Improving animal traction technology

Photo: Paul Starkey

Overview papers

A world-wide view of animal traction highlighting some key issues in eastern and southern Africa

Keynote paper and photographs by

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Abstract

The paper reviews the use of draft animals throughout the world, citing examples of the use of oxen, bulls, cows, buffaloes, horses, mules, donkeys and less common work animals. In most parts of the world, including Asia, Europe, the Americas, North Africa and Ethiopia there have been hundreds or even thousands of years of experience of using animal traction. Common to several regions are simple ard plows with long wooden beams, with the animals and implement controlled by one person.

In most of sub-Saharan Africa, animal traction has been introduced this century, and the processes of introduction are continuing. There has been relatively little time for indigenous support systems to develop and evolve, and past interventions by government agencies and donor-assisted projects have tended to be "top-down". Factory-made steel implements pulled by chains have been supplied, and two or more people usually work with animals. Oxen are the main work animals, but donkeys are increasingly used for transport and some cultivation in the semi-arid areas.

The paper goes on to raise some animal traction issues relating to profitability, animal management, tillage systems, implement supply, women, technology transfer and transport.

Introduction

In many parts of the world animal traction is an appropriate, affordable and sustainable technology. Work animals can be used to reduce drudgery and intensify agricultural production, so raising living standards throughout rural communities, benefiting men and women, young and old. Cattle, buffaloes, donkeys, mules, horses, camels and other working animals can provide smallholder farmers with vital power for crop cultivation and transport. Draft animals can also be used for other activities including water-raising, milling, logging, land-levelling and road construction.

This paper draws mainly on professional visits to many countries in Africa and the rest of the world. It starts by providing a global overview of animal traction and goes on to highlight some pertinent issues relating to the workshop themes.

Animal traction in Asia

Draft animals have been used in Asia for thousands of years. To this day, animal traction technology remains a widely used, highly persistent and economically essential component of many Asian smallholder farming systems. Cattle are the main work animals, and they are generally worked in pairs with withers yokes. It is rare for more than one person to work with a pair of draft animals. They are used for plowing and levelling rice swamps (Photo 1), and for plowing and harrowing upland soils (Photo 2). Most implements are pulled by a long wooden beam. They are made in villages largely from wood, but with steel shares. The use of steel mouldboard plows is gradually increasing, but wooden ard plows are very persistent. In India, wooden-beamed ards remain much more common than the inexpensive steel plows which have been available for decades (Photo 3). Simple seeders and weeders are also quite common, and in India blade

Photo 1: Cows pulling simple wooden leveller in a rice field, Indonesia

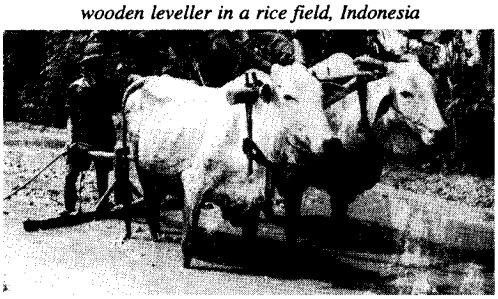


Photo 2: Woman sows while man uses wooden ard plow, India

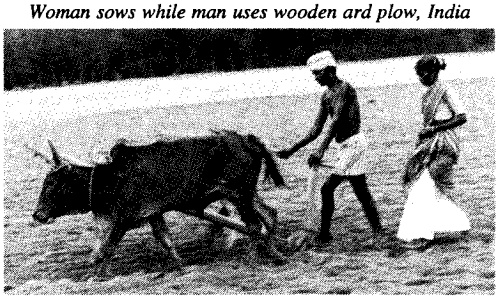


Photo 3: Contractors using oxen and simple wooden ard plows to cultivate rice field, India

harrows, implements with broad shares, are employed for secondary cultivation.

In Asia, oxen are commonly used to pull carts (Photo 4). In rural areas, the traditional designs tend to have two large wooden wheels. In urban centres, four-wheel trailers are more common, and these generally have pneumatic tyres.

Water buffalo are worked in some south-east Asian countries (Photo 5). They are particularly well-adapted to the cultivation of rice swamps, with large feet and the ability to thrive on diets based mainly on rice straw. They are used in pairs, or singly, for swamp rice cultivation. Although buffaloes are mainly employed for rice cultivation, they can be used for upland plowing and for pulling carts or sledges (Photo 6). They are less adapted to such operations than cattle, being less efficient at thermoregulation. The wallowing for which they are famous is a means of cooling themselves. In most Asian countries, working cattle are numerically more important than working buffaloes.

Photo 4: Ox carts with large wooden wheels, India

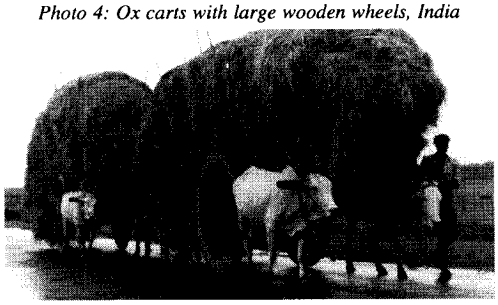


Photo 5: Single buffalo levelling rice field, Philippines

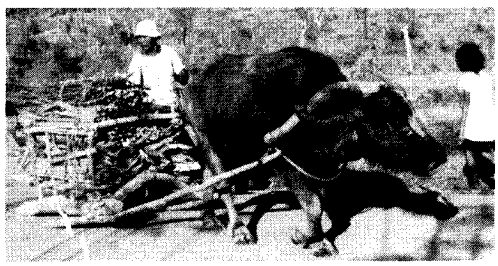


Photo 6:
Buffalo pulling wooden sledge, Philippines

Female working animals are very common in Asia. In Indonesia it has been estimated that 80% of working animals are cows or female buffaloes (Photo 1).

In the drier parts of Asia (including the Middle East) horses, donkeys and mules are employed. They tend to be used mainly for transport (Photo 7), but they may perform some cultivation (Photo 8).

Camels are used for pack transport and pulling carts. They are also used for cultivation, particularly in the Indian state of Rajasthan. Camels are worked singly. Around the Himalayas, yaks are employed for pack transport. In some countries of south-east Asia, elephants assist with logging.

Photo 7: Horses in tandem pulling cart, China

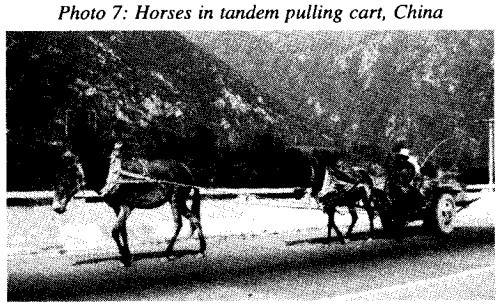


Photo 8: Plowing with a donkey, Palestine

Animal traction in the Americas

Animal traction was introduced into the Americas by the early colonialists, and some countries have been using animal power for hundreds of years.

In the tropical zone, work cattle are the main draft animals. These are usually worked in pairs, using horn/head yokes (Photo 9). Most animals are oxen or uncastrated bulls (Photo 10). It is rare to see more than one person working with a pair of animals. The traditional long-beamed, wooden ard plows are widely used. Traditional carts with two large wooden wheels (Photo 11) are slowly being replaced by carts with pneumatic tyres. In Central America, animal-powered mills made from wood or steel are used to crush sugar cane (Photo 12).

In parts of the Andes, llamas are used as pack animals. In the north-east hills of the Dominican Republic, uncastrated bulls are employed for pack transport. In one area of Honduras, goats fitted with horn/head yokes pull carts of water along flat roads (Photo 13).

Photo 9: Ridging with bulls fitted with horn/head yoke and muzzles, Guatamala

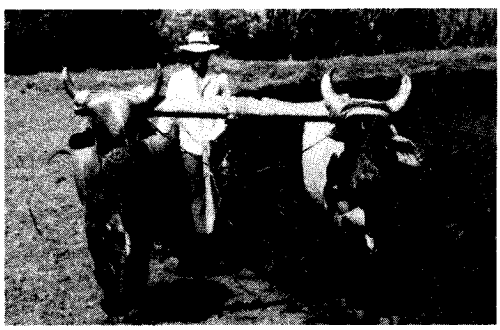
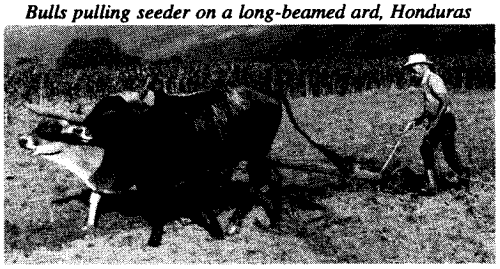


Photo 10:
Bulls pulling seeder on a long-beamed ard, Honduras



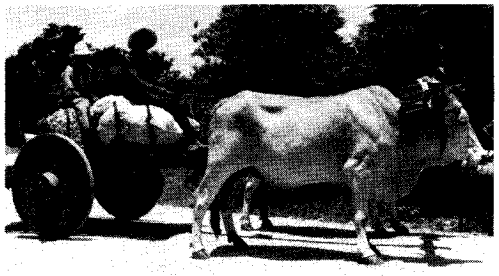


Photo 11: Large oxen pulling wooden-wheeled cart, El Salvador

Photo 12: Oxen turning sugar-cane crusher, Honduras

In the highland and temperate areas of north and south America, horses, mules and donkeys tend to be preferred to oxen. They walk faster, can give greater bursts of power and are well suited for transport operations. Horses, donkeys and mules are employed by some smallholder farmers for cultivation in Mexico, Chile and Argentina. In other countries they are mainly used for riding, carting and pack transport.

In the last century, oxen were important draft animals for farm cultivation in north America. Withers yokes, with broad bows were often employed, although some farmers, notably those in Quebec, used horn/head yokes. One person worked with a team of animals. Heavy horses (Photo 14) and mules steadily replaced oxen as farm equipment

Photo 13:
Goats pulling cart for collecting water, Honduras

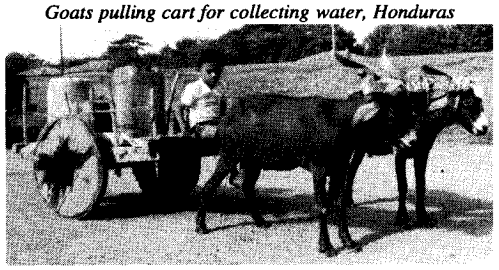


Photo 14: Heavy horses pulling seeder, USA

Photo 15: Amish farmer cultivating with horse, USA

diversified and harvesting implements with large power requirements were developed. Factory-made steel equipment pulled by traction chains superseded the more traditional, artisan-made implements. Horses were themselves gradually replaced by tractors in most farming systems. Nevertheless, even today, amid the modern farming systems of the United States of America, several thousand Amish farmers profitably make use of horses for all farm operations (Photo 15). Oxen are still used by smallholder farmers for winter logging operations. In New England ox-pulling contests remain popular (Photo 16).

Photo 16: Oxen training and pulling competition, USA

Photo 17: Heavy horses mowing hay, UK

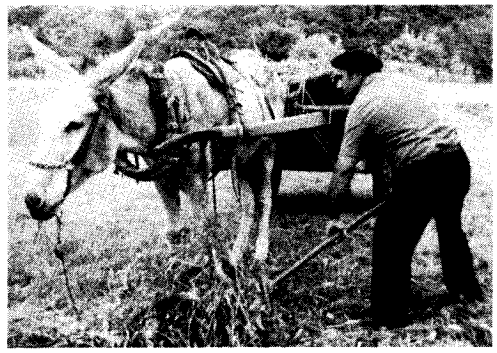


Photo 18: Donkey cart for hay transport, Spain

Animal traction in Europe

Europe has had centuries of tradition of using draft animals. Oxen were the original work animals, and these were worked with withers yokes in northern Europe and head/horn yokes in southern and western Europe. Oxen were mainly worked in pairs. One person controlled the oxen and a long-beamed wooden plow. Wagons, fitted with four large wooden wheels, replaced traditional two-wheeled carts for on-farm, rural and urban transport. Following the industrial revolution, farmers increasingly used factory-made, steel implements, pulled by traction chains.

Horses, fitted with collars, tended to supersede oxen in the northern and eastern countries of Europe (Photo 17). Horses were the preferred animals for transport operations in most of Europe. Wooden wheels gave way to pneumatic tyres.

During the present century, tractors have been replacing horses and oxen in European countries. Work oxen are still employed for cultivation and carting in some smallholder farming systems in southern Europe, and donkeys are quite widely maintained for transport (Photo 18). Heavy horses are used in several countries, notably Poland. For environmental and economic reasons, horses remain important for logging in Belgium and Scandinavia.

Photo 19: Donkey carrying forage, Egypt

Photo 20: Horse and donkey plowing together, Morocco

North Africa and Ethiopia

In North Africa animal traction has been used since the time of the Egyptian pharaohs (illustrations of oxen plowing are common in ancient Egyptian tombs and temples). Along the north African coast cows, donkeys, mules, horses and camels are widely used for cultivation, pack transport and pulling carts (Photo 19). In Morocco, these different species are even worked together in a variety of combinations using traditional belly yokes (Photos 20–22). In the Nile valley and delta, cows (female animals) and water buffaloes are also used for plowing (Photo 23). Donkeys, cattle, buffaloes and camels are used to power the *sakia* irrigation wheels (Photo 24). The use of four-wheel trailers for urban and rural transport is common throughout north Africa (Photo 25). Pneumatic or solid rubber tyres are becoming more common, although traditional wooden-spoked wheels are still widespread.

Ethiopia has had generations of experience of using draft animals. Work oxen and pack donkeys (Photo 26) have been part of Ethiopian farming systems for centuries. Farmers cultivate with pairs of oxen, using a withers yoke and a long-beamed *maresha* ard plow (Photo 27). The *maresha* plows are made by the farmers themselves, with local blacksmiths supplying the steel point and attachment ring. The plows are light enough for the farmer to carry to the field. Farmers work alone with their pair

Photo 21: Camel and mule plowing with ard, Morocco

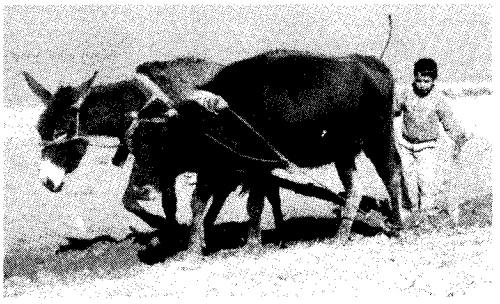


Photo 22: Boy plowing with a cow and a donkey, Morocco

Photo 23: Plowing with two cows (females) and a traditional wooden ard, Egypt

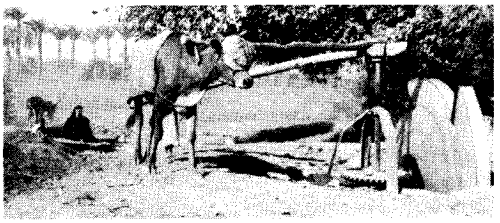


Photo 24: A milk cow turning a traditional sakia *water-lifting device, Egypt*

Photo 25: Donkey with collar pulling four-wheel trailer with rubber tyres, Egypt

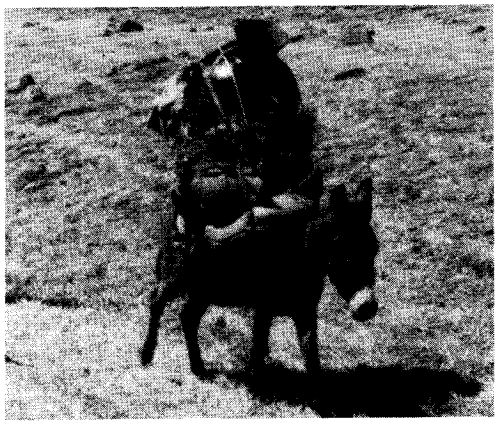


Photo 26: Pack donkey, Ethiopia

Photo 27: Plowing with oxen and a long-beamed maresha *ard, Ethiopia*

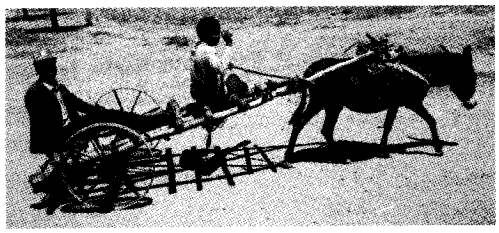


Photo 28: Locally designed donkey cart, Ethiopia

of oxen. The use of cows or bulls is most unusual, and oxen are seldom used to pull carts.

Large numbers of pack donkeys are used in Ethiopia, particularly in the highland areas. They carry fuel wood, building materials, fodder for animals and goods for marketing. Carts, pulled by horses, mules or donkeys, are used in some towns. In a few rural areas, simple and inexpensive donkey carts are spreading (Photo 28).

Sub-Saharan Africa

Animal traction in sub-Saharan Africa (excluding Ethiopia) differs greatly from that in other regions of the world because there has not been such a long tradition of animal power use. In most of sub-Saharan Africa, animal power for crop cultivation has been introduced during the present century (Starkey, 1991a).

There have been some long-standing uses of animal power. Certain pastoralists in West Africa and eastern Africa have had a long tradition of using cattle and donkeys as pack animals (Photo 29). The riding of horses and camels, and the use of pack transport has had a long tradition in the Sahelian zone of West Africa. As ports developed around Africa's west and east coast, work animals tended to be employed to assist local transport operations. In the islands to the east (Madagascar, Zanzibar and Pemba) cart transport was introduced long ago, and traditional skills in making wooden wheels remain to this day (Photos 30–31). In the south of the continent, the early European settlers started using oxen for transport and for farming.

Photo 29:
Traditional panniers used by pastoralists, Kenya

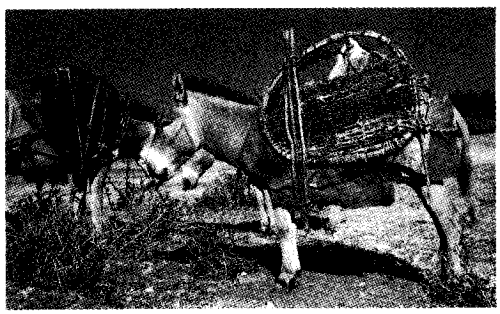


Photo 30:
Two oxen pulling wooden-wheeled cart, Madagascar

Photo 31:
Single ox pulling cart with wooden wheels, Zanzibar

Photo 32: Direct ridging with uncastrated bulls, Nigeria

Photo 34: Carrying manure in a single-donkey cart, Mali

Photo 33: Long-horned, zebu bulls making ridges with a plow, Tchad

Photo 35: Early weeding with a donkey and Houe occidentale *cultivator, Senegal*

In much of Africa, crop farming and cattle herding have tended to be separate activities, carried out by different tribal groups. Traditional cropping systems have been based on shifting cultivation. Roots of trees and shrubs have been maintained in the soil, as land has been temporarily cropped for a season or two. These factors reduced the potential for animal power to spread among traditional cropping systems (Pingali, Bigot and Binswanger, 1987).

Animal power was introduced into the smallholder farming systems of sub-Saharan Africa in relatively recent times. Although there were a few introductions before the 1920s, in most villages in West, Central, southern and eastern Africa, animal traction was introduced during the lifetime of the present village elders. The technology has been spreading, rapidly in some areas, more slowly in others. Formal and informal introductions have been continuing. In many countries there are areas where animal power was first introduced in the 1950s, 1960s, 1970s and 1980s. There are some villages that have started using animal power for the first time this year.

Animal traction in West Africa

West Africa can be divided into four broad agro-ecological zones which greatly influence the uses of animal traction. The most northerly zone, including the south of the Sahara desert and its arid fringes, there is little or no tillage for crop cultivation. Some work animals, notably camels, donkeys and horses, are used for riding and for pack transport. Water is the major constraint, and animal power may be used to pull water from wells, and to transport it on carts.

South of this zone is the Sahel region where annual rainfall is 400–1000 mm. This zone runs from Senegal and The Gambia in the west, to northern Nigeria, northern Cameroon and southern Tchad in the east; the Sahel zone encompasses southern Mali, southern Niger and much of Burkina Faso and includes areas where animal traction has been promoted by companies or projects developing the production of cotton and groundnuts. Humped zebu oxen are particularly important for farm power (Photos 32–33). They are worked in pairs, with withers yokes, and it is common for two or three people to work with a pair of animals (Photo 33). The long-beamed, wooden implements seen in other regions of the world are not used in West Africa. Oxen pull on a traction chain, attached to their yoke, to draw factory-made steel equipment. The first implements introduced to the region were plows and ridgers, manufactured in Europe. Plows remain the dominant implement in the south (higher rainfall areas) of the animal traction zone. In northern

Photo 36: Tine tillage with a donkey, Mali

Photo 38: Horse turning sugar cane crusher, Nigeria

Photo 37: Direct planting with horse and Super-eco *seeder, Senegal*

Photo 39: Training oxen of the small N'Dama breed, Guinea Bissau

Nigeria, farmers prefer ridgers, as direct ridging in light soils is quicker than plowing (Photo 32). In the more arid areas, farmers increasingly use cultivation tines for tillage, and in some areas, notably in Senegal, direct seeding is practised.

Although oxen are the main work animals in West Africa, cows are increasingly being used for work, for example in Sine Saloum, Senegal (Reh and Horst, 1982). In Tchad and northern Nigeria, farmers use uncastrated work bulls (Photos 32–33). There is general movement of cattle southwards, from breeding herds in the north to markets in the south. Farmers tend to buy young bulls, work them for one or two seasons and then sell them to butchers, having profited from their weight gains.

Oxen and donkeys are very important for transport in semi-arid areas. Large numbers of donkey carts with pneumatic tyres and factory-made axles are used in Sahelian countries (Photo 34). In Nigeria and Ghana, ox carts made from motor vehicle axles are common.

Donkeys are increasingly used for tine tillage, direct seeding and weeding (Photos 35–36). Horses are mainly kept for prestige purposes and high-value urban and rural transport. In the groundnut area of Senegal transport horses are employed to pull cultivators and planters (Photo 37). A few horses turn sugar cane mills in Nigeria (Photo 38).

South of the semi-arid zone is the semi-humid agro-ecological zone that runs eastwards from southern Senegal and Guinea, through northern parts of Sierra Leone, Côte d'Ivoire, Ghana, Togo and Benin. The higher rainfall in this zone is associated with thicker bush than that of the semi-arid zone. The de-stumping of farms to allow plowing can be a constraint to the spread of animal traction and the thick bush growth near paths can restrict the utility of carts. The dominant animals in this zone are humpless, trypanotolerant cattle, such as the N'Dama. These cattle can resist moderate challenges of trypanosomiasis, a disease transmitted by tsetse flies. Trypanotolerant cattle tend to be small, but they can usefully be employed (Photo 39). They are often fitted with horn/head yokes. Steel mouldboard plows are the main implements in this zone.

There are no distinct boundaries between the semi-arid and semi-humid zone, and in the transitional areas the humpless cattle coexist and crossbreed with humped zebu animals. The zebu cattle are preferred for their larger size, and the trypanotolerant cattle for their disease resistance. In the more humid areas donkeys seldom flourish.

Further south, in the coastal regions of Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria and Cameroon, there are very few cattle and no donkeys. Animal traction is almost nonexistent.

Photo 40: A water buffalo being assessed, Senegal

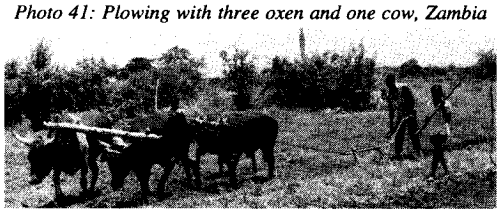
The animal traction zones mentioned are not static, but are gradually moving southward. This may be associated with regional changes in climate, increased deforestation and human population density and decreased disease challenge. The southern limits of the trypanotolerant cattle, the zebu cattle and donkeys seem to be extending southward year by year. For example, 30 years ago, donkeys were relatively uncommon in The Gambia. Now they are the dominant work animals. Donkeys are gradually moving southward in many countries including Senegal, Burkina Faso and Mali. Cattle are increasingly being brought into the coastal area, and animal traction is steadily spreading southward in most countries in West Africa.

Camels in West Africa are mainly kept for pack transport, but they are sometimes used for crop cultivation in the Sahelian zone. Surprisingly there is also one area in central Nigeria where camels are quite commonly employed for plowing. One project in northern Senegal has attempted to introduce water buffalo (Photo 40). Although they are larger than local cattle, they are less well adapted and unlikely ever to become common.

Southern and eastern Africa

Comparable agro-ecological zoning of animal traction also occurs in southern and eastern Africa, but the pattern is more patchy and less distinct than in West Africa. The areas of high animal traction include the Machakos area of southern Kenya, the cotton zone of northern Tanzania, the maize belts of southern Zambia and central Malawi and the communal areas of Zimbabwe, southern Mozambique and northern Namibia. In these areas the great majority of farmers use animal traction. They are mainly semi-arid areas, with rainfall of 600–1200 mm with local cattle-keeping traditions. Areas without animal traction tend to be high rainfall zones (eg, northern Zambia), tsetse infested areas with few cattle (eg, southern Tanzania and northern Mozambique) or arid areas with little crop cultivation (eg, northern Kenya, southern Namibia and the Masai steppe of Tanzania).

Photo 41: Plowing with three oxen and one cow, Zambia



Cattle are the main work animals. Oxen are most common, but cows are increasingly used in several countries. Cattle are yoked in pairs using withers yokes. In many countries it is common for two pairs to be linked and worked as teams of four (Photo 41). Six animals are sometimes used, and in Botswana it is common for eight or more animals to be hitched together (Photo 42).

Factory-made mouldboard plows are the most common implements. Throughout the region, the designs are broadly similar, and unlike those of West Africa, they have I-section beams. The "Safim" designs of southern Africa are widely used, but in most cases the farmers remove the hake adjustment mechanism.

Many farmers own simple sledges, made from tree branches (Photo 43). These provide low-cost transport, although they have been banned in some countries due to erosion problems. Interestingly, a similar widespread use of sledges has not developed in West Africa. Animal-drawn carts made from old vehicle axles are common in some areas (Zimbabwe, Botswana, Namibia, central Malawi, north-central Tanzania). Seed planters are not common, and many farmers plant in the furrow at

Photo 42: Eight thin animals training for work, Botswana

Photo 43: Four oxen pulling sledge, Namibia

Photo 44: Planting every third furrow while plowing, Zambia

Photo 45: Donkey cart used for rural transport, Zimbabwe

the time of plowing (Photo 44). The use of inter-row weeders is quite common in Zimbabwe. Elsewhere weeders are unusual, but in several countries there are signs that farmers are likely to adopt inter-row weeding soon.

Donkeys are increasingly used for cart transport (Photo 45) and, to a lesser extent, for packing and for cultivation (Photo 46). Their geographical range is spreading in many countries, including Zimbabwe, Namibia and Tanzania. Their low cost, ease of management and ability to withstand drought has encouraged their use.

Photo 46: Donkeys plowing, Zimbabwe. This was the first year the farmer had tried to plow with donkeys using home-made collars

Some key issues in southern and eastern Africa

Profitability

Animal traction is presently increasing in most countries in sub-Saharan Africa. This suggests that it must be profitable, although the economics are not always clear to the outsider. Within societies, animal traction may not benefit all members of society equally. Those who invest in animal traction themselves will have greatest access to it (with associated benefits of timeliness), but they also have more risk and more year-round labour. Indeed, animal traction is often seen as labour-shifting rather than labour-saving. Benefits of timeliness (with possible yield increases or risk reduction) may have to be paid for with out-of-season labour, and possibly the labour of the children delegated to look after the animals (Starkey, 1987a).

Animal transport can be crucial for the profitability of animal traction. One farmer in Malawi reported his first investment in animal traction was a pair of oxen and a plow. After three seasons spent plowing with his animals, he invested in a cart. The following season he reverted to manual cultivation of his fields (using hired labour) for his oxen earned more in transport fees than the cost of hired labour (Starkey, 1985). At harvest, income from carting can be particularly high, for hire rates such as "one bag kept for six bags carried" may represent 15% or more of harvest value, merely for transport.

Animal transport can stimulate marketing and economic activity, for headloading places severe limits on the weight of goods that can be carried to and from market (Photo 47). Animal transport also increases profitability through the greater use of manure and crop residues.

Photo 47: Farmer selling tomatoes from ox cart, northwest Zambia. The farmer said the cart improved marketing and this had allowed production to increase

Photo 48: Forage for animals collected by cart and stored in a tree, Namibia

Animal management

As the problems of drought have hit Africa, donkeys have become increasingly popular, for they can survive in arid and over-grazed conditions better than cattle. Drought conditions also exacerbate the serious problem of animal condition at the start of the plowing season. One low-cost method of improving animal condition is the stocking of crop residues, and this becomes increasingly feasible once animal-drawn carts are available (Photo 48).

As farming systems become more intensive, cows tend to be increasingly used for work. When insufficient oxen are available, cows are sometimes used to make up numbers in a team of four animals. Lack of harmful results may then lead to the practice continuing. However, if nutritional levels are inadequate (which is common) reproductive performance may be adversely affected. Nevertheless, farmers may find that even with mediocre reproductive performance, the use of cows for light work may be more profitable than maintaining oxen. For heavier work and regular transport, oxen are likely to be preferred.

Tillage systems

Despite research on alternative tillage systems in several countries, the mouldboard plow remains the dominant implement in eastern and southern Africa.

In Zambia, and elsewhere, plows tend to be used (against all extension advice) without an adjustable hake (Photo 41). They are generally held at an angle during work. In this way, they do not operate like the classic, well-adjusted, asymmetrical mouldboard plows shown in most extension manuals. In some ways they become a little more like the symmetrical ard plows widely used elsewhere in the tropics

Research in the region continues on alternative tillage systems, including ridging systems, tied-ridging, conservation tillage, direct planting and tine tillage. Farmers seem to want tillage systems with low power requirements, partly because their cattle are in poor condition and their donkeys are weak. However, they also want good weed control, and this has been a weak point for several alternatives to the mouldboard plow.

It appears that animal-drawn weeding technology is likely to spread quite rapidly in the coming decade, provided weeding implements are available in the rural areas (Photo 49). In some cases, the low level of animal-drawn weeder adoption seems due to farmer (and extensionist) unfamiliarity with the techniques and the length of yokes required. Another major constraint is fear that animals could damage the growing crops. In Guinea and Mali, special village-level training sessions have been held (Photo 50), with animals and their handlers practising on rows of sticks, before entering the crop fields (Sangaré et al, 1988). Such simple and rapid training of animals has given the owners of oxen the necessary confidence to start mechanical inter-row weeding.

Supply and distribution

In much of the world, including North Africa and Ethiopia, animal-drawn implements are made in villages. Close links between blacksmiths and farmers have led to acceptable equipment specifications and sometimes innovations. In Europe, most present-day large farm-equipment

Photo 49: Weeding cotton using oxen, Zimbabwe

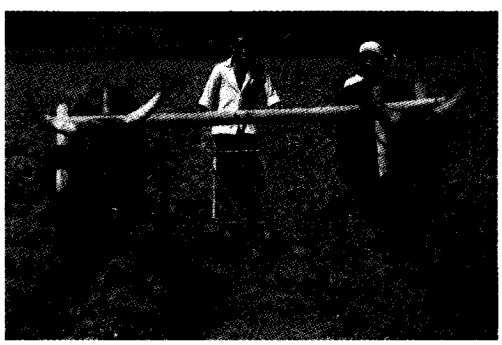


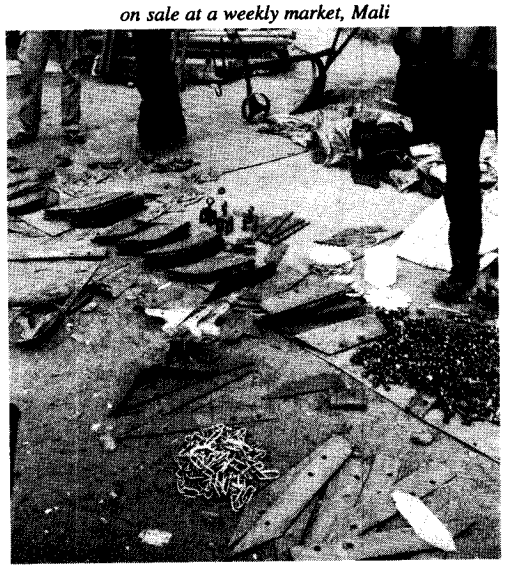
Photo 50: Training oxen to weed between rows, Guinea

companies had their origins in small blacksmith workshops. As they expanded, they established networks of dealers, ensuring local depots of equipment and spare parts.

In several countries in Africa, including Madagascar, Mali and Nigeria, some blacksmiths have started to make innovative designs of animal traction equipment. More commonly, blacksmiths tend to concentrate on making spare parts and repairing (or rebuilding) implements. Rural weekly markets are important for marketing artisanal products, such as spare parts (Photo 51). Blacksmiths tend to be severely constrained by lack of raw materials and may be unaware of techniques and tools that might assist implement production. In some areas, there are very few blacksmiths, making it difficult for farmers to obtain spares.

In sub-Saharan Africa, centralised systems for the production and distribution of implements have tended to inhibit village-level implement production and the development of close farmer–manufacturer relationships. Donor-assisted projects have tended to order equipment from abroad with large contracts for the successful tendering firms. This has often led to large stockpiles of centrally-purchased equipment that farmers perceive as being technically inappropriate (Photo 52) or of poor quality (Starkey, 1989). Zambia and Mozambique have both suffered from such donor-controlled inappropriate equipment provision. In Tanzania, the main Ubungo Farm Implements (UFI) factory had to cease plow production for several years, as large numbers of donor-funded imported plows saturated the market.

Photo 51: Products made by blacksmiths and by factories on sale at a weekly market, Mali



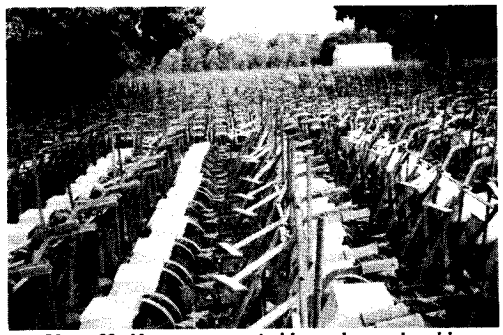


Photo 52: Numerous unsuitable seeders ordered by international tender but lying unused, Mali

Local production can be an answer, provided the equipment manufactured is considered appropriate to farmers. This might seem self-evident, but this has not always been the case with the top-down approach of certain donor-assisted projects. In Tanzania, external "experts" and their counterparts in Zana za Kilimo (ZZK) were responsible for the manufacture of several hundred unpopular plows concerning which there had been inadequate farmer consultation and market assessment (Starkey, 1989).

The successful supply of animal traction implements depends not only on appropriate hardware, but also on the necessary supporting infrastructure, including credit provision. In Senegal, the large Siscoma factory was making a range of implements and spare parts that appeared acceptable to farmers. However, when the government changed its policy on agricultural credit, sales slumped and stockpiles grew, forcing the firm into bankruptcy (Starkey, 1989).

Some projects have used credit to promote one particular type of implement. This top-down approach can be dangerous, for farmers without available cash may purchase sub-optimal equipment simply to make use of the credit. This was seen in Guinea Bissau, where almost all sales of heavy *Arara* implements and ox carts involved credit. Farmers who had cash available tended to buy lighter cultivators and donkey carts, which they generally preferred (Starkey, 1991b).

Women and animal traction

Historically, animal power in Africa has been a male-dominated technology. Cattle are commonly owned, or controlled, by men and most animal traction operations tend to be performed by men and boys, provided male labour is readily available. Women increasingly have access to, and control over, animal traction. The migration of male labour to urban centres means that many rural households are female-headed or female-managed. Lack of rural

Photo 53: Women weeding maize with oxen, Zaire

male labour means that women increasingly handle draft animals and implements (Photos 53–54).

In several countries, women's groups have purchased their own draft animals. This has not always been easy, because the management of work animals can be labour-intensive, and women are normally extremely busy fulfilling numerous time-consuming domestic tasks. In Sierra Leone, a women's group successfully used girls to work their animals, but the girls had to be replaced when they married. Eventually the women became tired of training girls, and hired a man to look after their animals. Other women's groups have also handed over daily responsibility for their animals to men, who sometimes exploit the situation and begin to control access to them.

In some societies, women have primary responsibility for weeding operations. In such cases, the extensification associated with animal traction could increase the work load of women. Similarly, the adoption of animal-drawn weeders could help diminish the work load of women, particularly if men operate the weeding implements.

Rural women often have major transport roles. The carrying of domestic water, wood and crop harvests

Photo 54:
Women weeding with draft cows, Zimbabwe

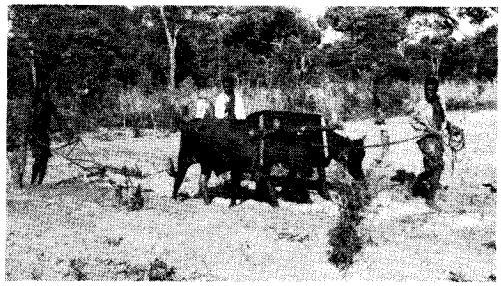


Photo 55: Farmers in first year of using work oxen in Zambia: the technology had been introduced into the area by a donor-assisted project but these people learned it from other farmers

is often the responsibility of women. The use of pack animals or animal-drawn carts can have particular benefits for women. If work animals are available, women may be able to delegate work relating to water transportation to children, who may even consider the task recreational.

If women can use animal power to release them from the size and weight limits of headloads, they can take more to and from market, increasing their marketing potential and stimulating the rural economy. Where men own animal-drawn carts, women may delegate some of their marketing duties to their husbands, although this has the risk that women lose control over the income generated by produce marketing. The purchase of animal-drawn carts often requires credit, but women generally have less access to credit than men. Increasing credit provision for carts for women could bring many social, economic and agricultural benefits.

The increasing adoption of donkeys as draft animals in the region may improve women's access to animal transport. Donkeys are particularly good for domestic transport operations and they can easily be managed by children. They also have fewer traditional associations with male ownership and dominance than do cattle.

Transfer of technology

Two very distinct types of technology transfer have been taking place in sub-Saharan Africa: formal and informal. The national extension services have generally provided relatively formal, top-down training. This has effectively taught farmers to start to use work animals in areas where animal traction was unknown. Credit provision to allow the acquisition of technology has sometimes been associated with such success.

Once animal traction has started in a region, much transfer has been informal, within families, from farmer to farmer or from regional immigrants to local farmers (Photo 55). Farmer-led innovation has

often been much more significant than formal extension advice. For example, in The Gambia, animal traction was not widely used prior to the 1950s. A formal extension process during the 1950s and 1960s successfully introduced the use of pairs of yoked oxen to pull ridgers and plows. During the 1970s and 1980s, the farmers themselves gradually switched to a very different system using single donkeys with breastband harnesses and light cultivators. Formal extension was important for introduction, but thereafter it did not keep up with the evolution of farming systems (Starkey, 1987b).

Similar examples can be seen in eastern and southern Africa. The more successful animal traction extension programmes have tended to be in the areas of new introduction. In areas where draft animals are already widely used, extension programmes seem to have had little success.

One problem has been the old transfer model. Public-sector researchers have developed "improved" animal traction technologies on research stations. These have then been promoted by the extension services, often to be rejected by farmers as technically or economically inappropriate to their farming systems. In most countries in the region, development programmes have tried to promote animal-drawn wheeled toolcarriers (Photo 56), but the transfer process has not succeeded: the technology has been "perfected yet rejected" (Starkey, 1988). Other examples of disappointing formal attempts at technology transfer include the single-ox harness in Ethiopia, water buffaloes in Senegal and Tanzania, good-but-heavy plows in Zambia and animal-powered gear systems in several countries (Gryseels et al, 1984; Starkey, 1990; Starkey, Dibbits and Mwenya, 1991; Abiye Astatke and Mohammed-Saleem, 1994). In contrast, successful farmer-to-farmer transfer appears to have been responsible for the increase in the use of donkeys and working cows in several countries in southern Africa. This adoption has sometimes been against the advice of extension agents.

Photo 56: Wheeled toolcarrier fitted with sweeps on a research station where it was developed, Botswana

Photo 57: Farmer trying out his idea of using a prototype over-the-row seeder as a furrow opener, Mbeya, Tanzania

In order to become more relevant, researchers are beginning to adopt more farmer-centred approaches, emphasising on-farm research–development. There is also a trend for projects to move away from formal farmer training to more participatory methods that build on farmer innovation and farmer-to-farmer transfer processes. For example, the Mbeya Oxenization Project tried to introduce an over-the-row weeder, believing this to be better than an inter-row model. The farmers did not seem convinced, but one felt the innovative equipment might have value as a furrow-opener (Photo 57). The technology may or may not be successful, but the process appears applicable to many animal traction situations—a motivated team working closely with farmers on their farms, offering them different alternatives and options, rather than prescriptions (Loewen-Rudgers et al, 1990; Mkomwa, 1992)

Transport

Observed trends suggest that animal-powered transport is likely to increase significantly in sub-Saharan Africa in the coming years. In many countries, donkey carts are becoming increasingly common. As noted above, this trend should have major social and economic benefits, particularly for women. Increasing use of animal carts is likely to improve both animal nutrition and the recycling of nutrients, as crop residues and manure are transported. It will also stimulate local economies, as people find it easier to transport and market produce. The larger circles of production and trade associated with animal transport will stimulate the

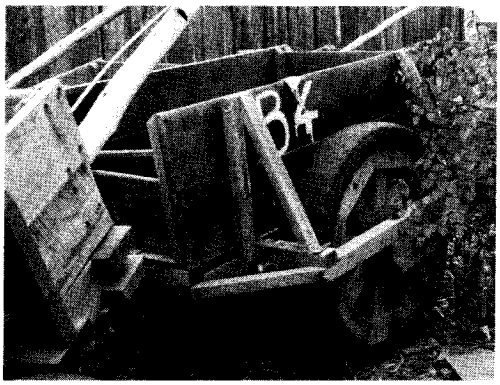


Photo 58: Wooden-wheeled carts rejected by farmers in north-western Zambia. The farmers eventually accepted carts with roller bearings and pneumatic tyres

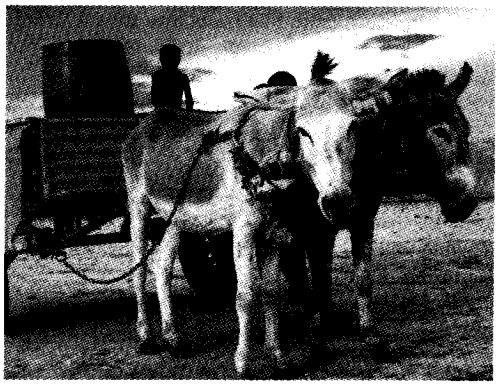


Photo 60: Harnessing system commonly used for donkeys in Namibia and elsewhere in the region. The weight of the beam is supported by a thin rope on the neck of the donkey

growth of animal traction support services. Although initial adoption of animal-drawn carts may be difficult (with problems of repairs and punctures), once a critical mass of carts is used in an area, a virtuous circle may well develop, with support services making further adoption easier.

The success of animal-drawn carts in West Africa has been associated with the use of roller-bearings and pneumatic tyres. In many countries factory-made axles have been available, and use has been made of old vehicle axles. In several countries in eastern and southern Africa, organisations have placed emphasis on "appropriate technology" solutions, with wooden wheels and bearings. In the 1980s, a project in eastern Zambia tried to promote such carts for many years, with minimal success. About the same time, another project, this time in north-western Zambia, started with a similar cart designs, but noticed the distinct lack of farmer enthusiasm for the "flintstone" models (Photo 58). The project tried various other options, and eventually settled for axles with roller bearings and pneumatic tyres. The number of these carts rapidly increased. The provision of suitable cart axles and credit appears to have been instrumental in stimulating rural transport and trade in that area (Starkey, Dibbits and Mwenya, 1991; Löffler, 1994).

In much of eastern and southern Africa, animal transport has been based largely on simple chain-drawn sledges and ox carts, equipped with a single draw bar. When donkeys have first been employed for carting (usually a farmer-led innovation) they have often been yoked, like oxen (Photo 59). Subsequently, donkey yokes have tended to be replaced by harnesses, often made from tyre rubber or machine belts. These have caused problems when the cart weight has been taken on the necks of the animals (Photo 60). This problem has been avoided in West Africa and elsewhere by using a two-shaft cart with a simple back saddle to take the weight of the cart (Photos 7, 25 and 34) . Some projects have experimented with similar designs in eastern and southern Africa (Photo 61), but these are not yet widely used. There still seems much scope for improving donkey harnesses throughout the region.

Photo 59: Two pairs of yoked donkeys pulling a cart made from an old pickup, Namibia

Photo 61: Prototype donkey cart in Malawi: the load from the two shafts is taken on the donkey's back

Conclusions

There was a time when animal traction was perceived by politicians and researchers as a backward technology that would be rapidly superseded. It is now increasingly seen as an economically and ecologically appropriate technology that will remain highly relevant in smallholder farming systems for the foreseeable future. Within southern and eastern Africa, it seems likely it will continue to spread, and diversify.

In general, development agencies have proved more successful at introducing animal traction technology than improving it. Progress is likely to be faster with the adoption of more farming-systems, farmer-centred, participatory processes and activities.

Regional farmer-led trends include greater use of donkeys and carts, increasing use of work cows and greater involvement of women in animal traction. There seems much scope in the region for improvements in harnessing and animal-drawn carts, greater use of animal-drawn weeders, greater conservation of crop residues to feed to work animals and improved access in rural areas to implements, cart axles, spares and credit.

Support to new animal traction initiatives from national governments and aid agencies is likely to be highest in areas where the technology can be seen to reduce environmental degradation, improve the quality of life of women and increase sustainable, private-sector agricultural production. All these important topics would be well tackled through a networking approach to improving animal traction.

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