6. The selection of equipment

6.1 Equipment evolution and development

It may appear self-evident that animal traction equipment must be appropriate to the local farming systems. Yet in most developing countries there have been examples of the promotion of equipment that (with the expertise of hindsight) was clearly not adapted to local conditions. Graveyards of abandoned or unused implements tell their own tales.

Farming systems are dynamic and constantly evolving. The continued development and adaptation of any equipment used within a farming system is ensured by two major processes: variation and selection. The analogy of evolution (or artificial breeding) is quite apt, for the refinement of organisms or equipment is based on the natural or artificial selection of the preferred options. If either variation or choice are lacking, there can be no scope for improvement. Successful breeding (or equipment) programmes involve the multiplication of the chosen and the culling of the inferior options. Selection must involve rejection. (The implication is that small equipment graveyards are an inevitable result of evolutionary pressures, but this should not justify the active promotion of dinosaurs!)

Historically, large or small changes in equipment have been made by innovative farmers themselves, often working with village artisans or local manufacturers. The choice of whether to use the old or new design has been taken by the farmers and their neighbours. This process is actively continuing all the time, in all communities. This system of evolutionary progress has led to the development of most agri-

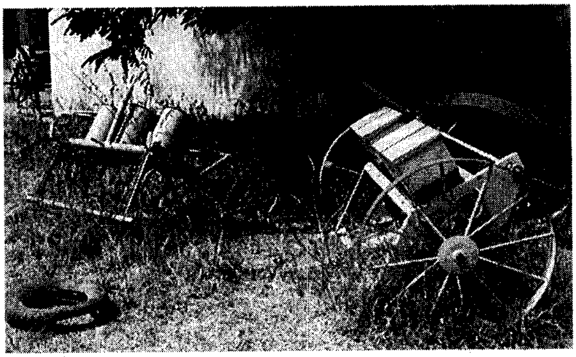


Fig. 6-1 and 6-2: Small equipment graveyards (such as the one below in Mali), are an inevitable consequence of the process of testing, selecting and rejecting animal-drawn implements. Larger stockpiles of unwanted implements (such as the consignment of heavy reversible plows seen in Togo, right) could be prevented if more attention was paid to the initial selection criteria.

Photos: Paul Starkey

cultural equipment in use today. The process is intrinsically efficient in the long term, but very slow by the standards and aspirations of modern governments and development projects. The process can therefore be speeded up by providing more variation and a greater degree of selection.

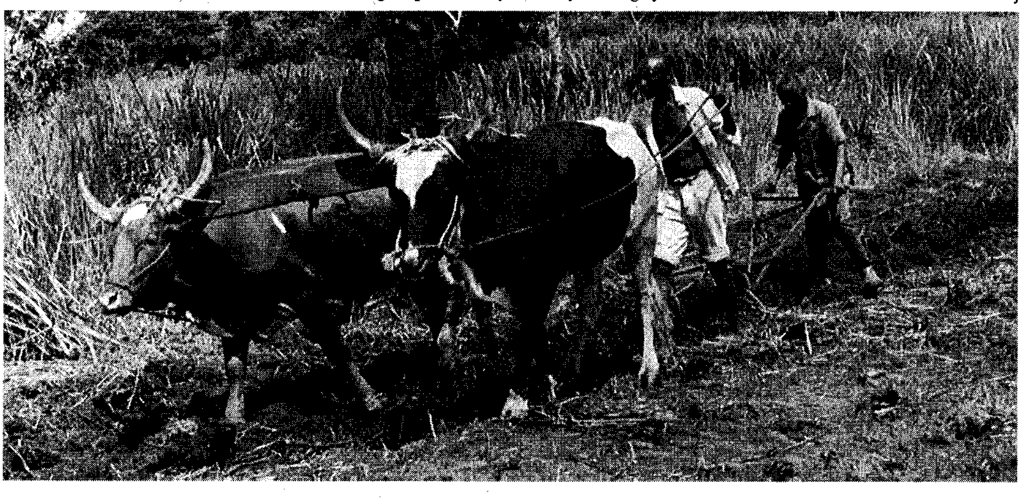
There are great advantages in creating the variation within the environment, by encouraging artisans and manufacturers to modify (and thereby possibly improve) existing equipment, or experiment with new designs. Nevertheless numerous and varied designs of animal traction equipment have already been created so that it is unrealistic and inefficient to try to develop new designs entirely in isolation. Unfortunately many projects have attempted to do just this, and have often succeeded only in "re-inventing the wheel", by developing designs of harnesses, seeders, toolcarriers or other implements similar to those already in existence. It is most important to benefit from existing knowledge and the experience of others elsewhere. In general, broad selection should be based on existing designs, while further modification, selection, rejection and evolutionary development may be best carried out within the local farming systems.

6.2 Definition of requirements

In recent years many animal traction programmes have neglected the important stage of definition. Before equipment is purchased or developed it is useful to write down, in as much detail as possible, precisely *why* it is needed, *what* it is required to do and *in what context* and *with what resources* it will be used. Only after the actual requirements have been clearly defined, should the detailed technical specifications be listed.

The definition of requirements must be derived from the farming systems in which the equipment will be used. Thus if farmers' fields have tree roots in them, any cultivation implement intended for that farming system should be able to cultivate in the presence of roots. Naturally farming systems are constantly changing so that the addition of a new item of equipment leads to some change (large or small) in the whole system. Thus the availability of an implement that can only work in root-free conditions *may* cause farmers to remove the stumps from their fields. It may, on the other hand, lead to the rejection of such an implement as inappropriate to the actual conditions. Thus a clear distinction must

Fig. 6-3: Plowing a field in eastern Zaire: the soils have tree stumps and strong rhizomes, access from the distant village is by narrow path, and the animals are disease-prone. All these factors should be considered when selecting implements for this farming system. Photo: Paul Starkey



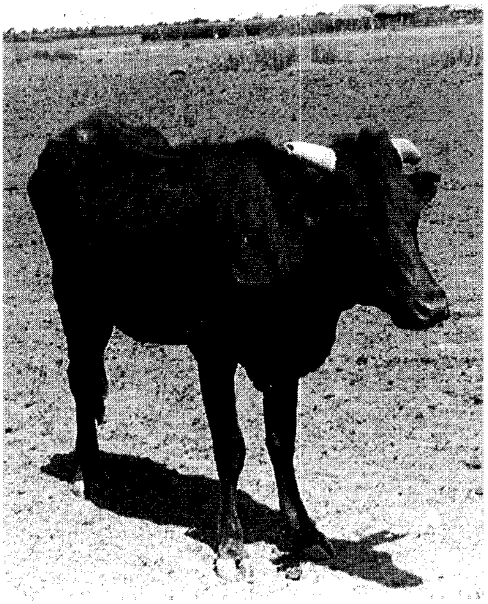


Photo: Paul Starkey

Fig. 6-4: At the end of the dry season in Botswana cattle are often emaciated, but still expected to work. Unless dramatic changes in nutrition are realistically envisaged, equipment has to be designed for use by such animals.

be made at the stage of definition between the *realities* of existing farming systems and any *assumptions* relating to prerequisite future changes that have been made. Common assumptions relating to animal traction equipment use have included:

- changes in the timing and duration of operations;
- increases in yields and profitability;
- improvements in the availability of technical services (such as repair and maintenance).

The disappointments of many animal traction programmes that made such presumptions should be taken as a warning. In general, optimistic assumptions should be avoided or kept to a minimum: wherever possible equipment requirements should be defined in such a way that the equipment can be used within the *actual conditions prevailing*. This may mean that in rapidly evolving farming systems, equipment needs may change frequently. Animal traction programmes may find it more beneficial to anticipate small but progressive changes in farmer demands for equipment rather than to promote technological leaps.

Realism is also required in assessing the available power of the animals. One of the most common mistakes made by animal traction programmes in recent years has been to seriously overestimate (or overlook) the draft capabilities of the farmers' animals. Many equipment designs produced by engineers on research stations have been rejected by farmers as too heavy for their animals. *If animals are normally in poor condition* at the time an operation is required then it should seem quite evident that *equipment must be capable of being pulled by animals in poor condition*. It seems quite pointless promoting heavy equipment developed and tested with large and well fed animals, if such beasts do not exist in the local farming systems!

The realistic approach being advocated here certainly does not preclude trying to improve the condition of the animals at the same time as equipment is being promoted. What is essential however is to carefully distinguish between present realities and optimistic assumptions. A "package deal" may well be envisaged in which the use of heavy equipment is directly linked to improved animal nutrition, *provided* it is understood by all concerned that such equipment is *not* designed for the existing farming system. In such a case the very ambitious nature of the objectives should be clearly understood since any "stronger animals" policy will have a very much wider scope than normal equipment-package credit-programmes. The promotion of "heavy" equipment necessitates successfully tackling one of the most difficult animal traction problems, that of finding a *realistic* and *economically acceptable* way of improving animal condition in normal village circumstances. Until proven, realistic and acceptable methods of improving draft power are available, animal traction equipment should be suited to the strength of existing animals.

In the early stage of definition environmental issues must be carefully assessed. In most farming systems there are techniques that conserve soil and water and others that degrade the environment. For example there may be certain ecosystems, including some in arid or mountainous areas, in which mouldboard plows, tines or disc harrows may tend to accelerate erosion, particularly if used without reference to prevailing slopes. There might be ecological implications in encouraging the use of wooden animal-drawn implements in the Sahel, where other pressures on timber resources have caused major deforestation. The impact on local cattle populations and grazing resources on a change from heavy draft cattle plows to lightweight donkey tines could be considerable.

It is also essential to thoroughly consider socioeconomic criteria. When assessing the requirements for any piece of equipment it is necessary to know how the farmers, together with their families and communities, judge the value of the operation performed by the implement. This may involve knowing who undertakes that operation (farmer/labourer; child/man/woman), the time taken to perform the operation and whether it is undertaken at a time when labour is plentiful or scarce. If the objective is to use animal power to replace human power, it is important to determine whether there would be a beneficial or detrimental shift in the category of labour or the time of operation. With an assessment of the value of the operation, it should be possible to gauge an affordable cost. Again realism is essential and optimistic assumptions should be avoided: far too many programmes that ended as disappointments had judged that farmers could have afforded high cost implements *assuming* that cultivated areas and yields had increase dramatically.

The importance of risk in determining farmer decision-making is often neglected. Subsistence farmers have been seen to select an option that minimizes risk and increases security, over an alternative that may be intrinsically more profitable, but which increases risk. For example some farmers in The Gambia opted for donkey powered equipment over ox-drawn alternatives largely because they considered that donkeys were less likely to be stolen. Farmers may prefer several single purpose implements to one multipurpose toolbar if they perceive that the risk of the one implement being damaged and leaving them without any usable tools is too great.

Fig. 6-5: On-farm evaluation of equipment by farmers is crucial to ensure the size, weight and technical characteristics of implements are to be appropriate for the animals, the people, and the farm conditions in which they are to be used. Here a mouldboard plow is tested by women farmers in Sierra Leone.

Photo: Paul Starkey

It must be remembered that, in reality, *there is no such thing as an average year.* Most years are exceptional in some ways, being particularly: dry, wet, late, early, hot, cold, calm, stormy, or with greater/fewer than normal weeds, insects, fires, social obligations or political upheavals. If this should seem self evident, it can be very illuminating to read the annual reports of the numerous research and development programmes working with animal traction. It has been frequently concluded that some piece of animal traction equipment or technique on trial was basically excellent, but unfortunately it did not do well *that year* because of exceptional circumstances! Seldom were such constraints major, once-in-a-generation catastrophes, and most were the normal "exceptional conditions" that a farmer must survive each year. It is clear that reliability under a wide range of conditions is often high in priority when farmers select appropriate equipment.

Finally, lest it be implied that farmers are infallible in their selection criteria, it must be remembered that they too are influenced by fashion, and that the prestige gained from the ownership of any piece of equipment may be more significant than technical characteristics. Some farmers will buy equipment mainly because it is new and innovative, while others will reject it for precisely the same reason. Even paint colour can have a decisive influence on whether one type of animal traction equipment is accepted or rejected.

6.3 Review of available production models

Having clearly defined the specifications in terms of the operational requirements, the available draft power, the economic resources and the physical, social and technological environment, it is sensible to review what proven technology exists that meets these requirements. A useful directory of information sources on agricultural implements is available from UNIDO (1982). Bordet *et al.* (1988) compiled publicity sheets from many manufacturers supplying animal-drawn implements to West Africa. A valuable guide for intending purchasers that provides illustrations of many different products together with manufacturers' addresses was prepared by ITDG (1985). Anyone using the ITDG publication should remember that it was based on manufacturers' publicity sheets available at the time of preparation. Some of the designs illustrated have been used by farmers in tens of thousands while others were actually very early production models that were subsequently rejected by farmers. Few manufacturers would admit this if they thought a new order might be forthcoming and so information should be obtained from people working closely with farmers in comparable environments. One source of addresses of potential contacts for such information (Ministries, projects, non-governmental organizations) is the GATE Animal Traction Directory: Africa (Starkey, 1988).

6.4 Review of previous adaptation work

In the past fifty years there have been literally *thousands* of person-years spent on animal traction equipment development and adaptation. While many of the experiences gained were never adequately recorded, a great deal of information is available to those prepared to seek for it. In many countries old annual reports (even those dating back to the colonial era) provide a useful starting point, and where formal reports are not easily available, it may be well worth posing some questions to long-established or retired agricultural officers or instructors.

Agricultural magazines and journals are rich sources of information, and examples of useful titles can be found in the bibliography of this book. Further animal traction bibliographies have been produced by Goe and Hailu (1983), Bartlett and Gibbon (1984), Marti, Allafort and Bigot (1985), Marti and Second

(1988), CTA-CEEMAT (1989) and Goe, Starkey and Sirak Teklu (1989).

Even more information can be obtained by personally contacting colleagues in other organizations. Particularly valuable information can come from personal correspondence and from unpublished reports supplied by colleagues. A recent detailed study of design and adaptation work on animal-drawn wheeled toolcarriers during the past 30 years illustrates how illuminating details may be found when published reports are followed up with personal correspondence (Starkey, 1988). This example of equipment that was "Perfected yet Rejected" showed just how much unnecessary duplication of effort can take place when people fail to examine and build on previous experiences. Similar studies on many aspects of animal traction (for example animal-powered gear systems, yoking designs or animal-drawn seeders) would undoubtedly demonstrate similar repetition of work.

While a review of previous experience should be regarded as an essential part of any equipment selection and development programme, caution is required in interpreting published reports and personal communications. People inevitably prefer to portray their work as highly successful and generally emphasize their triumphs rather than their disappointments. Although many of the most useful lessons come from apparent "failures", in practice few people are prepared to discuss or publish details of farmer rejection. In contrast very many rush into print when they have had an innovative idea, and describe their prototypes in glowing terms. Such optimistic communications are indeed most valuable, *provided* they are presented by their authors as interesting but unproven ideas, and provided they are understood merely to be this by their readers. Far too often equipment designs have been misleadingly presented, or wrongly interpreted, as being highly successful, even when they had not passed any tests relating to farmer adoption.

In many cases a few weeks or months spent tracking down relevant reports and communicating with colleagues in the same country, and in other countries, can save months or years of unproductive design or evaluation work.

6.5 Research and development

A summary of the stages involved in practical research and development work on animal traction equipment was drawn up by a discussion group at the Networkshop "Animal Power in Farming Systems" (Starkey and Ndiamé, 1988). The stages listed were:

1. Identification of needs: study of the farming system in which equipment will be used, and context of work for which it will be selected or developed.
2. Operational requirements: definition of exactly what the equipment is required to do.
3. Specifications: clear listing of weight, draft, size, working width (requirements, limits), affordable costs, technical level of users, maintenance requirements, working life.
4. Study of options: review of available equipment (locally or from other countries) that meets specified requirements.
5. Selection of design. If none available development of new prototype or adaptation of existing equipment.
6. On-station testing and evaluation of selected design.
7. On-farm testing and evaluation with farmers.
8. Standardization of appropriate design, with formal drawings.
9. Small batch production and distribution to farmers.
10. Further on-farm evaluation with farmers to establish durability and suitability.
11. Economic studies and assessment.
12. Large scale production and extension.

This list should not be taken as definitive (for example socioeconomic determinants such as risk have not been cited) but it is helpful for identifying a desirable methodological sequence. Although the list implies a series of logical processes, each dependent on the success of previous stage, this should be treated with caution. Economic studies could usefully be included as several stages of the development process, and there will be circumstances when technology can be tested by farmers without first having completed on-station evaluation. However the sequential concept can be helpful when identifying the areas in which individuals and organizations should concentrate their time and resources.

It is clear that stages 1-3 (identification, definition, specification) are highly specific to particular localities and farming systems. These will have to be carried out to a greater or lesser extent by each national or area programme, although there is much scope for building on the experience of previous work in nearby or similar ecosystems. Stage 4 (overview of options) is particularly important as this provides much scope for selection from existing variation, so building on existing knowledge.

Unfortunately, in recent times national agricultural engineering departments, projects, universities and international research centres have often started at the phase of prototype development in areas of particular interest to staff members. They have often neglected the earlier methodological steps (1-4) and omitted to precisely define priorities and actual requirements. It is often both arrogant and unrealistic to suppose that a new design is required and that it can be quickly and easily produced by a small organization (project, department or manufacturer). Actual experience in recent years has shown clearly that most animal traction equipment prototypes have been very expensive in terms of human time, and largely ineffectual in terms of farmer acceptance. Undoubtedly there must be room for imaginative invention and innovative experimentation in order to produce completely new designs for farmer evaluation and possible overall progress. Nevertheless with so much previous work in this field, those involved in development programmes with limited resources should understand that the creative adaptation of proven designs,

Fig. 6-6: On-station testing of a "Strad" cultivator in Nigeria. The animals, people, soil conditions and technological environment of a research station are seldom representative of the local farming systems.
Photo: Enoch Gwani

achieved by engineers working closely with farmers, is much more likely to bring beneficial results than are attempts to produce entirely new designs.

Adaptation work or prototype development should generally be undertaken in close cooperation with farmers, local manufacturers and village artisans. The importance of involving blacksmiths in equipment development is discussed further in Chapter 11. It is also most important that the testing and modification of equipment are carried out in conditions representative of those in which the equipment will be used. While there is a role for on-station trials in the screening of new designs, this stage should be kept to the minimum. Wherever possible from the very first year there should be replications of trials on farmers' fields. Where this is not possible, farmers' advice should still be sought, and they should be actively involved as participants or external consultants in planning, executing and evaluating research programmes.

The common image of farmers as always conservative can be quite misleading when it comes to research and the evaluation of new equipment designs. It is quite natural that farmers should be reluctant to risk their livelihoods and scarce resources on the wholescale adoption of unproven techniques. Had they been so gullible, many a farming family would have suffered badly as a result of the misplaced confidence, enthusiasm and persuasion of research and extension workers. Farmer realism in the face of unproven equipment designs should not be misinterpreted as indicating total resistance to change. In almost all circumstances there are farmers willing to *try out* new implements and techniques; indeed farmers are often ahead of researchers in this respect (Richards, 1985; Starkey, 1987). If farmers are asked to devote more than a small proportion of their land or labour to testing a new idea, there may well be a need for some form of insurance/compensation should the innovation prove disastrous. Should no farmers be willing to evaluate an implement with such guarantees, then it is probably more realistic to doubt the relevance of the innovation, rather than to cite farmer conservatism.

Should it be thought that the importance of farmer involvement is being belaboured, a review of animal traction equipment research programmes in almost any country would demonstrate what a vast amount of time has been wasted in recent years because of failure to involve farmers. The persistent recurrence of researchers developing equipment that is too heavy, too expensive, too complicated, too delicate, and/or too difficult to manoeuvre adds up to a frighteningly high waste of human and financial resources. To cite but one example during the past decade: a large team of ICRISAT scientists tried to develop a major "improved" system of farming based on new designs of animal-drawn equipment. The technology was developed, tested and "perfected" for several years on the research station before it was presented to farmers. Subsequent farmer adoption of the package was most disappointing. The research team then realised that only at a late stage in their programme, *when the farmers themselves had been confronted with the technology*, had many of the real constraints in the farming system been identified (von Oppen *et al.*, 1985).

The conclusions of the West African Networkshop on "Animal Power in Farming Systems" (Starkey and Ndiamé, 1988) seem apposite. Research and development relating to animal-drawn equipment should have a multidisciplinary and farming systems approach. More emphasis should be placed on social and economic criteria than has been common in the past. To prevent technically excellent but inappropriate equipment being developed, from the very first year of a research programme there should be replicates of on-station trials on farmers' fields. Finally farmers should be closely involved in planning and evaluation at all stages of a research programme.