Livestock as a source of energy in smallholder farming systems

R.A. Pearson

The current uses of draught animals in smallholder farming systems are discussed and the contribution that animal energy can make to crop production in these systems is examined. The indications are that animal energy will continue to be an economic option for many small-scale farmers well into this century. As populations increase and there is increasing pressure on resources so the needs of draught animal power farmers are changing. It is important that researchers and those involved in development recognise this. If they do, they can provide the support that the farmers will need in improving their livelihoods through the use of animal energy, in conjunction with the human and motorised forms of power that are available to them. Some future areas of research are identified.

Introduction

Draught animals continue to play an important role in agricultural production and transport in many tropical countries. Although draught animal power has been superseded by tractors on many of the large commercial farms in the tropics, it continues to be a relevant technology in small-scale agriculture. This is on farms where it is not economic or practical to use motorised forms of power. Draught animals are maintained over a wide range of agro-ecological zones, but are particularly common on small mixed farms where rain-fed crops are grown mainly for food production. In this paper some of the main issues facing the smallholder farmer in using draught animals into the future are discussed, taken largely from recent reviews by Pearson (1998) and Pearson *et al* (1999). The aim is to set the scene for the papers to follow.

Current uses of draught animals

Draught animals and humans still provide a considerable proportion of the total power used in agricultural production in developing countries (Table 1). While many of the countries in Asia and Latin America are mechanising their larger cash crop farms at a relatively rapid rate, there is still considerable variation within the countries of Africa in the use of tractors, draught animal power and human power. In sub-Saharan Africa, South Africa and Zimbabwe have the greatest use of tractors and least use of human power for crop production operations and Botswana and Zimbabwe make the greatest use of draught animal power. (Table 2).

Table 1: Proportional contribution (%) to total power use in 93 developing countries (FAO, 1987)

Area	Human	Animal[1]	Tractor[1]
N Africa	69	17	14
Sub-Saharan Africa	89	10	1
Asia (excluding China)	68	28	4
Latin America	59	19	22
Overall	71	23	6

[1] Estimated by converting energy expended to man-day equivalents per hectare

Table 2 Sources of power for primary land preparation (COMSEC, 1992)

Country	Percentage of cultivated land		
	Human power	Animal power	Engine power
India	18	21	61
China	22	26	52
Sub Saharan Africa	80	16	4
Botswana	20	40	40
Zimbabwe	15	30	55
South Africa	10	20	70
Tanzania	80	14	6
Kenya	84	12	4

R.A. Pearson
Brooke Hospital for Animals Overseas Training Adviser, Centre for Tropical Veterinary Medicine (CTVM), Easter Bush, Roslin, Midlothian, EH25 9RG, Scotland, UK

Continued mechanisation of agricultural practices will occur where it is economically feasible, and draught animals will be replaced on those farms that can produce enough to justify maintenance and use of two or four-wheeled tractor power. However the increasing costs of machinery operation, and the continued relevance of small farms in the poorer parts of the agricultural sector, mean that there is likely to be a continued need for draught animals in agriculture at least in the less productive areas. On farms where size and scale of enterprise rule out mechanical power, animal power is the only means the farmers have of cultivating land, other than use of family labour.

Although draught animals make their greatest contribution in agriculture, they also have an important role in transport particularly from the rural areas into markets in the urban or peri-urban areas. It has been estimated that about 20% of the population of the world relies largely on animal transport of goods. Animal carts and sledges are used to transport goods and people in rural areas especially where roads are unsuitable for motor vehicles. Often journeys are short and provide the means of servicing the smallholder farming system with inputs such as fertilisers, and seeds, the means to transport the harvest from field to homestead, produce to market, and grain to and from the mill. Animal power reduces the drudgery of many of the household activities such as water and fuel collection. Where wheeled vehicles cannot be used, such as in mountainous areas where roads are absent or poorly developed, pack animals may be used to transport goods. Working equids, particularly in certain parts of North Africa (e.g. Morocco, Ethiopia, Tunisia and Egypt) and Asia (e.g. India, Pakistan, Indonesia) make a considerable and important contribution to the urban economy, being used to transport produce into and within the urban areas. Camels in the Middle East, llamas in the South American highlands, yaks in Tibet and the surrounding countries and mules in the Western Himalayas are favoured for pack transport, due to their ability to work in these particular environments.

Again ownership and use of many of the pack animals is within the smallholder farming sector and the benefit from animal powered transport is often greatest within this sector. It improves their access to markets and the provision of inputs from outside.

Draught animals are also used in the timber industry and to power stationary equipment such as water pumps, sugar cane crushers and grinding mills. Less widespread is their use in the movement of materials in building projects and road, dam and reservoir construction within rural areas, many of the fringe activities of the smallholder farming systems. It is important to recognise that animal energy can be harnessed to provide several income generating activities for the smallholder farmer out-with their use in the production of food and cash crops. More versatile, and therefore more frequent, use of animal power is an ideal way to spread the maintenance costs. A resting draught animal still uses resources, unlike a 'resting' tractor.

Traditional or new technology?

In some areas of the world draught animals are part of the traditional way of cultivating the land, for instance in Egypt, India, Nepal, Indonesia, Ethiopia, North Africa and in most of Latin America, people are accustomed to keeping, training and managing their draught animals. Implements are readily available locally, usually made from local materials, with a local system to repair and replace them. Farm size and family structure tend to determine whether individual farmers keep animals themselves or make use of those available locally for loan or hire.

In some areas of the world draught animal power is a relatively new technology for use in cultivation and crop production. For instance in West Africa, and much of sub-Saharan Africa, until recently animal diseases prevented the keeping of animals in many areas and the traditional methods of cultivating the land made use of manual labour only. It is only within the last century that many people have made use of draught

animals on their farms in these areas. Because of the relative newness of the technology, compared to other places, there is not necessarily the infrastructure available locally to train and manage animals or produce and repair appropriate implements. As a result the animals and implements available are expensive and involve considerable investment by the farmer, before he can see the benefits and the drawbacks for himself. Often implements are imported or manufactured by companies selling a range of agricultural equipment. Although spares may be available the manufacturers or retailers can be some distance from the farm, and so repairs cannot be done *in situ* in the fields, as they so often can be with wooden implements.

Animals are often more difficult to train in these 'non-traditional' areas in Africa. This is because they are likely to have been kept in extensive grazing systems and therefore have had less contact with people and less handling than those draught animals reared near the home on small farms in Asia. In the African 'non-traditional' systems farmers can lack experience in handling and training animals. The consequences of these two factors are that when the animals are used for work several people work with them, often one person leading, one operating the implement and one or two others driving the animals. Thus when manual cultivation methods are replaced by animal power there may be less saving in human labour in practice than appears in theory, in certain activities.

Even within the traditional areas of animal power use, skill levels vary. There are some people who have poor skills in using animal power. They often have a low awareness of the technology and of the best way to use their animals and to look after and manage them. There is much less transfer of skills from the older generation to the younger one when people have turned to agriculture later in their lives, after having worked outside the sector. Low skill levels are also seen in the use of animal power in transport in the peri-urban sector, where people without a livestock background may turn to animal-drawn transport as a means of earning a living. These people provide an important link between the smallholder farmers and their markets. Increased awareness of management and use of draught animal power can improve the ease of working and income generation as well as being beneficial to the longevity, health and welfare of the animal.

The contribution of animal energy in cropping systems

Area cultivated

In semi arid areas farmers owning draught animals tend to have larger farms than those not owning animals. For example in Tanga region, Tanzania, a survey in 1990 showed that most farms were under 2 ha with only a small number over 3 ha. However the farmers owning animals tended to have farms over 3 ha (Starkey and Grimm, 1994). This pattern can be attributed to two factors (a) animal power requires greater investment than is need in manual labour so making it less attractive to farmers on the smaller farms (Reddy, 1988), (b) farmers with access to animal power increase the area they cultivate (Francis, 1988; Panin and de Haen, 1989; Sumberg and Gilbert, 1992). The implication is that there is a positive correlation between cultivated area and use of animal power.

Clearly expansion is possible with animal power in semi-arid areas that are farmed extensively, if only because farmers take less time to prepare and plant land if they use animal power than if they use manual tillage methods. Labour savings can be considerable. For example in a comparison of manual and animal power inputs into rice and maize production in central Nigeria land preparation took about 315 h/ha for rice (ploughing and harrowing) and 65.5 h/ha for maize (ridging) using manual labour but only 94 h/ha for rice and 28h/ha for maize when oxen were used (Lawrence *et al.*, 1997). When the use of animal power results in less suitable, marginal land being taken into cultivation, then it can encour-

age soil erosion and land degradation as well as poor crop yields. Kruit (1994) suggests that this has been the case in Niger, where animal power has been largely used to extend cropping area in order to increase total production. Stocking (1988) has highlighted similar problems in other countries using animal power in crop production.

Expansion is only possible where there is potential to expand. In the more intensively farmed humid areas, in Java and Bangladesh for example, where most cultivatable land is already under crops, it is virtually impossible to increase the area planted, however animal power can improve timeliness of farm activities and increase yields in this way.

Crop yields

Farmers with access to animal power tend to opt for more extensive production than those using hand-tillage techniques (Francis, 1988), with a resulting lower yield per hectare. However, provided the area cultivated is increased, output from the farm can increase.

Adoption of animal power in crop production is often associated with the use of other inputs such as improved seeds and fertiliser and so it can be difficult to distinguish which has had greatest effect. In the cotton growing regions of West Africa, for example, where animal power was encouraged by the cotton companies, food grain production increased in some areas when animal power was introduced. The production of food crops benefited not just from more timely tillage, but from the fertilisers which were applied to the cotton cash crop (Mahdavi, 1992).

The use of animal power can improve timeliness of planting (Shumba, 1984), and therefore can optimise yields per hectare in areas where growing seasons are short and time of planting is crucial to insure a good crop. However in areas where weeds are a problem, and good weed control is essential to optimise crop yields then use of animal power may result in lower yields per hectare. This can be due to two factors (a) soil inversion using an animal drawn implement (mouldboard plough or ridger for example) does not result in as good a weed smother as when soil inversion is done manually and (b) increased area cultivated means that weeding may be done less frequently and less well after crop emergence, resulting in a lower yield per hectare.

In a comparison of manual labour and animal power in the cultivation of rice and maize in an inland valley region in central Nigeria weed infestation was heavier and weeding took longer on the ox-cultivated plots in both rice and maize. This did not significantly affect yields on the weeded plots, but when weeding was not done, yields were almost halved for rice and were almost none existent for maize, whether animal power or manual labour had been used for land preparation (Lawrence *et al.*, 1997).

In northern Nigeria on different soil types use of animal power had a beneficial effect on weed control. Use of ox-drawn implements for ridging and remoulding ridges for millet and sorghum production resulted in plots of land which required less weeding than those prepared using the traditional hand hoe techniques (Olukosi and Ogungbile, 1994). The above two examples illustrate the inadvisability of attempting to generalise when assessing the impact of animal power on crop yields. Responses will vary depending on soil type, crop and rainfall pattern.

Transport - crop harvesting and marketing

Carts, although more expensive than a plough, can be used most of the year for a range of activities, which can be income generating. Animal transport can reduce post-harvest losses from pests by allowing timely removal of crops from the fields (see Anderson and Dennis, 1994). Farmers with a cart seem to make better use of crop residues than those farmers that do not have access to a cart and are better able to market their goods. Several studies have shown that farmers with a cart can get a higher price for their goods, since they can sell direct to markets and avoid having to sell

to a 'middleman' visiting the village (e.g. Scheinman, 1986). Farmers with a cart also find it easier to move manure or purchased fertiliser to the field to booster soil fertility. Greater use of fertiliser and manure has been recorded on farms which own an animal cart (Scheinman, 1986, Anderson and Dennis, 1994).

Similar benefits have been observed on a smaller scale in semi-arid areas where farmers own a donkey and it is used to carry manure or fertiliser to the field, to take residues from it and carry crops to market, whether or not these animals are also used in land preparation.

Changing needs of draught animal power farmers

The world population is predicted to increase from 5.4 billion to about 10 billion within a few decades, largely in developing countries. To feed this additional population, more land will need to be devoted to crops, reducing the land available for pasture and fodder (Sansoucy, 1995). This should mean that more crop residues and agro-industrial by-products will become available for feeding livestock. Farmers keeping livestock in these cropping systems, where grazing land is decreasing, will have to re-evaluate their feeding strategies and may have to adopt different feeding systems. In Africa numbers of small ruminants have tended to increase as a proportion of the livestock on farms as farm size and grazing areas have declined. This is except in those areas where draught animal power is used for cropping and transport (Leeuw and Rey, 1995). For example Goe (1991) found that in the southern portion of the semi-arid zone and in most of the sub-humid zone of Senegal although population pressure is increasing, work oxen still dominate the livestock enterprise of mixed farmers. In areas where draught animal power has been a feature of mixed farming enterprises the strategies to overcome the reduced quantity and quality of grazing land have been to move to motorised power, or to modify animal husbandry practices.

In parts of South Asia that have high population pressures and are farmed intensively, (e.g. in Vietnam, Thailand, Malaysia) the reduction in grazing land has meant in many of the rice growing areas a change over from buffalo to motorised power, in the form of two-wheeled power tillers and small tractors. However on small farms of less than 3 ha it is unlikely that draught animal power will disappear as it can compete economically with petrol-driven tractors under these conditions both in Asia (Campbell, 1993) and Africa (Panin, 1995). On farms where motorised power is not feasible many farmers are modifying their herd structure. The use of 'multipurpose' animals for work, i.e. the dairy cows and beef animals, removes the need to keep work oxen and hence saves on feed requirements. This is an increasingly common sight on draught animal farms, not just in Asia, but also in Africa where grazing land is declining. For example surveys by several member countries of the Animal Traction Network for Eastern and Southern Africa (ATNESA) have shown a steady increase in the use of cows for work in many areas. With the exception of places where it is culturally unacceptable to use cows for work, or cattle for meat, then the modern draught ruminant is usually now truly multi-purpose, providing milk, and or ultimately meat in addition to work and of course manure as fertiliser or fuel. In many semi-arid parts of the world, in Africa in particular, increasing pressure on feed resources and a succession of dry years have seen farmers switching from cattle to donkeys to provide power in crop production, because donkeys have a higher survival rate in droughts and are cheaper to maintain than cattle.

Throughout the world, in areas where the prevalence of animal diseases, particularly trypanosomiasis, has restricted animal keeping, traditional practices of crop cultivation have used manual power. In areas where changes in vegetation due to population pressure have reduced the incidence of disease vectors, the chances of animals catching some of the endemic cattle and equine diseases have decreased and as a result more

farmers are prepared to risk keeping working animals for transport and crop production. The Gambia 25 years ago had virtually no draught animals, but now draught animal power is widespread (Sumberg and Gilbert, 1992). Similarly, in other areas, better disease and vector control have meant that animal power is now available to more people in smallholder agriculture.

As more marginal land is brought into cultivation, to meet the increasing demands for food, then soil and water conservation become more necessary. Many farmers are becoming increasingly conscious of the need to maintain soil fertility and aware of the damage that erosion can cause. Engineers and soil scientists are working together with farmers in the development of implements and tillage techniques that can help to conserve soil and water, particularly in marginal areas. Some of the practices recommended for conservation tillage increase the demand for both labour and animal power (Ellis-Jones and Mudhara, 1998). This has implications in the selection of animals for work, and also on the acceptability of conservation methods by farmers with no opportunities to choose large animals for work.

Farmers are having to modify their animal husbandry practices in the more intensively farmed and densely populated areas of Asia and Africa. In these areas animals are tending to be tethered or kraaled for longer, both for security and due to the reduction in available grazing land. They are often fed on stored crop residues, collected fresh forage or purchased foods. Therefore more time is spent collecting and carrying food for the animals in the year than previously in these farming systems. Greater reliance on crop residues and purchased high quality feeds, for those that can afford them, and greater pressure on communally owned grazing resources have frequently been reported as systems become more intensive. Often greater reliance is also then placed on locally reared stock rather than those brought in from grazing systems.

A sufficiency of grazing land in the past has generally meant that draught animals have been left to forage on rangelands, particularly out of season, and supervision of feeding has been minimal. The greater control that cut-and-carry methods of feeding can bring, can involve the farmers in more decision-making. They can if they wish decide on the amount and type of feed that each class of livestock will receive in any season. The farmers needs sufficient information on the outcomes of this 'strategic' feeding to make best use of the farm feed resources. There is now considerable data available on the needs and consequences of feeding on the performance of draught animals to enable farmers to made informed decisions when managing these animals. This information can be used by local advisers to produce focused recommendations on management strategies for today's animals used for work.

Management of working animals

The management of draught animals should include efficient management of the power itself, both when it is required in seasonal tasks and over the rest of the year so that the resource is not wasted. Number of days worked depends on cropping patterns, animal availability and land ownership. For example in E Java work periods for draught cattle varied widely from 10 to 110 days per year even in one village (Komarudin-Ma'sum *et al.*, 1993). While in Tanzania use can vary from 60 to 180 days per year, within a relatively small area (Mgaya *et al.*, 1994), and ownership of a cart can mean a further increase in use. In southern Nepal and the plains in India, it is not uncommon for farmers to make use of their ox-carts for travel and transport on almost every day of the year, when the animals are not required for field tasks, and roads remain passable. Lending and borrowing and communal use of animals to ensure tasks are completed at the right time are practices that have been adopted by farmers to make the most of the animal power they have in an area.

Management of working animals does not just depend on the requirements for work, but also on the other outputs that are expected in addition to work. In areas where

religion prevents the use of cows for work or the rearing of cattle for meat, draught animals are only expected to provide manure in addition to work. The male animals in use have generally reached maturity. Compared to other productive outputs from cattle, a 450 kg ox doing a day's work of 5-6 h requires an energy intake equivalent to that needed to produce about 0.75 kg live weight gain or about 5-6 l of milk. Management is easier for these draught animals since the farmers only need to consider the work load and live weight of their animals. The same animals are often kept by one farmer for many years.

In areas where meat markets are good, some farmers regularly replace their working animals every 3-5 years. They buy in young animals at 3-4 years of age, train and work them until they are 8-9 years old and sell them for meat. For approximately the price of one 8-year-old steer, farmers can buy two young animals again. Farmers are prepared to accept a reduced work output from the new animals for 1-2 years as they gain experience. Some farmers even sell after only 1-2 years of work. This system of maintaining working animals can be found throughout Asia, Africa and Latin America where reliable markets for meat exist. It is becoming an increasingly popular way of managing work ruminants.

Diminishing land resources to maintain animals has led to an increase in the use of female animals for work. Management strategies become more complex when a farmer wished to use his cows (or mares) for work and expects them also to produce an offspring. Supplementary feeding is necessary to avoid weight loss and ensure good body condition before parturition so that early return to oestrus is possible (Pearson *et al.*,1999). The aim should be to feed to maintain live weight, but this is not always possible, when requirements for pregnancy and lactation as well as for work have to be met. Live weight loss in working female cattle and buffalo can lead to reduced ovarian activity and longer calving intervals (e.g. Winugroho and Situmorang, 1989; Zerbini *et al.*, 1993). However, in some countries, breed differences in the effects of nutritional stress on ovarian activity have been observed. Bali cattle appeared more sensitive than the Madura, Ongole and Brahman cross cattle in Indonesia (Wijono *et al.*, 1993). Total milk yield can also decrease on working days (Matthewman *et al.*, 1993; see Pearson *et al.*, 1999). Farmers recognising they cannot feed sufficient nutrients to maintain cow live weight often compromise. They accept they are unlikely to maintain production (milk yield and calving interval), if they also use their cows for work.

Future areas of research

Feeding and energy expenditure

Although considerable research effort has been put into establishing a feeding system for draught ruminants (see Lawrence and Pearson, 1999) some gaps remain and verification of the system is needed. Experiments should be devised to measure directly the efficiency of utilisation of ME for work. Other experiments and data collection in the field are needed to test the feeding system on as comprehensive a selection of animals as possible and find whether the system is a good predictor of animal performance and requirements over short (2-3 weeks) and long (1 year) periods.

Draught cows

Research has shown that dairy cows can be used for work, but that reductions in milk production and conception rate may result, particularly if food intake is insufficient to maintain live weight. Not surprisingly, diet has the greatest effect on body weight and body condition, milk production and reproduction of dairy cows, whether working or not. Increased intake and apparent digestibility of roughage diets by working cows to meet energy requirements may not be sufficient to counteract weight losses on poor diets. In terms of understanding the production characteristics of working cows, there is a need to quantify the energy partition to the different functions of work, lactation and reproduction. The mechanisms

by which body reserves contribute to the energy expenditure of working cows are not clear. Future research priorities should aim to define minimal nutrient requirements for pregnant and/or lactating working cows to allow for an optimal productive performance.

The relationship between work, milk production and reproduction requires additional research, with attention being given to determining breed differences, so that appropriate animals can be identified to meet milk/reproduction requirements in different regions, while supplying draught power at crucial times of the farming calendar. Work increases energy requirements of cows and nutrient intake needs to increase to meet these requirements if working cows are to be kept successfully. Therefore research needs also to focus on development technologies for ensuring adequate feed on farm, which would include the evaluation of locally available sources of supplements. In each location this research should be conducted with a consideration of the whole farm, and those other factors which might also influence adoption of the working female animal, whether it be a buffalo, a cow or a mare.

Herd productivity simulated over a period of 10 years indicated the greater returns to investment in adequately fed working dairy cows compared to non-working cows or to the traditional system. This was mainly the result of the higher value of the work output, in spite of the higher feed costs and relatively lower off-take of milk and calves (Shapiro *et al.*, 1994)). Farmers' access to suitable feeds and veterinary services should be examined. Farmers in peri-urban areas that are characterised by scarcity of land could find draught cow technology most attractive, given a profitable market for milk and calves and adequate supplies of feeds.

Disease and work

Investigations of a limited number of diseases have shown that they can markedly reduce the work capacity of draught cattle, within a short time of the animals becoming infected. Work can also reduce the trypanotolerance of N'Dama cattle. The mechanisms by which these effects operate, both the effects of disease on work and the effects of work on the immune responses to a disease challenge, remain to be established. The recent controlled studies (e.g. Clemence, 1997) suggest this is worthwhile, but is not an easy task. The variation in work performance and immune responses to infection in individual animals can be considerable, since many factors can be involved.

Not all diseases may have as dramatic an effect on working animals as the novel challenge of N'Dama cattle with *T. congolense* investigated by Clemence (1997). Field studies are required to quantify the impact of other diseases on work to assist in the development of appropriate cost effective control measures to maintain healthy working animals which are able to undertake the work required of them. Studies using genetically similar groups of cattle under controlled exercise conditions are appropriate to an investigation of the effects of work on the immune responses to various diseases.

Introduction of animal power

Because of the virtual disappearance of the tsetse fly from many parts of Africa, farmers now have the opportunity to use draught animals in situations where they have not previously existed. Future research should focus on the measures necessary to adapt animal power techniques in these regions, particularly to sub-humid or even humid tropical conditions and crops in Africa. Possibilities include the development of implements and techniques for the cultivation of vegetables and yams and the use of animal power in medium- and large- scale plantation crops especially those such as sugar cane and oil palm which produce by-products which can be used as animal feed.

Modifications in tillage practices to promote soil and water conservation

In many areas due to pressure on land and reductions in fallow periods, farmers are cultivating steeper hillsides, poorer soils and

land in areas of marginal rainfall. Soil and water conservation techniques are becoming increasingly important under these conditions as more marginal crop lands are brought into use. Investigations of the most suitable soil and water conservation practices to use within specific farming systems using draught animal power are needed. Recommendations for different crops and soil conditions will be increasingly needed into the future throughout the tropics, where rain is often uncertain, unpredictable and heavy when it does occur.

Dissemination of information

Despite the wealth of information in all aspects of animal power that is available from scientists and experienced draught animal farmers, there still remains a gap between the producers of the information and the users in many situations where animal energy is used. In sub-Saharan Africa for example farmers are asking for more advice on the use of animal power, on how to make use of donkeys, implements and tillage practices, what feeds are available, how to feed, how to prevent disease and injury as well as where to buy or borrow the animals and implements. In some countries people are also asking for information on animal-drawn transport to complement the use of animal energy in crop production., or on the use of dairy cows to reduce the costs of maintaining both dairy cows and work oxen. The challenge to those people involved in information dissemination is to link with the "providers" to produce information in a form in which it is accessible and understandable to those animal power users who are asking for the information. Working animals are often ill treated and overworked as a result of ignorance. Education and training in best practises offers benefits to the animals and their owners alike. Research may provide some answers but unless the results are disseminated then impact will be minimal. Dissemination should be the goal of the next century for draught animal power.

Conclusions

Despite their increasing availability, tractors and two-wheeled power tillers can be unsuitable or uneconomic for many farmers. On steep, inaccessible or terraced hillsides and on mixed farms where farm size and scale of crop production are small, animal power is often a better option than motorised power to supplement manual labour. This situation is unlikely to change dramatically in the near future and working animals will continue to be found in many areas of the world well into this century, when farmers using them will have to cope with competition for their land from a growing human population and increasing pressure on natural resources. This is likely to lead to the cultivation of more marginal land and a greater use of animals for multiple purposes (e.g. work and milk or work and meat) in order to reduce the numbers of animals kept on the farm.

References

Anderson, M. and Dennis, R. 1994. Improving animal-based transport: options, approaches, issues and impact. In: *Improving Animal Traction Technology* (eds. P. Starkey, E. Mwenya and J. Stares) pp 378-395. Proceedings of the 1st workshop of ATNESA, January 18-23 1992. Lusaka, Zambia, Technical Centre for Agricultural and Rural Co-operation (CTA), Wageningen, The Netherlands. 490p

Campbell, R.S.F. 1993. Draught animals in the AAAP zone and their economic future. In: *Draught Animal Power in the Asian-Australasian Region* (ed. W.J. Pryor). *pp 10-16. Workshop with 6th AAAP Societies Congress, Bangkok, Thailand. November 23-28 1992. ACIAR Proceedings Series No 46. Canberra, ACIAR.*

Clemence, R.G. 1997. Relationships between disease, work and nutrition in draught cattle and buffalo. *Ph.D. thesis. Centre for Tropical Veterinary Medicine, University of Edinburgh.*

COMSEC 1992. Report of an expert consultation on the establishment of NAMA. Nairobi, June 1992. Edited by G.C. Mrema. 108p, FPRD - Commonwealth Secretariat, London

Ellis-Jones J. and Mudhara, M. 1998. Factors affecting the adoption of soil and water conservation technologies in semi-arid Zimbabwe. In: *Soil and Water Conservation Technologies for Smallholder Farmers in Semi-arid Zimbabwe* - transfers between research and extension (eds. S.J. Twomlow and J. Ellis-Jones) pp 104-117. Proceedings of a Technical Workshop 3-7 April 1995, Masvingo, Zimbabwe, Silsoe Research Institute report OD/95/6.

FAO 1987. The next 25 years, FAO, Rome.

Francis, P.A. 1988. Ox draught power and agricultural formation in Northern Zambia. *Agricultural Systems*, 27, 15-28

Goe, M.R. 1991. Le bétail trypanotolérant pour la traction en Afrique occidentale et centrale. *Bulletin de liaison sur le bétail trypanotolerant*, 4, 5-10

Komarudin-Ma'sum, Ali Yusran, M. and Teleni, E. 1993. Draught animals systems in Indonesia 1.3 East Java. In: *Draught Animal Systems and Management: an Indonesian Study* (eds. E.Teleni, R.S.F. Campbell and D. Hoffmann).pp11-20. ACIAR Monograph No 19, ACIAR Canberra.

Kruit, F. 1994. Animal traction technology in Niger and some implications for Zambia. In: *Improving Animal Traction Technology* (eds. P. Starkey, E. Mwenya and J. Stares) pp 474-480. Proceedings of the 1st workshop of ATNESA, January 18-23 1992, Lusaka, Zambia, Technical Centre for Agricultural and Rural Co-operation (CTA), Wageningen, The Netherlands. 490p

Lawrence, P.R. and Pearson, R.A. 1999. *Feeding Standards for Cattle used for Work.* Centre for Tropical Veterinary Medicine, 59pp. ISBN 0-907146-082.???

Lawrence, P.R., Dijkman, J.T. and Jansen, H.G.P. 1997. The introduction of animal traction into inland valley regions. 1. Manual labour and animal traction in the cultivation of rice and maize: a comparison. *Journal of Agricultural Science, Cambridge*,129, 65-70

Leeuw, P.N. de and Rey, B. 1995. Analysis of current trends in the distribution patterns of ruminant livestock in tropical Africa. *World Animal Review*, 83 (2), 47- 59.

Mahdavi, G. 1992. Development of animal traction in cotton areas of French speaking African countries. In: The role of draught animal technology in rural development (eds: G den Hertog and J.A. van Huis). pp 83-87. Proceedings of the International Seminar, 2-12 April, 1990, Edinburgh. Pudoc Scientific Publishers, Wageningen, The Netherlands

Matthewman, R.W., Merritt, J.B., Oldham, J.D. and Horgan, G.W. 1993. Effect of exercise on milk yield, milk composition and blood metabolite concentrations in Hereford x Friesian cattle. *Asian-Australasian Journal of Animal Science*, 6, 607-617.

Mgaya, G.J.M., Simalenga, T.E. and Hatibu, N. 1994. Care and management of work oxen in Tanzania: initial survey results. In: *Improving Aimal Traction Technology* (eds. P. Starkey, E. Mwenya and J. Stares) pp 139-143. Proceedings of the 1st workshop of ATNESA, January 18-23 1992, Lusaka, Zambia, Technical Centre for Agricultural and Rural Co-operation (CTA), Wageningen, The Netherlands. 490p

Olukosi, J.O. and Ogungbile, A.O. 1994. Improving profitability of weeding technology in maize and sorghum production in Northern Nigeria. In: *Improving Animal Traction Technology* (eds. P. Starkey, E. Mwenya and J. Stares) pp 112-115. Proceedings of the 1st workshop of ATNESA, January 18-23 1992, Lusaka, Zambia, Technical Centre for Agricultural and Rural Co-operation (CTA), Wageningen, The Netherlands. 490p

Panin, A. 1995. Empirical evidence of mechanisation effects on smallholder crop production systems in Botswana. *Agricultural Systems*, 47, 199-210.

Panin, A. and de Haen, H. 1989. Economic evaluation of animal reaction: a comparative analysis of hoe and bullock farming systems in Northern Ghana. *Quarterly Journal of International Agriculture*, 28, 6-20

Pearson, R.A. 1998. Draught animals and their management - the future in rain-fed agriculture. *Annals of the Arid Zone* 37, 233-251

Pearson, R. A., Zerbini, E. and Lawrence, P.R. 1999. Recent advances in research on draught animals. *Animal Science*, **68,** 1-17.

Reddy, S.K. 1988. Use of animal power in West African farming systems: far level problems and applications of research perspectives from Mali. In: *Animal Power in Farming Systems* (eds. P. Starkey and F Ndiame). pp182-190. Proceedings of the 2nd West African Animal traction Networkshop, 17-26 September, 1986 Freetown Sierra Leone. Vieweg, GATE, GTZ, Eschborn, Germany. 363p.

Sansoucy, R. 1995. Better feed for animals: more food for people. *World Animal Review*, 82(1), comment.

Scheinman, D. 1986. Animal draught use in Tanga region: a descriptive and analytical study assessing the implications of past, present and future Kilimo and TIRDEP involvement. Tanga Integrated Rural Development Programme, Tanga, Tanzania. 237p.

Shapiro, B., Zerbini, E. and Gemeda, T.. 1994. The returns to investment in dual use of crossbred cows for milk production and draught work in the Ethiopian Highlands. Paper presented at the first Workshop of the Animal Traction Network for Ethiopia, held in Addis Ababa, 27-28 January, 1994.

Shumba, E.M. (1984) Animals and the cropping system in the communal areas of Zimbabwe. *Zimbabwe Science News*,18, 99-102

Starkey, P. and Grimm, J. 1994. The introduction of animal traction into Tanga region. Tanzania: experiences, impact and lessons. Tanga Draught Animal Project report. GTZ.66p

Stocking, M. 1988. Socio-economics of soil conservation in developing countries. *Journal of Soil and Water Conservation*. September-October 1988, pp 381-385

Sumberg, J and Gilbert, E. 1992 Agricultural mechanisation in the Gambia: drought, donkeys and minimum tillage. *African Livestock Research*,1, 1-10

Wijono, D.B., Affandhy, L. and Teleni, E. 1993. The relationship between live weight, body condition and ovarian activity in Indonesian cattle. In: *Draught Animal Power in the Asian-Australasian Region* (ed W.J. Pryor) pp 133 Workshop with 6th AAAP Societies Congress, Bangkok, Thailand, November 23-28 1992. ACIAR Proceedings Series No 46, Canberra, ACIAR.

Winugroho, M. and Situmorang, P. 1989. Nutrient intake, work load and other factors affecting reproduction of draught animals. In: *Draught Animals in Rural Development* (eds D. Hoffmann, J. Nari, R.J. Petheram) pp 186-189, ACIAR Proceedings Series No 27, Canberra, ACIAR.

Zerbini, E., Gemeda, T., Franceschini, R. Sherington, J. and Wold, A.G. 1993. Reproductive performance of F_1 crossbred dairy cows used for draught: Effect of work and diet supplementation. *Animal Production*. 57, 361-368.

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Close encounters...

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down to examine the animal. The pupils were beginning to dilate and the pulse was running low, I resorted to immediate resuscitation calling out for a bucket of water. I threw it all on his face, the recovery was ' slow and uneventful' as prof. P.O. George used to say in our anasthesia class.

He regained his feet and walked away as if nothing untoward had happened. I boarded the next bus with a swollen knee and an even more injured pride. Rashed my livestock assistant later informed me that it was regular entertainment. The buck belonged to the mosque nearby and it had a distinct dislike for people in trousers. I like to think of myself as the local hero for the next few days, I can't recall anybody having beated him in a fair fight.