide low, but reliable, out-

puts. Animal power adoption implies a great investment, that has to be paid for by increased or more valuable outputs. This often is achieved by monocropping saleable commodities, a strategy which is risk-increasing, since repeated monocrops are more likely to be devastated by weeds, pests or environmental conditions than are a range of mixed crops. Farmers adopting animal traction often try to keep two farming systems running parallel for the first few seasons, thus spreading their risks, but also preventing them from maximizing their benefits from animal traction adoption.

Social implications

Programmes attempting to introduce animal traction should be aware of the social costs and benefits of the technology. In some cases the benefits achieved by one gender or age group necessitate extra costs for another social group. One example of gender effects arises in some societies when animals are used only for primary cultivation, thus saving the traditional cultivators (often men) from the drudgery and allowing greater areas to be tilled. This may result in those responsible for weeding and harvesting (often women) actually having more work, without there being compensating social or economic benefits for these people. Children are often used to look after draft animals, and farmers adopting draft animals may be less willing to send their children to school if this interferes with herding duties.

Lack of social tradition of keeping large animals is often cited as an important reason why the introduction of draft animals is difficult. Nevertheless there seems to be strong evidence from many West African countries that farmers can very rapidly adopt a technology that is unfamiliar if it has clear social or economic benefits. While it is clear that traditions and taboos can be important in any society, these can rapidly change with time. In general social constraints to animal traction adoption are only cited when there is also another problem, and this is most commonly a lack of economic

profitability. For example, in two neighbouring regions in Zaire, one project made very slow progress at the same time as another achieved rapid success. In the area where animal traction adoption was very slow, farmer unfamiliarity with cattle was cited as a major constraint; there was also no market outlet for produce. In the second area, there was a main road. Along this it was possible to sell maize at twice the price that prevailed in the first area, since there was a high demand in a nearby town. As a result villages that had hardly ever seen cattle before, and in which no one was used to handling animals, rapidly adopted animal traction. In the area in which animal traction was clearly profitable, there was little talk of social constraints (Starkey, 1984).

Environmental issues

Finally, although there is emphasis here on the equipment, the animals and the socio-economic implications of animal power introduction, one should also be aware of the environmental impact of animal traction. Introducing draft animals in West Africa has been associated with the stumping of land and the introduction of mouldboard plows or ridgers which invert the soil. It has also often been associated with extensified, rather than intensified, production. Compared with traditional, long-duration, bush-fallow systems of cultivation, animal traction farming systems tend to cause greater erosion. Animal traction may also lead to great problems of weed infestation; for example clearing forests can lead to the development of unproductive fire-climax grasslands, dominated by grasses such as *Imperata cylindrica* whose tough rhizomes make further cultivation very difficult. It may well be argued that the problem in these cases is not animal traction but the change from the traditional systems that cannot sustain the growing populations, and that there are few viable alternatives to the use of animal power. Nevertheless inevitable, it does seem important to consider the environmental implications of introducing animal traction.

The intensification of animal traction

Increasing annual utilization

In terms of the workshop theme, intensifying the use of animal traction implies using draft animals for more days of the year. Very many working animals employed by farmers are only used for primary cultivation and only work for a few weeks each year. This may mean that it is difficult to justify spending a great deal of time on training animals, so that farmers do not have precise control over their animals, and some re-training is needed each year. Intensifying animal power may involve using draft animals for more cultivation operations, notably seeding and weeding or using animals for transport. This may have important implications for cropping techniques, particularly if row planting is adopted, and the extra work involved may necessitate more attention to animal feed resources.

Equipment

There is a very wide range of implements available to carry out seeding, secondary cultivation operations and transport. An elegant idea was to combine these into a single, multipurpose implement known as a wheeled toolcarrier, but as noted above, such implements have not been adopted by farmers. Simpler multipurpose toolbars such as the Houe Sine have had some success in Senegal and Mali where they are mainly used for tine cultivation, weeding and the "earthing-up" of ridges. In Togo and Burkina Faso a triangular cultivator is sold for tine cultivation and weeding, but sales are much lower than those for plows. In northern Nigeria ridging plows are used for weeding between ridges. In southern and eastern Africa, weeders are available which are fitted with levers to adjust row width, but although they have been in use by farmers for many years, overall adoption rates are low. In some countries, including parts

of Kenya, farmers have modified their plows for inter-row weeding.

A wide range of cart designs is also available. In Asia, most carts have been based on large wooden wheels. The large diameter of the wheels is useful when negotiating pot-holes and allows the wooden bearing to turn quite slowly. In Africa wheels with wooden spokes have seldom become popular. Reasons cited for this have included difficulties in obtaining well-seasoned timber, and the stresses caused by the large changes in humidity between the wet and dry periods of the year. Carts with steel wheels fixed to stub axles and oil-soaked wooden bearings have spread on a small scale in several African countries. They are most suited to light use, for with heavy use they tend to suffer welding fatigue and wear of thrust washers and bearing blocks. In many countries carts are made from wrecked cars and pick-ups. In several West African countries including Senegal and Mali, large numbers of carts with pneumatic tyres and sealed bearings have been purchased by farmers. Although expensive, these are generally considered to be the most satisfactory type of cart, and farmers have been seen to be prepared to cope with the inevitable puncture problems once they have appreciated the economic and social value of carts.

Equipment-nutrition interactions

The interaction of the different technologies for intensifying animal power use can be seen in relation to carts and animal nutrition. Draft animals in Africa generally obtain all, or most, of their food from rough grazing. For working a small number of days each year, many animals can make use of rough grazing, and simply lose some weight during the main work period. As the number of working days each year increases, the need for farmers to provide supplementary feed for their animals also increases. One of the cheapest and simplest means of providing supplementation is the conservation of crop residues, notably groundnut straw and maize stover. Such materials are

bulky and transporting them by headload is very inefficient. By contrast residues are ideal materials for being transported in animal-drawn carts, so that the use of carts makes the stocking of residues feasible. The association between the adoption of carts and the conservation of crop residues can be seen in several countries including Senegal, The Gambia and Mali. In Ethiopia, where conservation is widely practised, pack animals are used to carry the hay and straw. In both Ethiopia and West Africa, where animal transport has become an important income-generating activity (particularly around towns), markets have developed for feed supplies, such as crop residues. Farmers, without any assistance from development projects, have often responded rapidly to the demand for animal feeds by conserving crop residues, or even growing fodder specially. In contrast many feed supplements developed by researchers, and promoted by development projects, have had little uptake, often because they were not considered to be cost-effective. This again illustrates that profitable marketing opportunities are often a prerequisite for adopting a technology.

Social and economic effects

Animal-drawn carts can have important social and economic effects within communities. In Sierra Leone, ox-carts have been used to transport sick people, to take village officials to chieftom meetings and to allow village tailors to work at local markets. In Zambia, it was considered that in some regions agricultural production was suppressed by lack of marketing opportunities, and that marketing was constrained by lack of rural transport. As a result, farmers were assisted to purchase ox-carts, as an indirect means of stimulating crop production (Mack, 1984). In Malawi it was reported that some farmers found that their secondary transport operations became more profitable than their primary production (Starkey, 1985).

Intensified production may require different systems for managing draft animals during the year. In much of West Africa, animals remain in large herds for most of the year and are only kept within villages during the cultivation season. As the use of animals increases, there is a tendency for animals to remain in the villages for longer. This may have implications for the work of children, as herders. Since it is relatively inefficient for one person to supervise the grazing of a single pair of animals, community grazing schemes may be adopted, provided there is sufficient social cooperation. An alternative strategy adopted by some communities is to move towards the stall feeding of draft animals.

Diversification of animal traction

Novel uses of animal power

In the context of this workshop, diversifying the use of animal traction implies extending the use of power beyond the standard range of crop cultivation and transport operations. Examples of diversified uses include animal-powered systems for water raising or milling, such as those being evaluated by the German Appropriate Technology Exchange (GATE) in Senegal, Burkina Faso and the Central African Republic. Also under this category would fall the use of draft animals for water harvesting in arid areas such as the Turkana district of Kenya; the construction of ponds or terraces as being developed in Ethiopia; and the use of animal power for timber extraction, whether at a commercial level, such as in the forestry operations in Malawi and Swaziland, or at the village level, as is found in Togo. Diversification may also be taken to include the use of novel breeds or species, such as the evaluation of water buffalo in Senegal. Perhaps more importantly it can include the use of female animals for work, a subject of interest to farmers and research programmes in several countries in parts of Africa, including Senegal and Cameroun.

Equipment

The equipment for diversified operations is often very expensive, as in the case of animal-powered mills and gears. While in North Africa and Asia there have been traditional systems for grinding and for raising water based largely on wooden construction, many modern designs being evaluated are made of steel and are relatively complicated and expensive. Some designs being evaluated by the German Appropriate Technology Exchange (GATE) can be seen at Rolako during the field visit. It should be stressed that these should be considered prototypes, as yet unproven by sustained farmer adoption.

Other animal-drawn equipment, such as earth-moving scoops, have been used at agricultural stations and on large farms in Kenya, Zambia and Zimbabwe for decades. Recent work on pond construction in Ethiopia, stimulated by ILCA, has been based on similar scoop designs. Such earth-moving scoops have seldom been used by the small-scale farmer, partly because their cost relative to their use is also quite high. Whether one is talking of a large mill or an earth-moving scoop, it is unlikely that individual small farmers could justify purchasing such equipment, so that such implements are either likely to be owned communally or by contractors.

Social and economic implications

This has significant social and economic implications. An entrepreneur would probably require a major loan, and would expect to cover the cost of this in hire charges. On the other hand, if equipment were communally owned, there would have to be great social organization and cohesion to ensure that it was correctly and equitably used and maintained. Water harvesting, terracing and pond construction are likely to involve community decisions, not only because of the large investment but also because their success is likely to depend on how land is allocated within a community and on planning

over quite large catchment areas. Installation of grinding mills and water-raising systems in Senegal have often imposed new strains on communities in managing the resources. For example, if members of a community install a water-lifting device, it has to be decided whether non-contributors are allowed to benefit from it and, if so, whether charges should be or could be levied (Jacobi and Löwe, 1984). At some village grinding mills, users are expected to bring along their own animals to provide power (Busquets, 1986).

Innovative use of animals

When animal traction is well established using local animals, it may be possible to diversify the type of animal employed. The example of The Gambia showed how farmers can rapidly adapt to a new type of animal, if this is socially and economically desirable. In parts of Mali, Niger and northern Nigeria, farmers are increasingly using camels for crop cultivation, although absolute numbers are still very low. In northern Nigeria, farmers have started to stall-feed work bulls for beef production. In Sine Saloum in Senegal, farmers have increasingly employed cows for work (Lhoste, 1983; Reh and Horst, 1985). With high levels of management, and the availability of good quality feed such as groundnut hay, the use of cows can be economically attractive. In conditions of high management and clear economic profitability, it may even be possible to consider using exotic animals or crossbreds, although previous experiences indicate that any such initiatives should proceed with very great caution.

Innovative cropping systems

Several programmes in West Africa are looking at the options for diversifying the crops for which animal traction is currently used. In Côte d'Ivoire, Togo and Sierra Leone, there has been interest in the potential for using oxen to make ridges for growing root and tuber crops (Bigot *et al.*, 1983). In The Gambia the options for using N'Dama oxen for rice cultivation are

being studied. These are areas where networking can play an important role. For example, following this workshop the participants from The Gambia will be staying on to visit projects in Sierra Leone working in this field.

Conclusions

This paper has attempted to provide a perspective on the use of animal traction in Africa, and some of the influences of history, promotional schemes and research programmes in determining the present situation. One thing that is clear from the examples cited of Ethiopia, North Africa, Asia and The Gambia is that animal traction can be developed by farmer initiatives. Within West Africa there are many examples of traditional village credit and financial arrangements sustaining animal traction. In many countries animal husbandry practices developed by livestock owners themselves are more important for maintaining the health of animals than the over-stretched veterinary services. Harnessing systems and animal traction equipment have been developed by farmers in cooperation with local artisans. Moreover there is a very great tradition of farmers carrying out research and development studies themselves (Richards, 1985).

While farmers do not use the jargon and acronyms associated with the modern, academic form of Farming Systems Research, their methodology is often faultless. While farmer research is seldom replicated or reported, it is frequently more rigorous, in scientific and methodological terms, than the research of some development projects which try to prove the validity of their preconceived ideas. Thus there seems no justification for researchers or extension workers having patronizing attitudes towards farmers. Research and development projects are not prerequisites to innovation, but they can provide valuable opportunities for working with farmers to accelerate the processes of development.

The challenge of the workshop is to obtain a closer understanding of the farm level implica-

tions of the introduction, intensification and diversification of animal power in West African farming systems. As the workshop develops it is hoped that the problems of the farmers can become more clearly understood, that their major constraints can be defined, and that their crucial needs can be identified. Such an understanding would be a major achievement. Easy answers to farm level problems are unlikely to be found, but during the months that follow this workshop, participants will be able to reflect on appropriate means of overcoming the constraints. To facilitate this, a practical and realistic approach to animal power research and development should be elaborated, one that combines the farming systems perspective with a networking methodology.

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