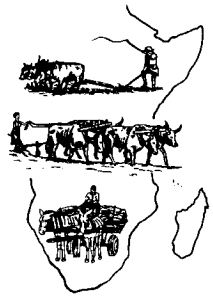
Improving animal traction technology



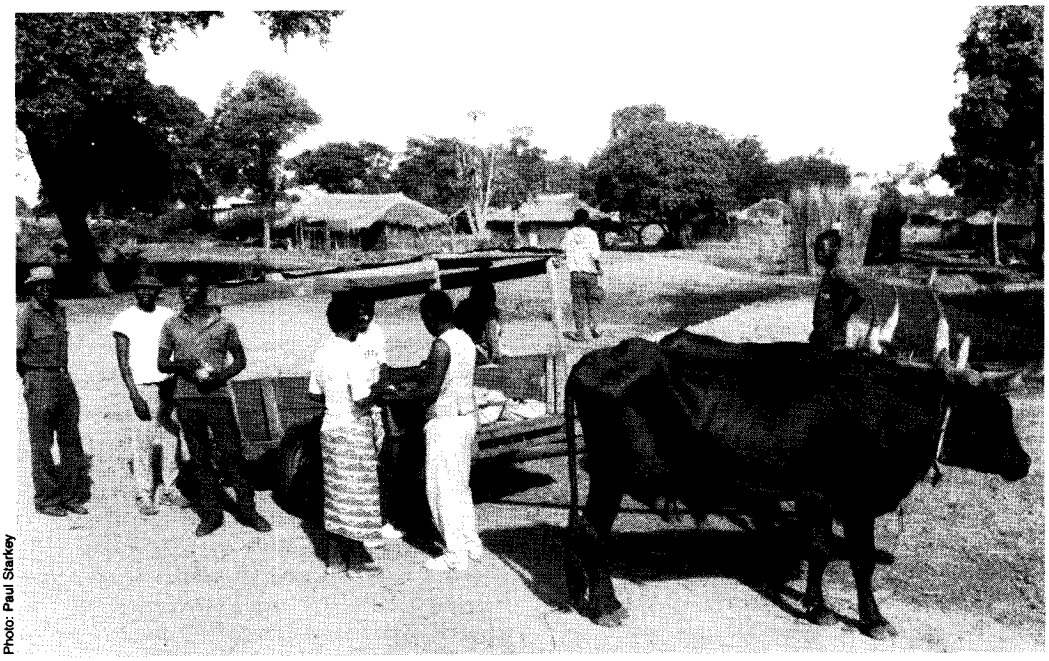


Photo: Paul Starkey

The profitability of animal traction

Increasing the profitability of draft animal power

by

A Panin[1] and J Ellis-Jones[2]

[1] *Department of Agricultural Economics and Extension*
Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana
[2] *Silsoe Research Institute, Wrest Park, Silsoe, Bedford MK45 4HS, UK*

Abstract

This paper examines the existing use and potential for draft animal power in sub-Saharan Africa. Regional differences are identified and indicative costs of human, animal and tractor power are compared. Animal traction is considered an appropriate technology, whose adoption and profit potential are limited by political, social, technical, economic and institutional constraints. These are critically analysed in the light of the urgent need to increase both productivity and sustainability of existing farming systems. It is concluded that draft animal power should play an increased role in the development process in the region and every effort should be made to alleviate the constraints to increased profitability.

Introduction

Animal traction has a long history in agricultural production. It has played, and still plays, an important role in meeting the power requirements of farming systems in many parts of the developing world.

The total world population of draft animals is estimated at 400 million, of which less than 5% are found in sub-Saharan Africa (Ramaswamy, 1988; Mrema, 1991).

The overall low level of use of animal traction technologies in sub-Saharan Africa raises doubts about its profitability and sustainability in small farming systems. Yet participants in a workshop on "Animal traction for agricultural development", held in Senegal in 1988, noted that the persistence of draft animal power and its spread in Africa suggest that animal traction can be profitable.

This observation requires study of the factors mitigating against increased profitability of draft animal power, in order to stimulate its increased adoption in sub-Saharan Africa. This paper analyses the problems associated with improving the profitability of animal traction.

The existing situation

Historical perspective

In much of sub-Saharan Africa draft animal power was initially introduced through European settler farmers, early development programmes and the migration of workers within the region. Although the technology was introduced over 70 years ago, its adoption has been patchy; it is used on less than 15% of arable land, mostly in the arid and semi-arid areas.

Oxen were the main draft animals introduced, although occasionally cows were used to make up teams. Donkeys, mules and horses were used where they were available.

Tractors were introduced from the 1940s onwards, in the periods leading up to independence and immediately thereafter. They were first used in the commercial (white) farm sector, but they spread quickly as tractor hire schemes for small farmers were promoted by aid agencies, donor countries and tractor manufacturers.

During this time tractors were considered the key to successful agricultural development and a natural progression from hand and draft animal power. Tractor schemes were taken as good examples of mechanised agriculture by the emerging African elites who were engaged in the political struggle for independence. Political leaders were unlikely to refuse assistance based on increased use of tractors. Consequently, large-scale tractorisation schemes were initiated in most sub-Saharan African countries in the 1960s. In Tanzania, for instance, 60% of government investment in settlement schemes was in the form of agricultural machinery, implements and vehicles, with heavy reliance on expatriate managers (Mrema, 1991a; 1991b).

Similar policies were initiated in the nominally independent homelands of South Africa during the late 1970s and early 1980s (Ellis-Jones, 1991).

This large-scale introduction of tractors, be it through government hire schemes or state, settlement or cooperative farms, was not successful. The failures are still having a pronounced influence on agricultural mechanisation policies.

Duality of agricultural production

Agricultural production is, and is likely to continue to be, undertaken in a dual structure of medium to large commercial and peasant smallholder farms, often referred to as the formal and informal sectors. Pressures on egalitarian grounds for land redistribution to promote smallholder production will continue, especially in South Africa and to a lesser extent in Zimbabwe and other countries having a substantial large-farm sector. It is important that the two sectors are accurately defined, through the use of farm surveys, so that appropriate strategies for each can be developed.

In parts of sub-Saharan Africa there are large differences arising from the history of white settlement and the interests of large commercial companies, whose management systems are comparable with those found in the USA and the European Community.

Typically one can find sub-subsistence farmers (especially where there are large numbers of migrant workers, whose families scratch a living on small rural plots), subsistence farmers, emerging commercial farmers, small-, medium- and large-scale commercial farms and plantation cropping estates. Larger farms can be organised as communes, cooperatives, parastatal or private commercial entities. In reality most forms of agricultural organisation exist in the same country, regardless of that country's political ideology.

In most cases large farms, regardless of ownership, have adopted tractor technologies, whereas small farms use a variety of power sources, sometimes only hand tools, sometimes draft animal power or tractors, and often a mixture of all three.

Increasing farm size has been associated with a transition from hand tools through animals to tractor-based mechanisation technology. However, hand tools are required in all farming systems, and a combination of tractors and draft animal power is increasingly being considered by commercial farmers.

Table 1: Proportional contribution (%) of total power use in 93 developing countries

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

Source: FAO (1987)

Importance of draft animal power

Review of the present use of animals

Animals are used within a range of farming systems, where the output is often multi-purpose providing milk, meat, manure (for fertiliser or fuel), hides, skins and horns, replacement animals, draft power and social needs (status in the community, capital accumulation, rituals, *lobola*, etc).

The cost of keeping stock can therefore be spread over a number of uses. The greater the spread, the lower will be the cost of providing draft animal power.

Importance of animals as a power source

The contributions of different power sources in the production of food in developing countries vary widely, as shown in Table 1. Sub-Saharan Africa ranks lowest in the use of both tractors and animals, and highest in human power sources. Clearly there is great potential for increasing the use of draft animal power in this region.

Although considerable variation occurs, depending on individual circumstances, most studies indicate that it costs more than twice as much to prepare a hectare of land using a tractor as it does using draft animal power (Table 2). Hand labour can be the cheapest power source, but the maximum area for which it can be used is 2 ha.

Relevance of improving draft animal traction profitability in Africa

Despite the limitations of available data, it is clear that agricultural performance in sub-Saharan Africa has deteriorated in recent years (Eicher, 1984; Lele, 1984). Annual rates of increase of food crop production in the region lag behind those of the population, resulting in a decline in per capita output. A large proportion of Africa's population is either undernourished or chronically malnourished.

Table 2: Workrates, daily outputs and plowing costs using different power sources

	Tractor 50 kw	*Animal 2 oxen*	*Human 1 man*
Work rate (hours/ha)	2–3	25	100
Work day length (hours)	8–16	5	5
Daily output (ha/day)	3–7	0.2	0.05
Cost[1] (US$/ha)	100	30–50	50–100

[1] *These are approximate costs for comparison. They will vary considerably depending on actual and opportunity labour costs*

Source: Morris (1983)

One of the main features of African agriculture is its low productivity. This has resulted from a combination of socioeconomic factors of which dependence on human labour for most farm operations is crucial. As noted by many writers (ILCA, 1981; Lele, 1984), increases in crop production in Africa result from increases in the area under cultivation, rather than from gains in productivity per unit of input. With current rates of population growth, the main way to avoid food shortages is to focus attention on technologies that raise productivity of labour.

Most African countries have attempted to mechanise agriculture through the use of tractors. The results have been disappointing. Attempts with draft animal power have also experienced problems. However, the high cost of imported machinery and spare parts, disappointing experience with tractorisation and the ever-increasing foreign exchange problem, have motivated many African countries to redirect their agricultural policies to include draft animal power (Dibbits, 1988; Sindazi, 1988; Silumesii and Musonda, 1991; Twum and Gyarteng, 1991), and to actively encourage its use (Starkey, 1988a). Yet the use of draft animal power is still limited in sub-Saharan Africa. There are marked regional concentrations resulting from historical differences, farmer attitudes and the spread of livestock diseases; intensity of use is highest in eastern Africa, followed by southern Africa (Jahnke, 1982).

Efforts to improve the image and profitability of draft animal power are being supported by national and international aid agencies. The World Bank strongly recommends the use of this technology in order to raise the productivity of labour (IBRD, 1989).

Draft animal power is potentially an appropriate technology. It is relatively inexpensive, not too complicated, and can help to increase productivity (Norman, Newman and Onedradago, 1981). Experience in various sub-Saharan African countries (Sindazi, 1988), suggests that animal traction is increasing.

Means of improving profitability of draft animal power

Many factors affect the profitability of draft animal power in sub-Saharan Africa. Prominent among these are farmers' attitudes and economic, technical and institutional issues.

Farmers' attitudes, choices and perceptions

Although draft animals are the most cost-effective source of farm power, farmers' perceptions can have an important bearing on the choice of power source.

A decision to purchase a draft animal is not made only on business grounds. Reduction in drudgery, provision of family transport and increased status are other factors that farmers consider. Farmers' attitudes may also limit the use of draft animal power. For instance, when fodder and grazing are a constraint, tractors may be used, even if it is more cost-effective to use animals and pay for feed. Such attitudes tend to favour use of tractors where these are available.

Economic factors

Attempts to increase the use of draft animal power have often concentrated on removing the technical constraints and increasing the physical supply of draft animals, without adequate consideration of the economic realities faced by small farmers.

The demand from farmers tends to be for power *per se*, regardless of source. The amount of power demanded is unlikely to be changed by price changes.

It is therefore sensible to identify those factors which have significant effects on the supply of draft animal power relative to other types of farm power. Gregory (1989) identified these as being:

- the relative costs of different sources of farm power. Draft animals are the least costly sources of farm power and increased use would increase small farm incomes and improve the economic efficiency of agricultural production. However, overvalued exchange rates, low import duties for tractors relative to other goods and the availability of cheap loans for tractors are factors that make tractors cheaper. These factors mitigate against draft animal power
- the proportion of the cost of the draft animal which has to be covered by its farm work. Greater use of animals will reduce the proportion of capital and maintenance costs of draft work per unit of land. There is a great demand in most rural areas for transport (of firewood, water, building materials and harvested crops). In fact, transport contracting offers great income-generating opportunities
- the work output and efficiency of the draft animal during the land preparation season. Increasing draft efficiency by using cost-neutral technologies will decrease the relative cost of draft animal power. This is likely to be

attractive to farmers, who will probably reject technologies that increase costs. Technical initiatives to promote draft animal power should concentrate on those factors which offer the greatest return.

Technical factors

Integration of cash crops into farming systems

Attempts to introduce draft animal power into agriculture have not always taken account of the complexity of the farming systems and the interactions between them and the social, political and ecological systems, as well as the ability of farmers to manage new elements in their farming system.

Resources (such as land and labour) in rural farming communities are generally allocated with strong emphasis on meeting households' subsistence needs and minimising the risks involved in production. In most cases, households only give attention to cash crops after they are sure that their own needs can be satisfied.

It has been suggested that draft animal power leads to increased production of cash crops. Certainly this has been the case in areas where draft animal power has been introduced and promoted as a development project aimed at increasing cash crop production. However, some surveys have indicated that the introduction of draft animal power has not induced any significant changes in the traditional cropping patterns (Barett et al, 1982; McIntire, 1983; Panin, 1986).

Staple food crops, which still dominate as farmers adopt draft animal power, can suffer from internal market forces. Production which is surplus to household requirements is offered to the market at relatively low prices, whereas the prices farmers have to pay for their inputs can be very high; this reduces the potential profitability of draft animal power investment. Mwinjilo (1991), observed that the overall aggregate price increase of the draft animal power package and inputs used in Malawi between 1978 and 1982 far exceeded crop price increases, leading to reduction in gross margin.

The use of draft animal power substantially increases the financial burden on farmers, particularly during the early years of adoption (Reddy, 1988; Panin, 1989). This can make the investment unattractive. One way to overcome this problem is to embark on some cash cropping. Groundnuts and other cash crops can increase the profitability of draft animal power more than staple food crops such as millet, maize and sorghum (Delgado and McIntire, 1982; Panin, 1987). However, care needs to be taken in selecting the types of cash crop and the amount of land to be allocated to them, because production of staple food crops must still be sufficient to meet household requirements.

Draft animal power in isolation should not be regarded as the "optimal solution" to the productivity problem.

Raising crop yields

The use of animal traction can increase crop yields through either intensification or extensification of land use systems. Draft animal power enables farmers to work faster and undertake additional agronomic practices such as deeper ridging, mulching, application of fertilisers and better weed control, all of which considerably improve agricultural productivity (Normal, Newman and Onedradago, 1981). In areas where arable land is abundant, animal traction is often used to expand the cultivated area (Barett et al, 1982; Francis, 1988; Sumberg and Gilbert, 1992). This implies that there is a positive correlation between the land area farmed by a household and the use of draft animal power. That notwithstanding, it is inappropriate to attribute the increased area totally to the use of draft animal power; in many cases households which use draft animal power have a larger labour force than households which do not (Panin, 1987; Sumberg and Gilbert, 1992).

Although there seems to be a consensus in the literature on the relationship between the use of draft animal power and the total cultivated area per household, the same cannot be said for the effects of draft animal use on crop yields (Singh, 1988). Reports from experimental stations show that yields increase substantially on draft animal power farms (Eicher and Baker, 1982; Pingali, Bigot and Binswanger, 1987), but evidence from farmers' fields indicates only modest yield increases (Lassiter, 1982; Panin, 1987). On experimental stations, animal traction is complemented by improved seeds, fertiliser, pesticides and other inputs, whereas on farmers' lands this is often not the case. Also, the level of management is usually greater on experiment stations. However, on-station results clearly indicate a potential for increasing crop yields at the farm level. The question that still remains is how lessons drawn from experiment stations can be carried over to the farmers. Research on agronomic practices leading to intensification of land use systems should be encouraged in order to exploit appropriate methods suitable to the farming conditions.

Animal nutrition

Throughout sub-Saharan Africa traditional animal management systems are extensive. The use of communal, often over-utilised grazing, with limited access to crop residues during the dry season or winter months, is the norm. This adversely effects both the quantity and quality of feed available.

Without proper nutrition work animals cannot provide the power required from them. Guma (1988), Rocha (1988) and Tembo and Elliot (1988) cite weakness of draft animals at the beginning of the cultivation period as one of the major factors limiting draft animal productivity in Swaziland, Mozambique and Zimbabwe. Unfortunately, forage is in short supply during this period, and the animals are often in poor condition, and likely to remain so. Undernourished animals can work, but timeliness is likely to suffer.

One solution is to establish low-cost feeding systems, especially in arid and semi-arid areas. Maize stover, groundnut or bean hay and, occasionally, cottonseed cake have been used in this way when they are available.

Another strategy to improve nutrition of work animals is to introduce fodder production into the farming systems. Successful alley farming methods which have emerged from national and international research stations should be introduced to farmers, and wide-scale adoption should be encouraged.

Alternatively, major farm operations could be undertaken when animals are still in good condition. Plowing and ridging could be done immediately after harvest when soils have sufficient residual moisture for deep plowing. This system, despite its associated problems, has had a good response among communal farmers in Zimbabwe (Tembo and Elliot, 1988).

Cows as draft animals

Development programmes initially concentrated on selecting the most powerful animals for the most demanding tasks. Other characteristics such as resistance to disease, low maintenance, quiet temperament, ease of handling and training are now receiving increased attention.

Oxen still comprise the greatest number of work animals in sub-Saharan Africa. Cows, although they dominate the cattle population, are seldom used for draft. However, the cost of maintaining oxen only for work can easily exceed the benefits. For example, it has been estimated in Sierra Leone that, on average, oxen work for only 41 days each year (Corbel, 1988). Under such circumstances the use of female animals, particularly cows, for draft has many advantages. Benefits such as milk and progeny will reduce the costs of draft animal power. Experience shows that cow traction is technically feasible and is a means of raising net farm incomes (Matthewman, 1987; Panin and Brokken, 1992).

Additional benefits arising from the adoption of cow traction include the earlier sale of male animals, thereby reducing the total number of livestock and increasing the feed available for the remaining animals.

However, successful cow traction requires improved management skills of farmers. Cows should not be used in the last month before calving or in the first month of lactation. Research is required to optimise the production of draft animal power, progeny and milk.

Increasing the meat value of the animal

The profitability of draft animal power is affected by the value (as meat) of the animal at the end of its working life. Residual values of donkeys, mules and horses (which, in most of sub-Saharan Africa, are not eaten) are low, which may mitigate against their increased use as draft animals.

Empirical evidence indicates that the salvage values of draft animals can exceed the purchase prices (Barett et al, 1982; Panin, 1987), particularly when the animal is in good condition. This could itself encourage additional feeding of draft animals.

In some countries in sub-Saharan Africa draft animal power reduces the practice of keeping cattle too long (Starkey, 1990). Thus the payback period of the investment is shortened and liquidity problems are reduced, as also are the risks involved in keeping the animals on the farm for several years. Farmers should be made aware of the potential benefits from this.

Animal health

In large parts of sub-Saharan Africa tsetse infestation and animal trypanosomiasis limit livestock production. The introduction of trypanotolerant breeds, largely in West Africa, has had some success, but the power output of these breeds is lower than that of non-tolerant breeds. Other endemic diseases (foot and mouth, blackquarter and septicaemia), and problems of a local or sporadic nature (tick-borne diseases, brucellosis, internal parasites, etc), can also have a serious impact on the availability and utility of draft animals.

Protection against many of these diseases is possible, provided there are adequate distribution systems to deliver the appropriate veterinary

product—hence the importance of appropriate infrastructure and improved veterinary services.

There is, however, a need to ascertain the economic importance of these diseases in the draft animal population, in particular the interactions between diseases and parasites and the effect these have on the work output of draft animals.

Equipment availability

A great deal of equipment has been developed for use with draft animals. The implements most commonly adopted are plows, ridgers and carts. Starkey (1988b), in his book "Perfected yet rejected", has clearly shown that some of the technologies developed over the past three decades have not been adopted. One reason is that the technologies did not develop to solve problems identified on the farm, but rather from engineers' perceptions of what was required.

However, Starkey (1988b) has also argued that better circulation of available technology to researchers and extension agents could lead to greater profitability. Better identification of farmers' constraints, and farmer participation in research and development, are likely to lead to technologies that are more affordable. Research should consider the animal, harness, implement and operator as a system rather than concentrate on one aspect in isolation (O'Neill, 1990).

With increased attention being paid to improvements in draft animal power, particularly feeding and health, better use of the increased power will require a greater range and improved quality of the equipment. By offering implements for land preparation, planting, weeding and other crop care operations, water pumping and improvement in ox cart design, greater profitability of draft animal power may be achieved. Transport is a major area where profitability can be enhanced.

Labour productivity

The productivity of labour in African agriculture is very low. Often two or three people work with a team of two oxen, whereas in most parts of Asia only a single person is required.

Barett et al (1982) and Singh (1988) show that the use of draft animal power may not increase the area cultivated per active worker. This implies that draft animal power, as used in many African countries does not substitute for labour. From this observation, the low profitability of animal traction resulting from the low labour productivity should not come as a surprise. Rather, the causes of this poor performance need further investigation.

Expansion of cultivated area by households using draft animal power can be constrained by a lack of implements for weeding and harvesting. The most common use of draft animal power in Africa is for primary tillage and transport (Reddy, 1988); its application to weeding and harvesting is limited. However, a positive correlation has been found between cultivated area and total annual labour input for weeding and for harvesting (Panin, 1987). The selective use of animal traction technology shifts the labour demand for these two operations. The effective execution of both operations depends mainly on the available household labour. This explains why the land-to-worker ratio is generally the same for households which do and do not use draft animal power. Hence, in order to achieve higher yields through extensification of land use, appropriate weeding and/or harvesting equipment should be included in the animal traction package offered to farmers.

Institutional factors

The profitability of draft animal power is heavily dependent on support services and infrastructure. Appropriate research and development, extension, credit, input and service supplies and manpower development are all essential ingredients that require careful planning and coordinating in promoting the use of animal traction.

Improving research and development

Research programmes and development work in animal production and draft animal power tend to proceed independently; they are often uncoordinated and consultation between interested groups is inadequate. Emphasis should be given to problem-orientd research determined in the context of farmers' needs. Appropriate technologies should be screened using technical, environmental and socioeconomic criteria. Research should be integrated closely with credit, input supply, extension and training activities.

The following coordinated research and development activities need to be intensified:

- farming systems research to identify the role and potential profitability of draft animal power
- adaptation, development and design of draft animal technologies, to remove the present constraints. The approach should be multi-disciplinary and should include the farmers, the implements, the animals and the effects on the environment
- development of methods to encourage adoption and diffusion of innovation by both farmers and manufacturers

- formulation, monitoring and evaluation of draft animal power activities, especially the status and performance of credit, extension, manufacturing facilities and government policy instruments (import licensing, tariff regulations, etc).

Extension

Extension efforts will be required to support a draft animal power programme providing inputs for selecting, rearing, training, care and use of work animals, as well as selection and use of equipment. This should be an integrated programme involving livestock specialists, vets, agricultural engineers and socioeconomists.

Industrial extension will be required to provide local manufacturers with assistance in assessing market needs, skills training and business management. Promotional support and assistance with demonstrations and audio-visual material should be provided to help market completed products.

For draft animal power to be sustained, adequate repair facilities, skills, materials, parts and consumables need to be made available. Repair and servicing networks must be close to farmers in the rural areas and not restricted to the main urban centres. This is likely to require the support of local artisans and blacksmiths.

Credit availability

Agricultural credit is a development resource which can give a high degree of direction to both the pace and the form of mechanisation.

In the past, public credit institutions often provided loans for tractors and equipment at subsidised rates. As a result, tractor sales soared, and draft animal power and labour were displaced. Such practices cause market distortions, which are ultimately not sustainable.

Credit facilities for the purchase of animals and equipment packages need to be formulated according to farmers' needs and ability to repay. Rates and terms should reflect a balance between the desire to promote draft animal power and the need to maintain a realistic relationship with rates for the purchase of other agricultural inputs.

Suitable credit packages for local manufacturers should include finance for buildings, plant and equipment and working capital for development, manufacture and marketing.

Personnel development

A wide range of personnel is required to formulate and implement a draft animal power programme. These include farmers, extension agents and researchers, who need training aimed specifically at improving the use of work animals in existing farm systems. Technicians, managers and administrators need training in manufacturing, maintenance and repair on the one hand and in commercial administrative skills on the other.

Transport, communications and infrastructure

Transport and communications directly influence the acquisition, delivery, operation and maintenance of draft animal power. A strategy to promote animal traction must recognise the limitations of existing facilities. It may be necessary to improve infrastructure directly to establish new rural workshops with better communications for distributors and manufacturers.

Evaluation of draft animal power investments

At farm level

An investment in draft animals and implements represents both a capital (acquisition) cost and maintenance costs over the working life of the animal. Evaluation of such an investment involves detailed cash flow analysis as well as consideration of opportunity costs of capital.

For the investment to be attractive to farmers, the anticipated benefits should be considerably greater than the costs. As pointed out by Binswanger (1986), farmer adoption of a technological innovation will depend on the degree to which the innovation reduces the unit costs of inputs used in the production process. Also, one of the findings of a group discussion in a workshop on "Animal power in farming systems", held in Sierra Leone in 1986, was that unfavourable terms of trade between the costs of inputs and those of the outputs affect profitability of animal traction (Starkey, 1988a).

The benefits of animal traction accrue from increased crop production, services (eg, hiring and transportation), the salvage value of the animals and reduced costs of inputs.

The methodology most often used in draft animal power studies is cross-sectional comparison of various types of animal traction farms with the predominantly hand-hoe farms at a given moment in time. However, such cross-sectional data do not provide an accurate and realistic representation of essential time related production issues, such as: changes in investment outlays on the farm; the critical learning period required by new adopters; changes in net production value arising from variations in crop mixtures and yields; and liquidity requirements of the investment.

Starkey (1990) points out that time series data should be used for the analysis of economic impacts of animal traction, in order to ensure that observed trends in production are not spurious. Unfortunately, there is not a single known case of a farm level study on the economics of animal traction in Africa which has used time series data extending over a period of two years. Attempts to remedy this situation are made by using projections based on average figures (Lassiter, 1982; Panin, 1989).

Another problem in assessing animal traction profitability is that profitability measures used in most studies have been derived from gross margin analysis. Gross margin comparisons refer to one aspect of the farm enterprise, thus isolating animal traction activities from the rest of the farm business. Yet is necessary to look at the total profitability of the farm because the use of animal traction technology for one enterprise in the farm can have positive multiplicative effects on all other enterprises of the farm business.

At a national level

What appears financially attractive to a farmer may not be suitable or sustainable in the overall economy of a country. An evaluation of draft animal power investments at a national level requires a substantiation of the values of the costs of the manpower, financial and natural resources allocated to the programme. It would take account of any subsidies or incentives to farmers, a credit programme or tax exemptions, as well determination of any foreign currency component. Likewise the value of the direct and indirect benefits would be assessed. Direct benefits include increased farm incomes, an increase in agricultural production, reduction in imports and increased employment. Indirect benefits include institutional and infrastructural development (training, extension, skilled manpower, transport, communications), impacts on the industrial sector (local production of implements), increased food supplies and security, and possibly lower consumer prices.

Conclusions

Profitability and adoption of draft animal power are interlinked. If farmers perceive technology to be profitable, by either reducing costs or increasing income, without necessitating major changes in farming systems, they are likely to adopt that technology.

The profitability of draft animal power in sub-Saharan Africa can be substantially increased. However, this is not the complete answer to the agricultural mechanisation problem. The limited adoption of animal traction, despite 70 years of extension effort and its apparent advantage over hand tool technology, indicates that there are still serious technical and socioeconomic problems to be overcome. Promotion of draft animal power technologies must be based on sound financial and economic analysis.

Animal traction needs to be supported by sound fiscal policies (exchange rates, credit policies, taxation, import duties and pricing policies) which, if used correctly, can have major benefits on promoting draft animal power in a balanced way. However, to bias such measures in favour of draft animal power in the short term will not ensure long-term sustainability.

Recommendations

To allow draft animal power to play its rightful role in the development process the following actions should now be given priority.

- Detailed farming systems research needs to be carried out to establish the technical, economic, social and political constraints to improving the profitability of draft animal power
- Improved coordination and communication between aid agencies, research programmes, extension services, farmers and private sector manufacturers and distributors should be promoted, with emphasis being given to formulating appropriate mechanisation strategies
- Research and extension must be improved. Priority should be given to adaptive research and dissemination of existing technology
- Intensified training efforts should be promoted to provide the manpower for draft animal power
- Government policy instruments for credit, taxation, exchange rates and import duties should be closely examined to ensure that they do not mitigate against draft animal power.

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