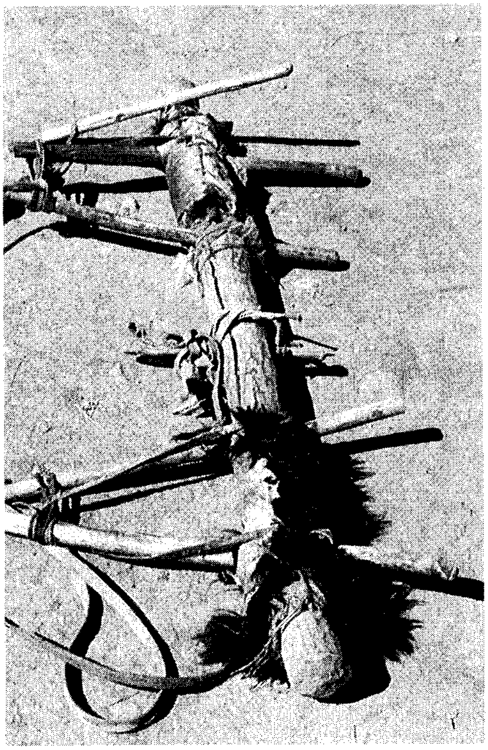
5. Harnessing: issues and resources

5.1 The manufacture of yokes and harnesses

Harnesses are generally made by local artisans. This is important in ensuring that they are readily available, they can be speedily repaired and their design specifications can be rapidly adapted in the light of farmer feedback. Yokes can be easily and rapidly carved from strong but light wood and local artisans are generally aware of trees that have appropriate combinations of weight and strength. Particular attention should be paid to the final smoothing of the wood. If padding is required, animal hair is durable, and a soft but strong felt-like material if available may be suitable. Sheepskin or soft leather is effective but tends to harden if not treated. Coarse sacking is not ideal, since it tends to be very abrasive (Matthews, 1986). For fixing the implement or chain, a steel ring attached to a bolt can be easily made by a local blacksmith and inserted into the centre of the yoke. In Ethiopia farmers generally make their own yokes using wood that they may have buried for several months to prevent cracking. Six holes are made with a chisel and simple wooden pegs are placed in them (Goe, 1987). Padding is made of leather and sheep skin and straps of hide are used both to attach the plow beam to the yoke and to loop round the necks of the oxen (Fig. 5-1).

Although wood is by far the most common and appropriate material for the manufacture of yokes, steel yokes are not unknown. Some single withers yokes used in Europe, such as the Swiss harness (Fig. 4-3b), have been made from leather and steel. A prototype steel collar-type yoke was designed in India in the 1960s (Ayre, 1982) but was not adopted. In the 1980s a workshop in Lesotho, supported by a United Nations project, started manufacturing steel withers yokes (Lesotho Steel, undated), although these were technically inferior to local wooden yokes. There are also reports of externally-funded projects importing steel yokes manufactured in Europe into countries such as Sudan and Somalia. While

Fig. 5-1: Yoke made by farmers in Ethiopia. (Note the sheepskin padding. The leather thong at the bottom left is part of a traditional hide whip).
Photo: Paul Starkey



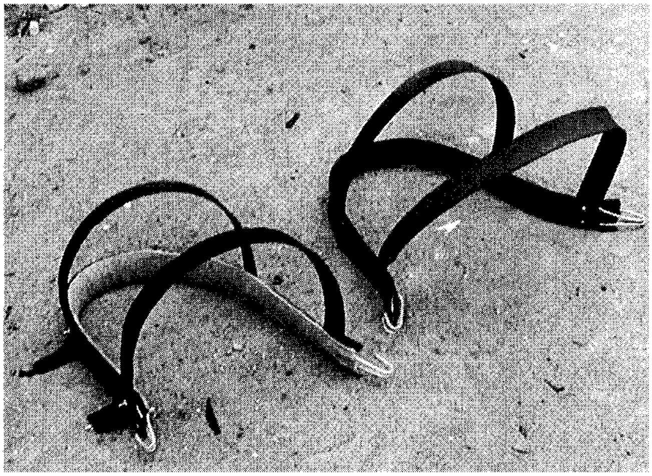


Photo: Paul Starkey

Fig. 5-2: Lined (left) and unlined (right) donkey harnesses made from tyre rubber by Mochudi Farmers Brigade, Botswana.

the order of such yokes may have been temporarily expedient in areas where wood was scarce and there was no tradition of animal traction, long-term objectives would probably have been more rapidly achieved had cooperating farmers or artisans been assisted to make wooden yokes themselves. Whereas many types of wood have appropriate combinations of weight, strength, elasticity and price, tubular steel is generally heavy, expensive and relatively difficult to pad effectively. While tubular aluminium yokes would have a better ratio of strength to weight than steel, they are expensive, easily distorted and require primary materials seldom found in villages. For these reasons the use of wood for making yokes is strongly recommended.

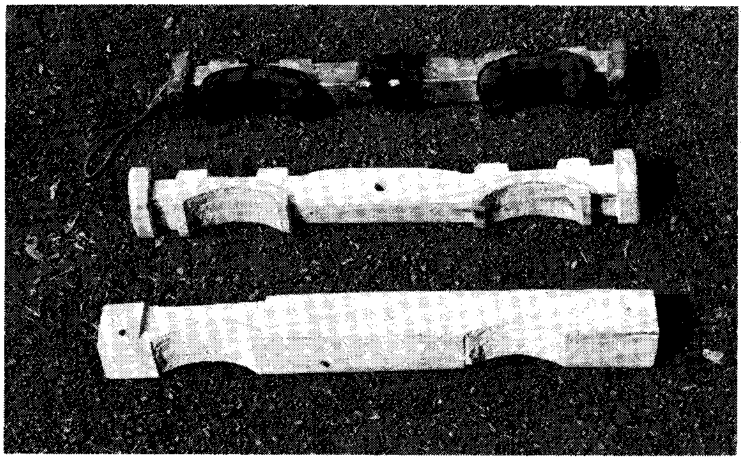


Fig. 5-3: Three stages of carving a horn yoke in Sierra Leone.

Photo: Paul Starkey

Schemes to develop the use of equine collar harnesses have often failed due to problems of local manufacture. It is estimated that in France a leather collar made by a well-equipped artisan takes at least 22 hours of highly skilled work (Duchenne, 1984). Transferring such skills into a new area is quite possible given time, available materials, good feedback from farmers and a realistic market. However there have been numerous attempts during the past 100 years to transfer traditional skills in the manufacturing of collars, but few have succeeded. An initial constraint has been difficulty in obtaining high grades of leather, but the major long-term problem has been lack of market demand. In Botswana a project to use donkeys for road construction found that the local harnesses made of rubber from tyres quickly broke and were unsuitable for sustained heavy use. Imported leather harnesses were found satisfactory but the price of one harness was twice that of a donkey, and the harness for a team was 60% of the cost of a tipping cart (McCutcheon, 1985). For the project, concerned more with timeliness than capital outlay, the expensive harnesses were considered more cost-effective than the cheaper alternatives. Local manufacture would have been feasible but equipping and training of artisans would have had to have been followed by sustained demand, and it appeared questionable whether individuals would opt for the high-quality, high-price alternative.

In another initiative in Botswana, the Mochudi Farmers Brigade tested a large number of harnessing systems, and eventually promoted the local manufacture of a simple breast band harness for donkeys. This was made of car-tyre rubber, but the load bearing bands were lined with soft material (Fig. 5-2). The long-term success of recent artisanal training schemes in Kenya and Zambia based on the production of three-pad collars for donkeys

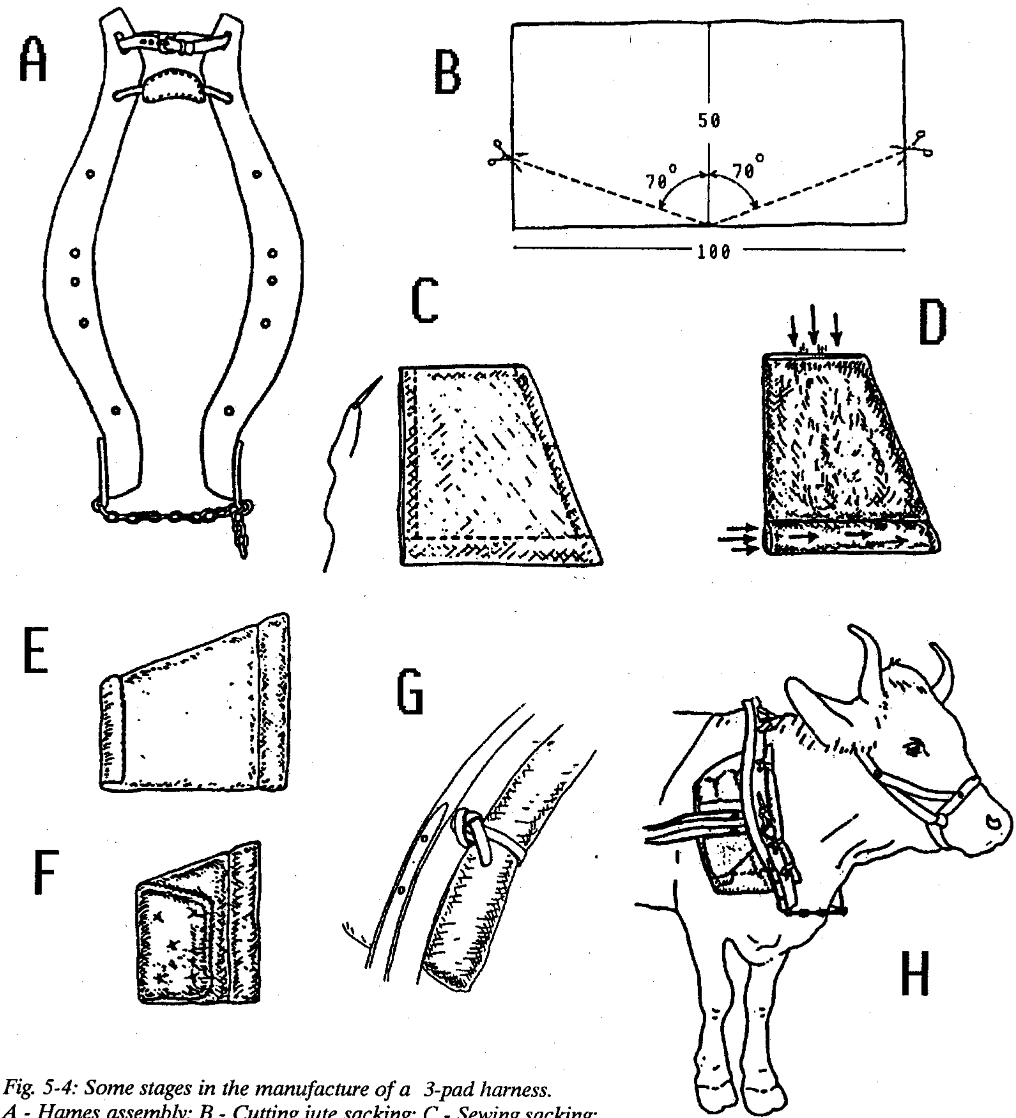


Fig. 5-4: Some stages in the manufacture of a 3-pad harness.
A - Hames assembly; B - Cutting jute sacking; C - Sewing sacking;
D - Stuffing pads; E, F - Folding pads; G - Tying pad to hame; H - Final harness.

Source: after Micuta, 1984

and cattle (Dibbits, 1985a, 1985b; Micuta, 1985) will depend on sustained demand at prices economically acceptable to both producer and consumer.

In industrialized countries where animals are now mainly harnessed for recreational use, synthetic webbing harnesses are beginning to replace traditional leather straps. These are strong, light, rot-proof and washable and cheaper than leather. Such purpose-made materials are not yet readily available in rural areas in developing countries, but farmers/artisans have already been seen to experiment with synthetic materials used for fertilizer or grain sacks (Fig. 3-33). Furthermore in towns where draft animals are used, it is not uncommon to see other innovative materials derived from imported goods being used for harnesses. Such experimentation may well eventually lead to the discovery of appropriate new harnessing materials and techniques, and researchers should be aware that such informal evaluation may well be taking place near them.

5.2 Some practical problems with harnessing systems

Many of the problems associated with any harnessing system are not attributable to defects in the basic design, but are due to poor finishing or incorrect positioning or adjustment. Many sores and abrasions are caused by rough wood, by joints or stitching that are not smoothed or covered, or by the failure to use soft padding. Further discomfort can be caused if the yoke or harness is unnecessarily heavy for its required tasks. Breastbands and collars need to be particularly smooth and well fitting. Problems are commonly due to the use of rough materials, stitching irritating the animals' skin or to straps being too long or short for an ideal line of pull.

Head yokes should be attached firmly to the horns. If one watches animals with loose fitting head yokes, one can see the discomfort caused to the animals as the yoke vibrates against the head, or when the movement of one animal causes the yoke, acting as a lever, to twist against the head of its partner. Such discomfort may lead to "protest" head movements designed to loosen the yoke which actually exacerbates the problem until the yoke is re-tied. The central yoke ring, or other system for attaching the beam or traction chain should be so positioned as to allow a straight pull from the centre of the yoke to the implement. If the attachment is raised or lowered, it will tend to act as a lever and cause the neck yoke to rotate, putting extra strain on the attachment ropes and causing discomfort.

Withers yokes do not need to be tightly attached, but problems are often experienced by poor fitting of the descending bars and/or leather strap. These should be smooth to prevent damage to the skin of the animals during fitting and use. If they are to be used primarily as spacers, they do not need to be strong, but if they are designed to take some of the load, then greater strength is required. Whether or not the descending bars take load will depend on their spacing and the point of attachment of the traction chain or beam. If the point of attachment is below the yoke (as in many traditional European yokes), then the distance between the centre of the yoke and the attachment point will act as a small lever. This will mean that during work, the yoke will tend to rotate, and if the descending arms are relatively close together, they will come into contact with the animals' shoulders. In such circumstances smooth broad descending bars are required (in Europe and North America, broad poles shaped into a U-form were often used). If the bars are spaced far apart and/or the thong is tight, then the rotation of the yoke may cause the thong to start pressing against the neck of the animal. This can cause considerable discomfort. If the point of attachment is higher than the centre of the yoke, the yoke will tend to rotate in the opposite direction, the bars moving forward until the leather thong presses against the throat of the animal (Fig. 5-5). This is also uncomfortable and inefficient, and can be remedied by attaching the beam or traction chain below the centre of the yoke.

Photo: Paul Starkey

Fig. 5-5: Example of a harnessing system causing an animal discomfort as the rotation of the withers yoke makes the cord press against the animal's throat.

In any locality there are likely to be examples of well-finished and correctly fitted harnesses, and others that cause discomfort. The potential for improvement is therefore enormous, although claims should not be exaggerated. Some authors have argued that their favourite yoking system could halve the number of animals needed for a particular operation; this (it has been suggested) would have the same impact as either increasing the number of working cattle by 20-50% or of releasing large quantities of additional animal feed. Such claims are almost certainly spurious, being based on extrapolating *ad absurdam* the results of simple trials. Controlled experimental work at the University of Edinburgh demonstrated that while there was not a great difference between the technical efficiency of various designs of yokes and collars, animals were certainly more willing to work if the harnessing system was comfortable (Lawrence, 1983). The implication is that while the metabolic energy required to perform an operation is broadly comparable whichever harnessing system is employed, the "nervous energy" required from both animal and human may be much greater with an uncomfortable yoke. Animals need more encouragement and goading if their harness is uncomfortable, and the discomfort of the animal can be matched by the frustration of the farmer.

It is clearly in the interests of the animals themselves and of the farmers that harnessing systems are made and fitted comfortably. In all countries where animals are used for work, there is probably great scope for improving overall harness comfort, and thereby the productivity of both animals and farmers, by very simple and inexpensive modifications or adjustments to the systems already in use.

5.3 Research and development on harnessing systems

In recent years there have been a great many calls for more systematic research on harnessing systems (Smith, 1981; Goe, 1983; Copland, 1985; Matthews, 1986; Bordet *et al*, Drawing: Peter Lawrence

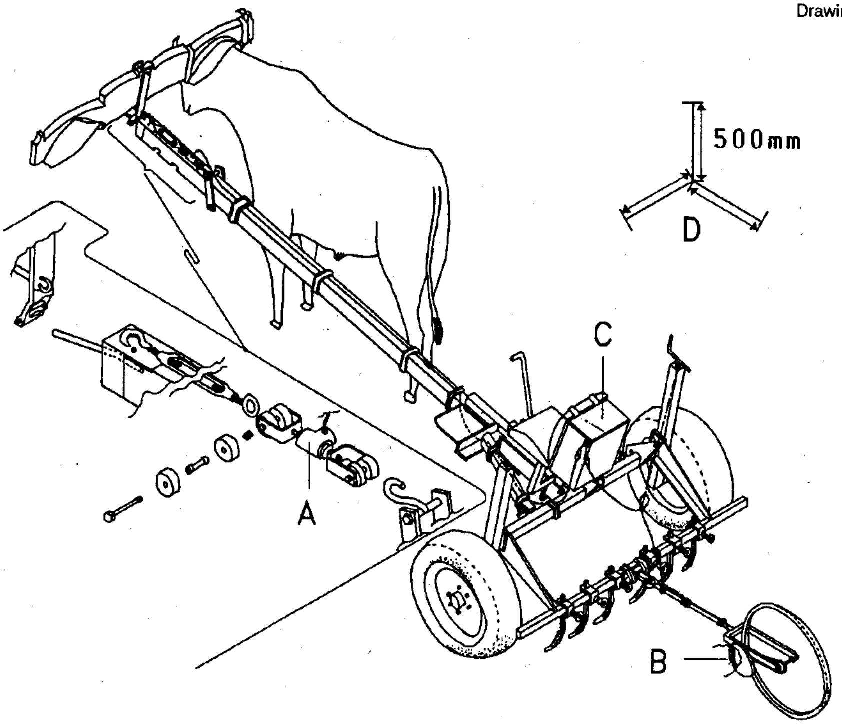


Fig. 5-6: Wheeled toolcarrier adapted as an "ergometer" for data logging by the CTVM, Edinburgh. A: Loadcell (measures force). B: Odometer (measures distance). C: Microprocessor (computes work). D: Isometric scale for the drawing.

1988; Starkey and Faye, 1988). However before launching new research initiatives, it is wise to be aware of the methodology and results of previous studies.

Some research studies on yoking systems in Europe have been descriptive and have reviewed the different harnessing systems in use in an area, and obtained farmer opinions on the relative merits of different systems (Delamarre, 1969; de Oliveira *et al.*, 1973). Similar studies in developing countries could be valuable in providing a geographical or historical perspective, and be helpful in inhibiting unreasonable optimism over supposedly "new" harnessing systems.

Other workers have concentrated on comparing two or more harnessing systems. A few of these should be dismissed from the point of view of research as well-meaning, but spurious, being designed in the form of demonstrations to *prove* that a "new" or "improved" design was better than an existing design. Commonly these have confused two or more parameters but have nevertheless tried to present their results in a semi-scientific form. Unless there has been some form of replication, randomization, control and objective measurements, then *results presented as percentage improvements in efficiency should be treated with great caution*. Nevertheless provided they are acknowledged as such, evaluation trials based primarily on subjective judgements rather than measurements can be extremely useful as a means for assessing options (e.g. Froese, 1980). Demonstrations can encourage innovative farmers to experiment with different designs, but it should always be remembered that draft animals may require time to become used to changes in their harnessing system.

Replicated trials involving the measurement of force (dynamometer readings), time, distance travelled, speed and work achieved have been reported from: India by Vaugh (1945), Swamy-Rao (1964) and Varshney *et al.* (1982), Bangladesh by Hussain *et al.* (1980) and Barton (1988), Bolivia by Salazar (1981), Burundi by Barton(1985), Costa Rica by Lawrence and Pearson (1985), Thailand by Garner (1957), the United Kingdom by Barton (1985) and the United States (Kivikko, 1987). In addition, trials involving the detailed recording of animals' physiological responses to different yokes have been recorded for buffaloes and Brahman oxen walking on treadmills (Lawrence, 1983; Islam, 1985). Some of the findings of these various trials have been discussed by Duchenne (1984), Matthews (1986) and in Chapters 3 and 4 of this book.

There is not space for a detailed review of the various research results here, but five main observations seem noteworthy.

- Firstly the various "improved" forms of padded yokes and collars do seem to have allowed greater work relative to *some* traditional designs. This may be because comfortable harnesses make animals more willing to walk faster and/or pull harder.
- Secondly some quite high apparent benefits in technical efficiency did not generally lead to major differences in achieved on-farm work, such as the area cultivated in a week.
- Thirdly when a large range of yokes has been tested there have generally been examples of *alternative* traditional designs that have been much cheaper than the "improved" designs, and which have been of comparable efficiency (in some trials - such as those of Vaugh, 1945, Hussain *et al.*, 1980, and Varshney *et al.*, 1982 - some traditional harnesses have out-performed "improved" designs).
- Fourthly most "improved" yokes appear to have been significantly more expensive or more complicated than traditional yokes.
- Finally despite a detailed review of the literature and personal communications with many of the authors referred to in this section, it appears that there are *no known reports* of cases where the various "improved" designs mentioned have been widely adopted by farmers.

Recent advances in electronics have made it possible to collect large quantities of data and to process it rapidly using computers. Lawrence and Pearson (1985) described a wheeled toolcarrier adapted to collect data on force, time and distance in the field (Fig. 5-6). The instrumentation used for these earlier studies has since been developed at the Centre for Tropical Veterinary Medicine, UK, into a portable ergometer capable of accurately measuring draft force, animal power output, work done and distance travelled for periods of time that can range from a few seconds to a full working day (Lawrence, 1987). Another system of data capture developed by AFRC-Engineering, UK, has been described by Matthews and Kemp (1985), O'Neill *et al.* (1987) and Kemp (1987). This system involves almost constant measurement of physiological parameters (temperature, heart rate, respiration rate), walking characteristics (speed, walking rhythm, distance), work loads (forces, angles) and the external weather conditions (sun, temperature, wind). Using small sensors linked to a portable computer, farmers' animals can be used in on-farm trials, and by correlating the information obtained with simultaneous video-camera recording, comprehensive overall pictures can be obtained. Such data collection should be able to provide detailed comparisons of different yoking types and if combined with appropriate analyses (and farmer opinion!) may be able to assist in the identification of low-cost and simple means of increasing the efficiency of yokes. Several institutions including AFRC-Engineering (England), CTVM (Scotland), CEEMAT (France), CIAE (India) and ILCA (Ethiopia) are cooperating in this high-technology approach to animal traction research,

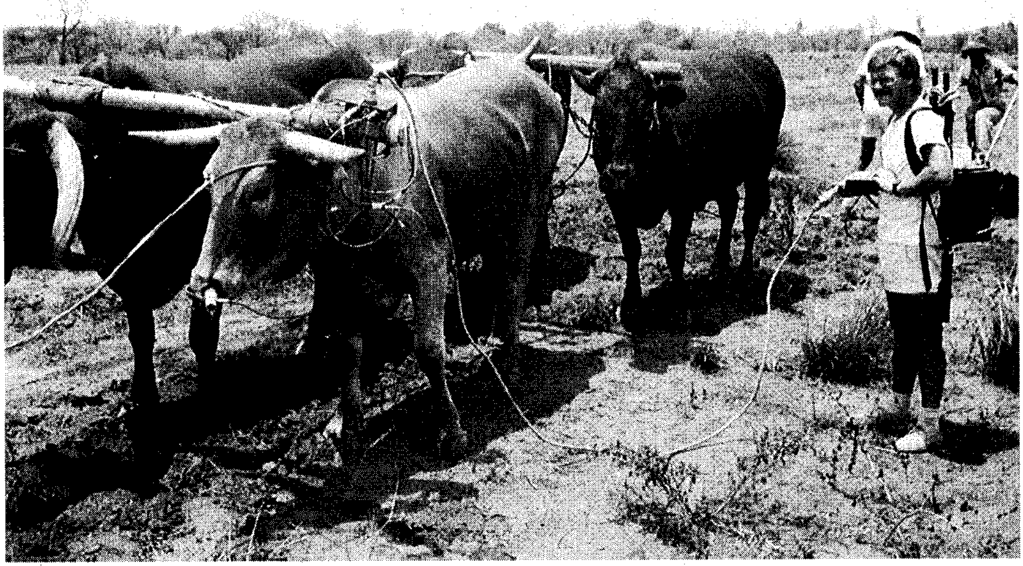


Photo: AFRC-Engineering archives

Fig. 5-7: Prototype data-logging instruments developed by AFRC-Engineering being used in Botswana. The wires from the load-cells and sensors attached to the animals pass through an "umbilical cord" to a battery-powered computer, held by a research worker.

and in 1987/88 field trials were held in India, Botswana, Burkina Faso, Morocco and Nepal. Matthews (1986) suggested that the development returns from small scale, *ad hoc* harnessing research programmes are likely to be minimal. It could be added that returns to any harnessing programme may depend more on its relevance to the needs of particular farmers than the technology employed.

In conclusion development workers contemplating research on harnessing systems should:

- Consider whether harnessing is actually a limiting factor.
- Review the subject from a historical and geographical perspective, and identify popular designs used successfully by farmers in the region, or elsewhere.
- Define the harnessing criteria to be studied, clearly distinguishing between those separate elements that are often confused (single, double or multiple animals; rigid or flexible linkages; combined or independent hitching systems).
- Note that socioeconomic aspects of harnesses (convenience, cost, fashion, status) seem to be at least as important as technical specifications, so that it may be more valuable to ask farmers to test harnessing systems themselves, under their own conditions, rather than undertaking replicated trials to measure technical efficiency.
- Consider whether objective measurements (as opposed to farmer assessment) are actually essential; if they are, then cooperation with an institution capable of mass data collection and analysis might be sensible.
- Remember with humility that, while there have been historical examples of farmer-initiated innovations, there seems little evidence that any *experimental research*, whether using simple mechanical dynamometers or computers, has yet had any significant impact on harnessing at farm level.

5.4 Choice of harnessing systems

For hundreds of years harnessing systems in many parts of the world have been strongly influenced by fashion, prejudice and tradition and their present form often strongly reflects local artisanal skills and interests. Archaeological evidence suggests that head yokes originated in ancient Egypt, withers yokes in ancient Mesopotamia and collars may have first been developed from modified withers yokes in China (Duchenne, 1984). All main types of harnessing system have been used in Europe since the eleventh century and there are written records spanning over six hundred years debating the relative advantages and disadvantages of horn yokes, withers yokes, breast bands and collars (Delamarre, 1969; Fenton, 1969). The pattern of debate and evolution is fascinating, with wars and grain prices discouraging the use of horses and collars and innovators in each generation trying out the yokes others regarded scornfully as "foreign" to their region. However the pattern of evolution is not technically conclusive for while collars became almost universal for heavy work with horses, for cattle head yokes, withers yokes and collars all had their advocates and their regions of sustained use.

In Africa, Senegal and The Gambia (Senegambia) provide a particularly interesting example of harnessing diversity for during the past eighty years farmers have used double head yokes, double withers yokes, single yokes, breast bands and collars. Senegambia has over half a million working animals including large numbers of horses, donkeys, Zebu cattle and taurine cattle (Havard, 1985). Its farmers have a proven record of rapid diffusion of innovations, with donkey technology and breastbands rapidly spreading through informal farmer channels in an area previously dominated by oxen and head yokes (Starkey, 1987). All harnessing types still exist, but bovines are almost never used singly or with collars. There is a tendency for N'Dama taurines to be harnessed with double head yokes, and Zebus to be used with withers yokes, but this is not absolute. Equines are seldom yoked; equine breastbands are widespread but collars are rare. Thus Senegalese farmers seem to prefer double yokes for bovines and breastbands for equines.

Fashion and prejudice are not confined to farmers. Some recent reviews have been forceful in their condemnation of traditional yokes and promotion of favoured "improved" styles. Vietmeyer (1982) stated "a classic of bad design is the traditional yoke used for oxen and water buffalo - the straight beam on which the animal pushes with its forehead or neck". He went on to cite claims of 70 percent improvements in efficiency using bovine collars and concluded that yoking with a rigid bar should always be replaced with independent hitching. The suggestion that traditional bovine yokes can be inefficient and cruel has been made by many people including Smith (1981), Micuta (1985), Ramaswamy (1985) and Barwell and Hathway (1986). However a less dismissive stance was taken by Goe (1983). While admitting traditional yokes were not optimal, he suggested that before attempting to introduce new types of yokes, it would be worthwhile to assess the merits of the traditional types used in a particular area, and select the best for modification. In the light of the lack of rapid diffusion of technically efficient "improved" yokes designed by researchers, this seems a more positive approach.

To illustrate the complex interaction of ergonomic design, fashion and local adaptations one can take, by way of analogy, an example from a different area of development. Traditional methods of transporting water between remote sites can involve carrying containers in the hands, using two containers balanced on a pole or shoulder yoke, by headload or by back and head-strap. The use of wheeled water containers has often failed to catch on due to expense, inappropriateness to the terrain or local preferences. Clearly jagged edges on any container are potentially injurious and dangerous and if the surface of the container or carrying pole is rough, padding may be used. The absolute weight of water a person *can* carry by any method is related more to the person's strength than to the design of the container. The weight *actually* carried may be greatly influenced by design. Buckets with round, broad handles have a larger contact area and are less painful to hold when full, so that one may be more willing to carry a heavier weight of water if the bucket has a broad handle. Nevertheless broad bucket handles are by no means universal, and narrower handles with some rags as padding may be as effective. Improving the handle of an existing bucket may improve comfort and possibly reduce the number of rests needed, but if the limiting factor is actually the small size of the bucket or the availability of water at source, there will be no dramatic changes observed by improving the handle. It is not intended to digress further on the ergonomics of water transportation, but the parallels with yoking systems should be clear and seeing similar problems in another context may help to clarify the key issues under consideration here.

In conclusion, any technology is likely to be a compromise between economic cost and technical excellence. In addition the importance of social considerations (including fashion) should never be underestimated. While it appears that independently hitched collar type harnesses may be the most technically efficient, they are also generally the most expensive and complicated to use. Differences in efficiency between a well-padded and a poorly padded local yoke or a well fitted and a badly fitted harness may well be as great as differences between the harnessing systems themselves. It is likely that the main harnessing types will continue to be the double or single withers yoke, the double head yoke and the breastband. In the short term the most likely improvements will be very simple changes in contouring and padding. In many areas improvements in overall harnessing efficiency are more likely to come from encouraging the correct use of farmer-proven designs from within a region rather than from promoting innovations.

5.5 Further reading and information sources

Clear, well-illustrated reviews of the subject have been prepared by Duchenne (1984) and Poitrineau (1990). Advice of a practical nature can be found in Watson (1981). Illustrations of modern attempts at "improved" yokes together with a general discussion of issues and merits are provided in Barwell and Ayre (1982). Drawings of yoke types currently used in Africa and discussions of advantages and disadvantages can be found in CEEMAT (1971), FAO/CEEMAT (1972), Hopfen (1969) and Viebig (1982). An illustrated review of technical principles is provided by Devnani (1981) and a general discussion of issues is given by Matthews (1986). Details of harnessing arrangements used for carting can be found in Barwell and Hathway (1986). Many interesting articles but of more limited scope or relating to specific research projects have been cited in Chapters 3, 4 and 5 and details of these references are given in Chapter 12. Among institutions involved in this area are ACIAR-DAP, AFRC-Engineering, Bellerive RT, CEEMAT, CIAE, CTVM, GRDR, GRET, ILCA, IT-Transport and Tillers International and the full names and addresses of these organizations are given in the Appendix. African countries with organizations undertaking trials on different harnessing systems in 1988 included: Botswana (ATIP), Ethiopia (ILCA, AIRIC), The Gambia (GARD), Kenya (University of Nairobi), Mali (DRSPR), Morocco (INRA-MIAC), Niger (Projet FAO, ISC), Sudan (JMRDP), Togo (PROPTA), Zambia (MoA-ADP Project) and Zimbabwe (IAE) and further details of these and other relevant organizations can be found in the GATE Animal Traction Directory: Africa (Starkey, 1988).