8. Equipment for transport

8.1. Pack animals

Donkeys and mules are the main pack animals in most regions of the world. Mules are produced by crossing a female horse with a male donkey. Mules are larger and stronger than donkeys, but donkeys are cheaper to buy and to maintain. The reliability of donkeys is legendary. Once trained, donkeys can follow particular routes with minimal supervision; they will wait patiently for several hours and they can often be trusted to return "home" unattended. Horses can be fast and efficient pack animals, although they are not as hardy as donkeys. Being more expensive to purchase and maintain than donkeys, horses are used mainly for high-value or strategic operations. Camels are excellent pack animals, unrivalled in their ability to cope with severe desert conditions, but they also are more costly than donkeys. Llamas and yaks are locally used in the foothills of the Andes and Himalayas. It is rare for cattle to be used as pack animals.

Donkeys are maintained as pack animals in many African countries, particularly in north Africa, the Sahel, Ethiopia and parts of eastern Africa. Their employment has often been a long-standing tradition. When donkeys are used for pack work, it is normal to place some form of protective padding over their backs. This may be sheepskin, sacking or discarded cloth. Soft loads such as sand, fertilizers, canvas water containers and straw are placed symmetrically over the back and held in place by one (or more) leather or rubber straps around the girth or belly, and under the base of the tail. Hard loads such as firewood, stones or rigid containers are generally supported on simple wooden symmetrical saddle frames sitting on light padding and held in place with tail and girth straps. Simple pannier baskets may also be used (Fig. 8-3). Pannier baskets with opening bottoms that allow loads to be shed easily have been used in Western Samoa (FAO, 1986). In Ethiopia,

Fig. 8-1: Donkeys in Ethiopia are widely used for transporting firewood. Photo: Michael Goe

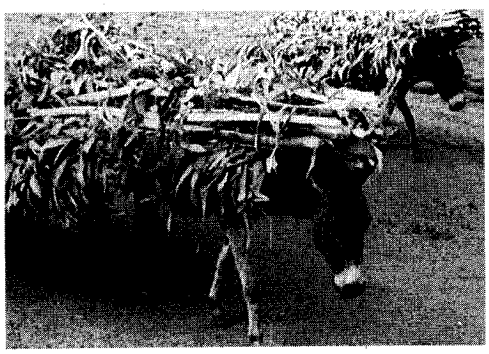
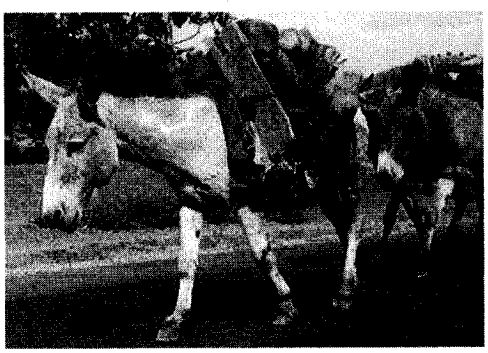


Fig. 8-2: A donkey in Ethiopia with wooden saddle for transporting stones. Photo: Paul Starkey



Sources: Hopfen, 1969; Viebig, 1982; ITDG, 1972

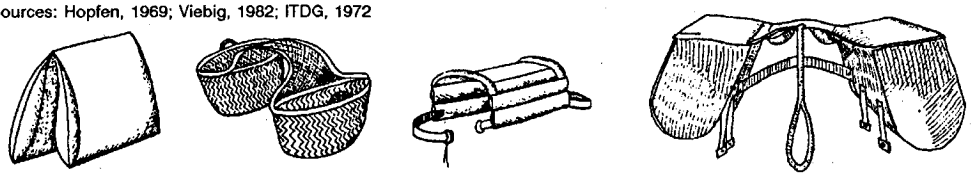
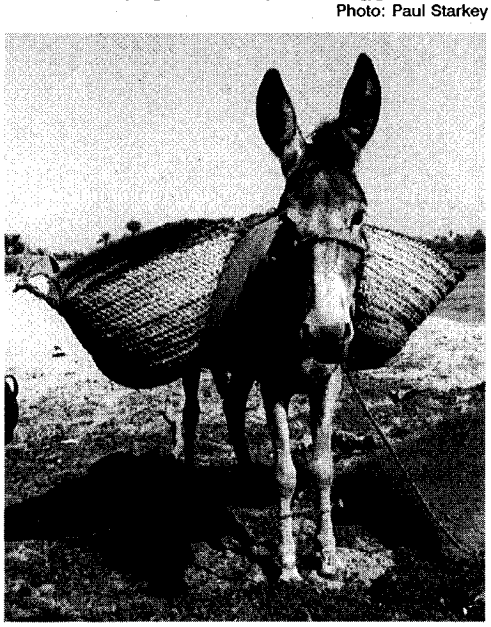


Fig. 8-3: Some pack saddle designs.

donkeys are widely used as pack animals and animals averaging 100-110 kg bodyweight regularly carry loads of 25-50 kg over distances of up to 20 km (Goe, 1987).

The distribution of donkeys in Africa is restricted by several ecological factors, notably the disease trypanosomiasis. With cattle being much more readily available, there has been some interest in the potential of cattle as pack animals (Smith, 1981; Spencer, 1988). While cattle do not readily take loads on their back, they can certainly be trained to do so. In parts of Mali and Chad cattle may be ridden for personal transport by farmers (Fig. 4-13), and some pastoralists in Sudan and Somalia use cattle to transport their effects when moving between sites (as was illustrated in Fig. 4-15). Bovine pack saddles were developed in Tanzania (King, 1940), but were not adopted (see section 4.6). As animals can pull greater loads than they can carry, in most areas work relating to ox-carts will probably be more productive than trying to develop systems of using cattle as pack animals. Where narrow paths restrict the use of conventional carts, it has been suggested that transport of goods could be on sledges (Ramaswamy, 1981) or very narrow carts (Hinz, 1985).

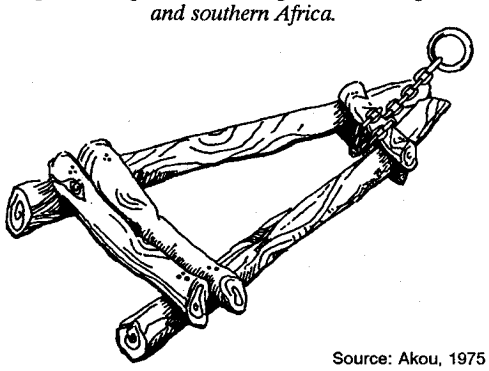
Fig. 8-4: Donkey with basket-work panniers used for carrying manure to fields in Egypt.
Photo: Paul Starkey



8.2. Sledges

Wooden sledges are quite widely used in certain areas of eastern and southern Africa, Madagascar and parts of Asia and Latin America. In southern Africa simple sledges are made by joining two wooden beams in the form of a V, or by selecting a naturally occurring fork in the branch or trunk of a tree, perhaps 150 mm in diameter (Kjærby, 1983; Müller, 1987). A traction chain is attached to the single end of the "V" or "Y" (Fig. 8-5). The load is supported by the two arms onto which a simple

Fig. 8-5: Simple wooden sledge as used in Uganda and southern Africa.



Source: Akou, 1975

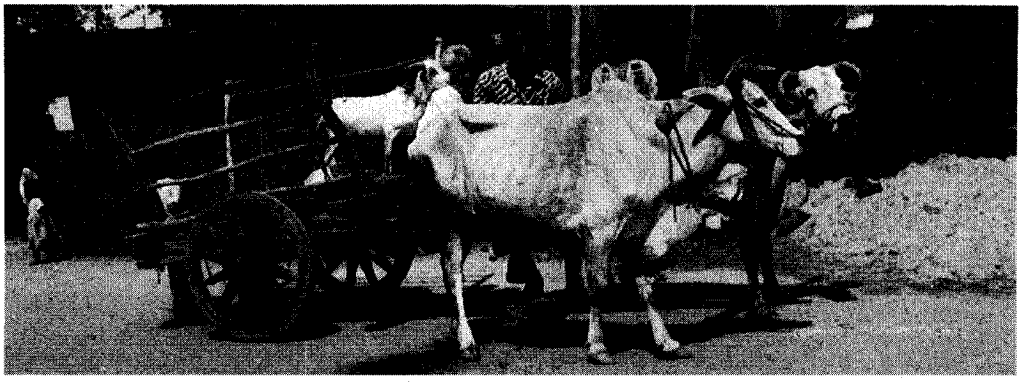


Photo: Paul Starkey

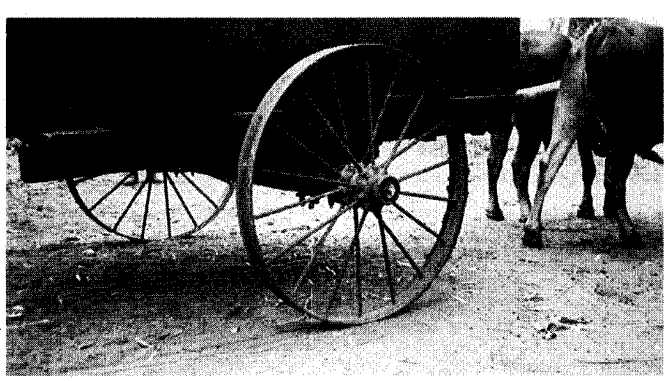
Fig. 8-6: Traditional ox cart with wooden wheels in India.

platform can be built, and sides can be fitted if required. More expensive sledges can be made using separate wooden or steel runners, onto which can be mounted a variety of bodies. Such refined sledges have been evaluated for transport work on oil palm plantations in Malaysia.(Kehoe and Chan, 1987).

The advantages of sledges are that they are cheap and simple to make and maintain. They have a low centre of gravity and they are narrow, enabling them to be used on tracks too narrow or steep for carts. They can often be used in sandy, muddy or rutted conditions where a cart might become stuck. However these advantages are offset by many disadvantages. In most conditions they require more effort to pull than does a cart. They have limited clearance and can be stopped dead by projecting stumps. Most importantly they tend to accelerate erosion by leaving rutted tracks, often only passable by other sledges, which become water courses during heavy rains. In several areas of southern Africa, including Lesotho and Zimbabwe, the dangers caused to the environment by sledges have led them to be officially discouraged and even banned.

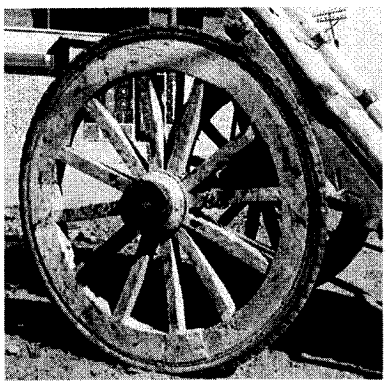
8.3 Carts with two wheels

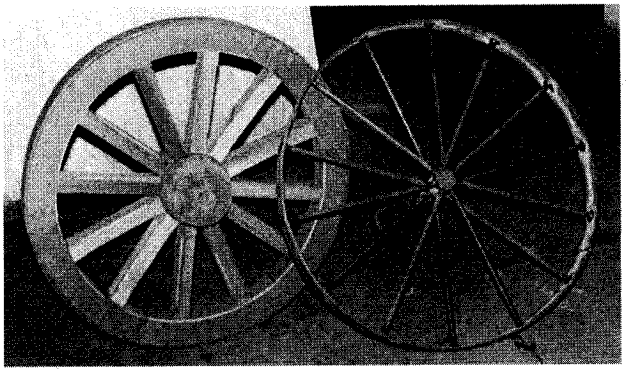
Carts pulled by animals are widely used for rural transport; there may be 40 million in operation worldwide, the majority in Asia. Many carts are constructed in a way that combines artisanal skill with traditional folk arts. Most carts employed in the world are made mainly of wood, and use traditional designs of wooden-spoked wheels (Fig. 8-6, 8-8). However carts with steel frames and pneumatic tyres are becoming increasingly common. Two-wheeled animal-drawn carts are much more common than four-wheel carts due to their lower cost, lighter weight, lower complexity and greater manoeuvrability.



About 700,000 animal-drawn carts are in use in Africa. Near

Fig. 8-7: Large steel cart wheels used in Mozambique.
Photo: Paul Starkey





Photos: Paul Starkey

*Figs. 8-8, 8-9: **Left:** Wooden wheel on cart in Egypt. **Centre and Right:** Wooden and steel wheels fabricated in a small workshop in Zaïre. The production of wooden-spoked wheels has since stopped.*

cities and market towns, carts may be operated full-time on a hire basis by transport entrepreneurs. Only about ten percent of African farmers who own draft animals have a cart, but the importance of carts to the agricultural sector is much greater than the simple numbers imply. While other implements are used for a small number of days each year, carts are generally used throughout the year. Thus in terms of overall implement usage in Africa, the total number of cart-days each year would be second only to the number of plow-days.

In some African countries, such as Senegal, animals were used for pulling carts around ports and towns long before they were employed in agriculture. In other countries animal draft power was first introduced for cultivation, and animal-drawn transport came later. Once a suitable and affordable cart design becomes available, the adoption of carts can be quite rapid and even eclipse the agricultural usages of draft animals. Examples can be cited of farmers who managed to buy carts for their work oxen and then found it more profitable to hire-out the cart and hire-in manual labour, than to continue to plow with the oxen. Interesting parallels may be drawn with tractor usage in Africa, where employment for transport has often exceeded use for cultivation (Binswanger, 1984).

All major types of draft animal can be used for pulling carts. Cattle are strong but slow, and particularly suited for short but heavy transport work around fields and on rough tracks. In India, long-legged breeds of cattle are also used for hauling goods over long distances. Donkeys are light, but will readily trot along roads, and are particularly useful for taking light loads to and from markets. Horses are strong and fast and are generally used for carrying high value loads, including people and traded goods. In general, the designs of carts for cattle, horses and donkeys are similar, although donkey carts may be lighter and less strong. Parallel shafts are commonly used for single animals and central drawbars for pairs of animals.

8.4 Wheel options for carts

Large wooden wheels with wooden spokes were standard in most parts of the world before the development of pneumatic tyres and such designs are still widely used in Asia and Latin America. Wooden-spoked wheels have for many years been made and used in Egypt, North Africa and the islands of Madagascar and Mauritius but although there have been many attempts to introduce comparable artisanal manufacture in Sub-Saharan Africa, such wheels have not been widely adopted by small farmers. One recent project initiative in

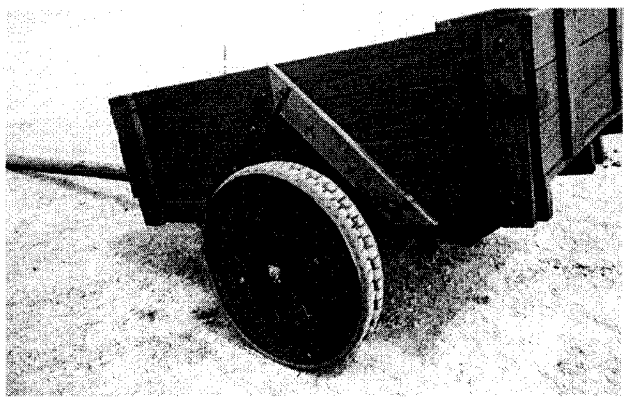


Fig. 8-10: Wooden-wheeled cart nicknamed "Flintstones" in Zambia.
Photo: Paul Starkey

Zaïre, where timber is plentiful, found that each wooden-spoked wheel required well-seasoned wood and about one month's skilled labour. With large fluctuations in the ambient humidity between seasons, any inferior work or poorly seasoned timber quickly became apparent as wheels buckled and disintegrated. It was concluded that steel wheels of similar diameter might be more durable.

Prototype wheels using taut sisal string for spokes have been developed (Hinz, 1988). Rims have been constructed from two wooden hexagons, that have been offset to provide a twelve-pointed figure that has subsequently been shaped into a circle and covered with tyre rubber (Fig. 8-11). Sisal threads, that have been tightened by twisting and held in place by small batons, support the wooden hubs. Preliminary field trials using a narrow animal-drawn cart have been carried out in Tanzania (Hinz, 1985). In principle such designs could offer cart wheels that could be made in villages from locally available materials. However until the problems of maintaining such wheels under field conditions can be adequately solved, the technology will not be able to progress beyond the stage of experimental prototypes.

Wheels can be constructed from wood even if the technical refinement and complexity of spokes is neglected. In several parts of Asia and Latin America long-standing designs of such "solid" wooden wheels are to be seen, but they are much less common than wheels with spokes. Solid wheels are heavier, relative to their strength, than spoked wheels, and so large-diameter solid wheels are rare. In Africa several designs of "solid" wooden wheel have been evaluated. Some designs are made by cutting a circle from parallel timbers, glued or nailed into position. These are then supported by other timbers or by a second circle made from boards aligned in a different direction. The wheels are usually given a rubber tread cut from an old tyre. One design developed in Zambia, involves bolting together two wooden circles, between which are clamped the walls of two halves of a split lorry or Landrover tyre, so positioned that the original tread becomes the tread of the new wheel, albeit arranged "sides to middle" (Fig. 8-10).

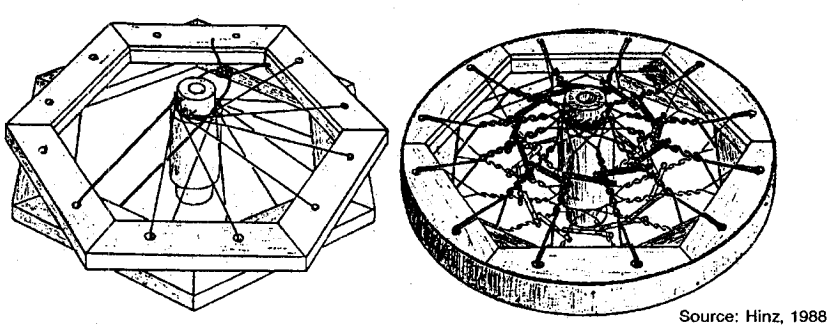


Fig. 8-11: Prototype wooden wheels using string spokes. Field tests have indicated that there are still several practical problems to resolve.

Source: Hinz, 1988

Source: after Barwell and Hathway, 1986; Bjorlykke and Lunde, 1983

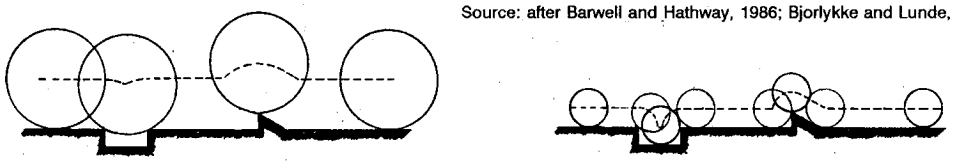


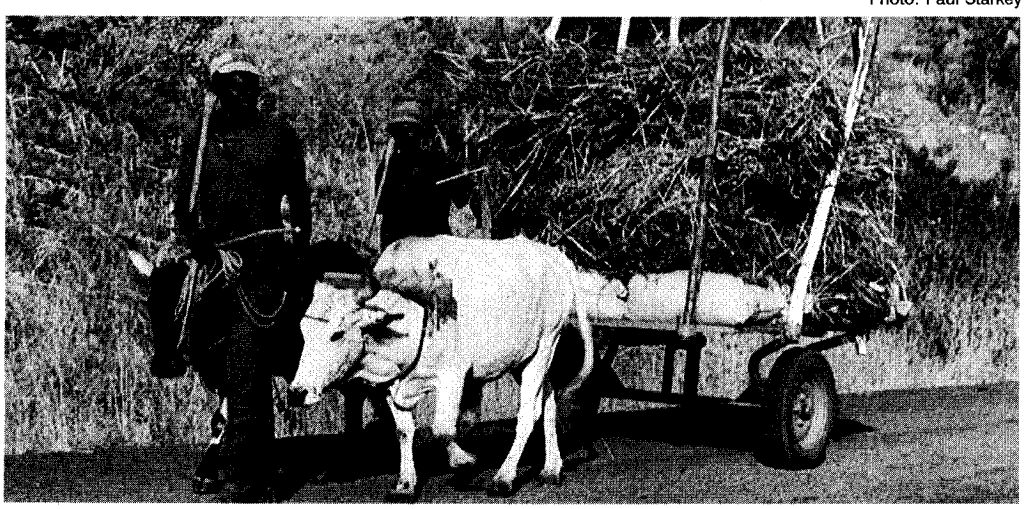
Fig. 8-12: Diagram illustrating how large-diameter wheels (left) are better able to negotiate ruts and holes than small-diameter wheels (right). The ability of a wheel to accept poor conditions is dependent not only on wheel diameter, but also on the width and type of tread and the strength, weight and elasticity of the tyres or wheel rims.

One problem with such a design is that mud can enter between the two halves, tending to separate them. The main advantage of such wheels it that they do not puncture and can be made mainly from local materials by village artisans. However they are heavy and they are not considered fashionable or prestigious (in one country they have earned the name "Flintstone" carts, after the famous "stone-age" cartoon characters).

Steel-spoked wheels are generally lighter than solid wooden wheels, and they are easier to manufacture and maintain than wooden-spoked wheels. They are usually of larger diameter than wheels fitted with pneumatic tyres and thus may be preferred for use on rough tracks where their larger diameter is advantageous for negotiating ruts and holes. However steel wheels are much less resilient than wheels fitted with pneumatic tyres and so they tend to transmit unabsorbed shock loads to the wheel bearings, cart body, passengers and animals. Their lack of resilience also makes steel wheels more likely to damage roads and tracks. In Mozambique and Angola, large-diameter steel-spoked wheels have become quite widespread while elsewhere in southern and eastern Africa several projects have tried to promote smaller diameter wheels. Steel wheels are relatively cheap to make and easy to maintain. One problem is that shock loads and stresses imposed on steel-spoked wheels can cause fatigue in the welds joining the spokes and the rim; if weld failures are not noticed and repaired, the whole wheel may distort or even collapse. However farmers adopting carts with steel wheels are much more likely to have problems with the wheel bearing than with the wheels themselves.

Fig. 8-13: Ox cart with pneumatic tyres, Burkina Faso.

Photo: Paul Starkey



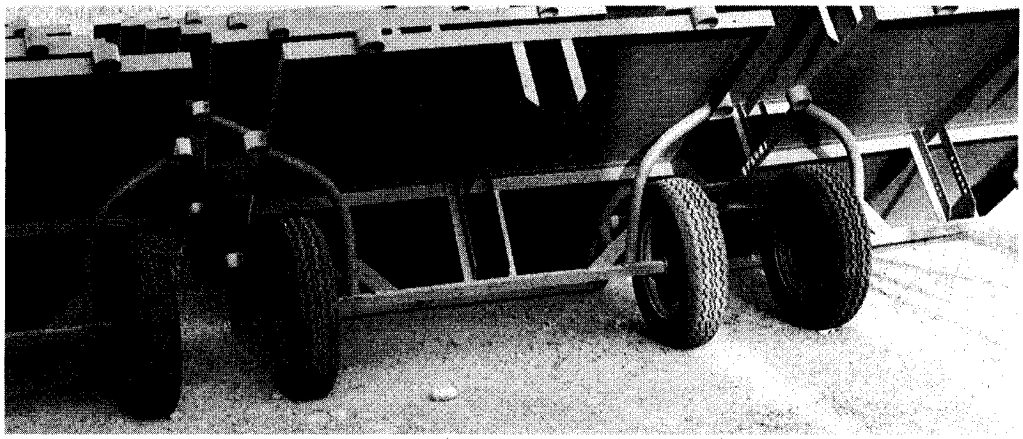


Photo: Paul Starkey

Fig. 8-14: Steel-based two-wheel carts made at the UPROMA workshop in Togo using imported roller bearings and factory-reject car tyres.

In recent years small wheels fitted with pneumatic tyres have become the accepted standard for animal-drawn carts in many African countries. The adoption of common automobile tyre sizes on carts allows farmers the option of making use of old vehicle tyres. In practice, farmers have often found that the problems caused by punctures make worn-out tyres a false economy. Since the specifications of new car tyres are unnecessarily high for slow moving carts, special lower-cost animal-drawn vehicle tyres have been produced in India. However the development of these large diameter tyres was based on the potentially enormous Indian domestic market (with around 15 million carts) and similar investment in special cart tyres seems unlikely in African countries. An alternative approach, widely used in West Africa, is to purchase at considerable discount the reject tyres from large factories. Low grade, reject tyres are dangerous if put on cars but they can be safely used with animal-drawn carts. In a few countries the use of standard car tyres on carts may be seen as a disadvantage, for during shortages of car spares, compatible cart tyres become targets for theft.

Fig. 8-15: Cart based on old vehicle axle being pulled by team of donkeys in Botswana.
Photo: Paul Starkey

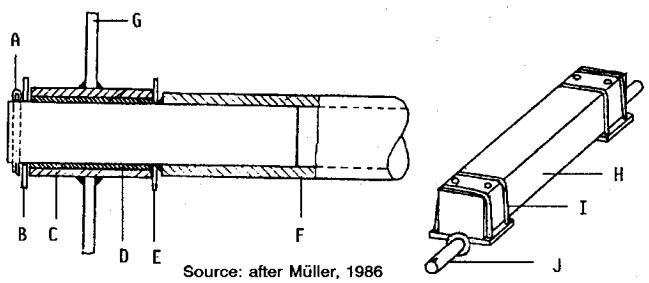
The use of small wheels (400-600mm diameter) allows cart platforms to extend over the wheels in a manner that is impracticable with large wheels (800-1800mm). Such a design provides a wide, but not too high, loading area and easy access from the sides, and thus greater convenience. Nevertheless small wheels are more likely to be obstructed by potholes and ruts than large wheels (Fig. 8-12).

In many countries, a proportion of carts in use has been made from old car axles or from the entire rear section of light pick-up trucks. These are generally heavier than carts with purpose-built axles, but where the necessary scrap vehicles and skills are available, such carts can be very effective. The increasing popularity of front-wheel-drive cars means that lightweight differential-type axles are rare, but some pick-ups have suitable axles. The independent stub axles from the front or rear of a car can be welded onto a steel beam or attached to a wooden frame, but the necessary dismantling, refitting and correct alignment is not easy. There has been at least one example of a development project receiving container loads of assorted scrap axles from industrialized countries (Scheinman, 1986). If such importation is paid for by aid organizations, it may be considered an expedient temporary measure. However the real cost of such importation is likely to be high in comparison to the value of the product. Such funds might be better spent on developing more sustainable systems that would encourage some standardization of tyre and bearing sizes to facilitate the long-term provision of spare parts. In general the construction of carts based on old axles can be regarded as useful, small-scale initiatives for entrepreneurs or small organizations. For larger organizations, particularly those in areas of high demand for carts, the restricted availability of scrap parts, their heavier weight and the quite modest cost savings, suggest that car axles and pick-up bodies should be regarded as supplementary rather than primary sources of animal-drawn carts.

8.5 Cart axles and bearings

Simple bush bearings made of cylinders of cast iron, hard wood or steel tube *can* be very effective, provided they are well prepared, appropriately lubricated and regularly maintained. The majority of the world's carts still use simple bush bearings. Many traditional wooden carts are based on a large wooden hub, rotating around a greased steel axle. In the centre of the hub may be inserted a replacable bush bearing, with cast iron often being preferred to hard wood or steel tube. Such bearings are commonly associated with large-diameter wheels on which the hub rotates relatively slowly. Furthermore traditional wooden wheels have big hubs, allowing long bearings with a large surface area which, if well made and maintained, can last a long time (even if they do impose significant frictional loads). Such large-diameter wooden wheels with simple bush bearings are widely used in Asia and Latin America, and to a limited extent in North Africa and Madagascar, but are very rare in Sub-Saharan Africa.

Many metal wheels are also designed to rotate around a fixed steel axle, and the search for



Source: after Müller, 1986

Fig. 8-16:
Fixed axle with bush bearing tested in Zambia.
A - Split pin; B - Washer; C - Wheel hub; D - Bearing (bronze, nylon or PVC); E - Washer; F - Stub axle; G - Spoke; H - Wooden beam; I - U-bolts; J - Stub axle.

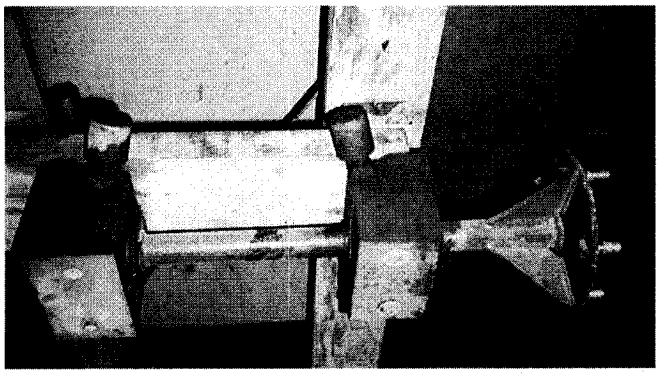


Fig. 8-17: "Live" (i.e. rotating) stub axle with oil-soaked wooden bearings being evaluated in Zambia.

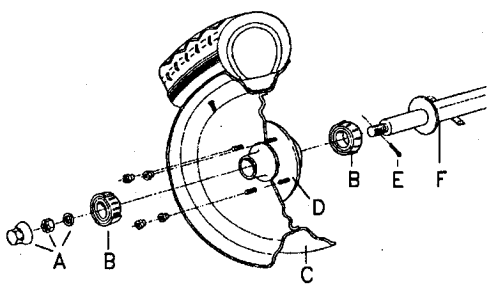
Photo: Paul Starkey

suitable bush-bearing materials has occupied the staff of many projects in Africa. Metal wheels are often of medium diameter so that the speed of rotation of the hub is faster than that of large, traditional cartwheels, and consequently the rate of wear of bearings is greater. In Tanzania some projects, such as that at Iringa, have tried to use oil-soaked wooden bushes as replaceable bearings. It was assumed that wooden bushes would be cheap and very easy to replace. In practice in the early years both new and replacement bushes rapidly disintegrated leaving very wobbly wheels. Furthermore the wooden bushes were not sufficiently uniform to be fitted easily into the wheel hubs. As a consequence farmers tended to tolerate worn bushes longer than they should, until the steel hubs of the wobbling wheels started wearing themselves. In Zambia comparable problems with locally produced hardwood bushes led to experimentation with other materials. PVC bushes were evaluated, but these were expensive and wore rapidly. Bronze bearings (made from locally mined copper) have also been tried in Zambia, and these have been found more durable than hardwood or PVC bearings.

It is a matter for debate as to whether bushes should be lubricated or left dry. If they are greased, sand and grit may mix with the grease to form a highly abrasive grinding paste. If left dry, there may be more noise and friction, but abrasive particles can escape as easily as they enter. Some woods, metals and synthetic materials are "self-lubricating", slowly releasing natural or artificial lubricants as they wear. Mild steel does not have very good bearing characteristics, but it is readily available and easy to work. Although bush-bearings are a major source of frustration to projects and farmers, with regular repair and maintenance they can be kept going for many years: in Ethiopia horse-pulled light carts dating back several decades are still in regular use, even though the original bearings have long-since been replaced by wheel centres made from steel pipes and bushes (where present) made from a range of local materials including rags.

A different approach to bearings, that has also been tried in Tanzania, Zambia and elsewhere, is the use of "live" (rotating) stub axles made of water pipe or old half-shafts from pick-ups and lorries. The axles are held in place by two bearings, each made of two oil-soaked blocks of wood, hollowed out to the shape of the axle and bolted together (ITDG, undated). Thrust washers are welded onto the axle, to restrict lateral movement. The bearing blocks are bolted onto the wooden chassis.

Fig. 8-18: Wheel and axle unit with roller bearing and pneumatic tyres, as widely used in West Africa.
A. Dust cap, lock nut and washer.
B. Tapered roller bearing. C. Wheel rim.
D. Wheel hub. E. Split pin. F. Axle shaft.

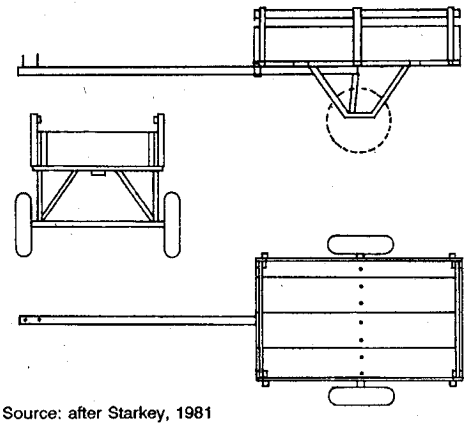


Source: after Matthews and Pullen, 1976

Carts with wooden block bearings are generally heavier to pull than other designs, due to the inherent friction and the weight of the cart. Bearing blocks have to be kept tightly clamped together and the relative simplicity of the design should not disguise the fact that axles will only run freely and truly if the bearing tolerances are correct. Carts with oil-soaked wooden bearing blocks have been introduced on a small scale by projects in many parts of Africa, but the carts are commonly criticised for their heavy weight.

Where the use of specially fabricated animal-drawn carts is common in Africa (Senegal and Mali each have over 100,000 in use), the preferred designs have been based on straight steel axles with machined ends to which are fitted wheel hubs with sealed rolling-element bearings. A simple steel cart frame is bolted onto the axle and a wooden or steel platform is fitted into this (Fig. 8-19). While such designs are not particularly cheap, they are usually long-lasting, with the only regular problem being tyre punctures. Roller bearings are also used in carts made from old car axles.

In conclusion development projects are often faced with the choice between expensive, high technology roller bearings, or various "appropriate technology" options. Many projects have spent a great deal of time and endured much frustration trying to perfect the simpler technology, but long-term maintenance problems have often been serious and adoption rates disappointing. Since transport is often very profitable, the higher cost of roller bearings that allow carts to be used very frequently, yet with little maintenance, may well be justified in the long term. With the benefit of hindsight it is apparent that several projects in Africa might have had more impact if they had provided credit to allow farmers to purchase higher-cost products, rather than employing people to try to develop low-cost alternatives.



Source: after Starkey, 1981

Fig. 8-19: Cart design of the type widely used in West Africa, being based on fixed solid steel axle, roller bearings and imported wheels and tyres.

8.6 Tyre punctures

Punctures are a major problem with animal-drawn carts with pneumatic tyres, and these have sometimes led to the total abandonment of an otherwise unspoiled cart. There seems no simple solution to this problem, which has recently been reviewed by Ayre and Smith (1987). Several

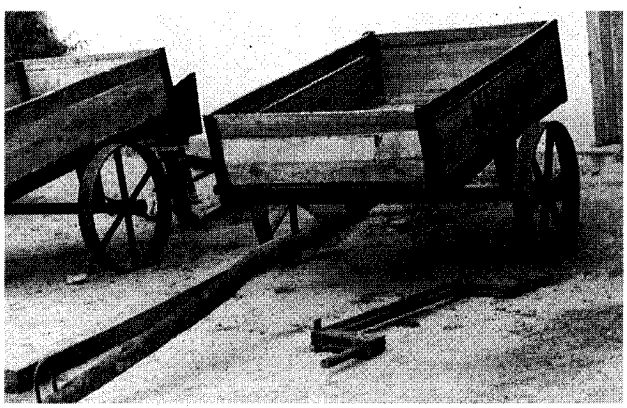


Fig. 8-20: Ox carts with steel wheels fabricated in the workshop of a development project in Tanzania. In foreground is an example of an arched axle assembly. Great difficulties were experienced with the bearings, oil-soaked wooden sleeves that fitted between the wheel hub and the stub axles.

Photo: Paul Starkey

years were spent on testing the efficiency of sawdust-filled tyres in Kenya (SFMP, 1984). In a standard car rim three extra holes were drilled, equally spaced in relation to the valve hole. A tyre, without an inner tube, was fitted to the rim and sawdust was inserted into the tyres through the four holes and compressed with a metal rod. Filling each tyre with sawdust took two people about four hours. The rim was sealed by hammering wooden pegs into the holes. Subsequently a local manufacturer developed purpose-built split-rims which made the filling process easier (Ayre and Smith, 1987). Although sawdust-filled tyres have been officially promoted, farmer adoption has been low. Sawdust-filled tyres are heavy, (particularly if water enters the tyre after immersion in a puddle), the sawdust rots if it becomes damp and the rolling resistance of the tyre is quite high.

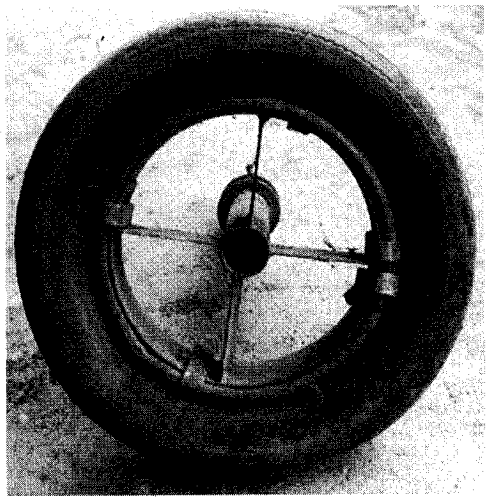


Photo: Paul Starkey

Fig. 8-22: Low-cost axle unit developed in Kenya. The axle which comprised a split-rim wheel, sawdust-filled tyre, water-pipe axle and steel-washer thrust bearings intended for use with oil-soaked wooden bearings, has yet to be widely used.

Although puncture repair is often cited as a major constraint, it has also been widely ob-

Fig. 8-21: Two-wheel donkey cart in Mali. This type of cart is very common in West Africa. Provided the load is well balanced, donkeys can pull impressive loads along flat roads, but care has to be taken when mounting or descending road embankments.

Photo: Paul Starkey

served that once a reasonable number of pneumatic tyres (carts, bicycles, motorcycles or pick-ups) are in use in an area, entrepreneurial puncture repair services spring up in even quite small villages. Thus in areas of introduction, development projects might find it more productive to facilitate the adoption of "critical" numbers that justify local services in specific areas, rather than trying to spread their efforts thinly over a wide area.

8.7 Brakes, loads and assembly

The fitting of brakes on carts is not common in flat areas, but may be desirable. Brakes are important to save the animals from discomfort where steep slopes are encountered. Such slopes may be major hills or simply the steep sides of a road embankment. Even on flat ground, a loaded cart pulled at normal speed has a considerable momentum, and absorbing this through the harnessing system on a downward slope can be very uncomfortable for the animals. The choice of harnessing system (chapter 3) can influence the efficiency with which animals can brake carts with their own bodies. Horn/head yokes are firmly attached to the animals and so facilitate braking. On the other hand withers/shoulder yokes are more loosely fitted and if animals try to stop a cart that has built up significant momentum, the yoke can move forward and even rise up over the animals' heads. In such circumstances a breeching strap attached to the harness or drawbar is useful for transferring the braking load to the rear of the animal and away from the vulnerable neck or head. A bar fitted to the cart immediately behind the animals can have a comparable effect to a breeching strap, and such bars are commonly fitted to carts in India. Basic wheel brakes can be made from concave wooden blocks (or even just logs) that are pushed against the wheel or tyre surface. In the simplest case no fixings are necessary, although a lever mechanism can be arranged. Some manufactured wheels for carts come with internal brake shoes. Old car brakes can be quite easily adapted if mechanical parking-brake linkages (not simply hydraulic mechanisms) are available.

Most carts are designed to withstand loads of up to one tonne. The ability of animals to pull such loads will depend on the road surfaces and the inclines. An easy load to pull on a tarred road surface may be impossible to pull on a track with steeply sided holes or muddy ruts. Single donkeys can generally pull loads of 500kg, single horses can pull 700-1000kg, while pairs of oxen can pull one tonne, or more. Pairs of oxen of large Indian draft

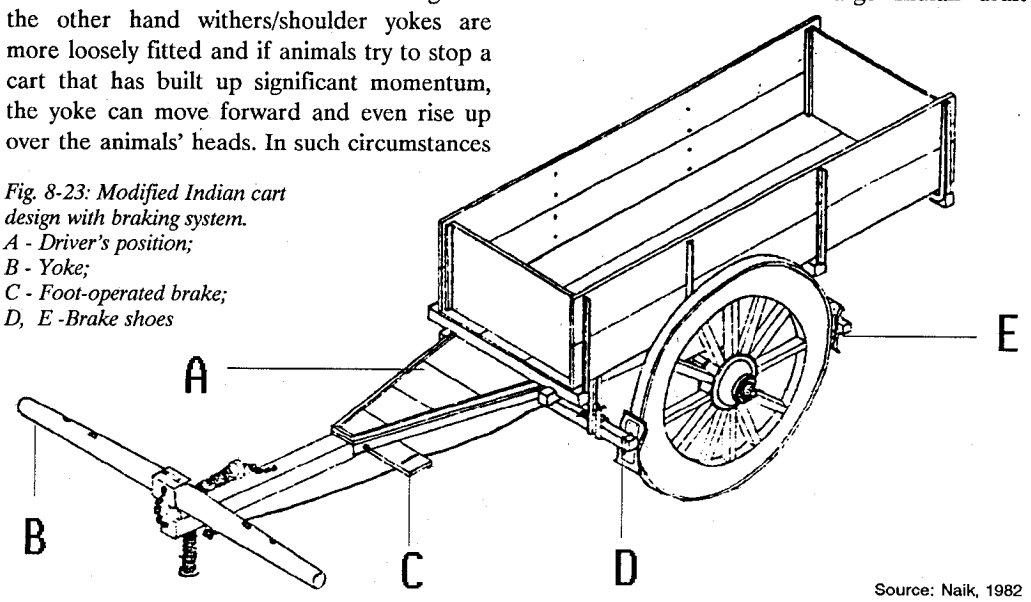


Fig. 8-23: Modified Indian cart design with braking system.
A - Driver's position;
B - Yoke;
C - Foot-operated brake;
D, E -Brake shoes

Source: Naik, 1982

breeds are reported to be able to pull 1.5 tonne loads over 60km of rough roads in a day (Williamson and Payne, 1959). Balancing the load on two wheeled carts is important, as any imbalance will cause upward or downward forces on the animals' harnessing systems. A heavy load shifting backwards during use can cause a donkey to be literally lifted off its feet, with disastrous consequences.

Assembled carts are very expensive to transport over long distances, due to their great volume. For this reason, and to facilitate local construction and repair services, carts should be made, or assembled, as close to the point of use as practicable. Several African countries, including Burkina Faso, Mozambique and Togo, have adopted the system of supplying basic cart kits to rural centres. Simple kits may comprise two wheels, an axle and the struts that fix this axle to a wooden platform. Others may contain a complete steel frame in component form and even a steel drawbar. Some components may have to be imported (several countries import complete axle and wheel assemblies), while others may have been made in local workshops. Artisans, traders and/or small workshops assemble the kits and build on wooden platforms, and perhaps removable sides, for sale to the end-users.

8.8 Wheeled toolcarriers and four-wheel trailers

Wheeled toolcarriers have often been designed to be converted into carts, and many ended up being used only in the cart mode. However wheeled toolcarriers fitted with a cart platform have generally had high centres of gravity, making them liable to topple when encountering ruts. As noted in Chapter 9, farmers have found it more convenient to use purpose-built carts and separate cultivating implements. Such a combination can generally be obtained for the same price as a multipurpose wheeled toolcarrier (Starkey, 1988).

Four-wheeled carts, or trailers, are used for urban transport in many towns in Asia, and some in Africa and Latin America. They are also used on some estates and plantations. The four wheels support the whole load, so that animal power is only needed for forward movement. This allows heavy loads to be pulled, particularly if the road surface is smooth. Four-wheeled trailers can be left with loads in place even when the animals are not present (two-wheeled carts tip-up when left, although it is a useful practice to always carry pieces of wood to support the front and rear of the cart to prevent such tipping). While two-wheeled carts can pivot around the wheels during sharp turns, four-wheeled

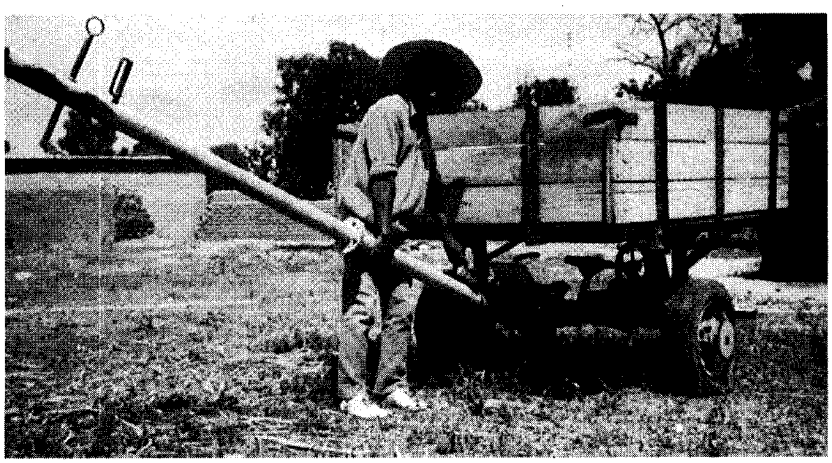


Fig. 8-24:
A cart-body on a "Nikart" wheeled toolcarrier in Mali. The farmer found his normal cart more satisfactory and stopped using the toolcarrier altogether. Although toolcarriers have been used as carts, they have seldom been as good as purpose-built carts.
Photo: Paul Starkey

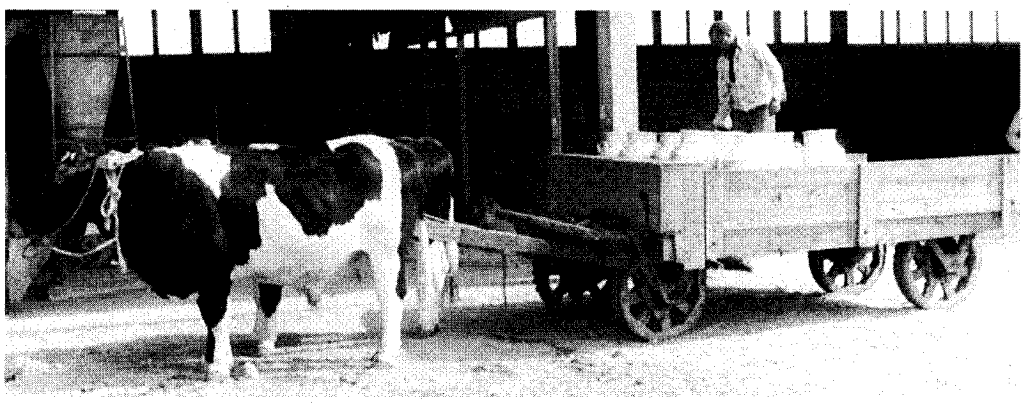


Photo: Paul Starkey

Fig. 8-25: A four-wheel trailer with wooden wheels being used with Friesian oxen at an agricultural research and training centre in Tanzania.

trailers need some form of articulation to ensure manoeuvrability, which makes the design of trailers significantly more complex than just adding a set of wheels to a two-wheeled cart. While two-wheeled carts are likely to increase rapidly in rural Africa, it is unlikely that four-wheeled trailers will become common.

8.9 Further sources of information

A useful illustrated discussion of the issues involved in the design and manufacture of animal-drawn carts has been produced by ILO and Intermediate Technology Publications (Barwell and Hathway, 1986). Filmstrips and booklets providing simple extension advice relating to the operation and maintenance of pneumatic-tyred carts are available from FAO (1983). An interesting review of attempts to develop animal-drawn carts in Zambia has been provided by Müller (1987). The GATE journal issue 1/89 of March 1989 had the theme of low-cost transport and contained articles relating to animal-drawn transport.

There is much information available on traditional and more recent designs of animal-drawn carts in India. The subject was discussed by Ramaswamy (1979) who subsequently produced a detailed, illustrated publication recording many of the traditional cart designs in use in India (Ramaswamy, 1985). An annotated bibliography, containing over 300 citations relating to animal-drawn vehicles drawn from both Indian and international publications was prepared by Deshpande and Ojha (1983). The same authors have prepared an illustrated monograph on traditional and improved bullock carts (Deshpande and Ojha, 1984).

Staff of CTVM at Edinburgh University have a research interest in the employment of donkeys, mules and horses in developing countries, and an initial brief report on the use of donkeys for pack transport was provided by Fielding (1988). The existence of an American Pack Animal Study group was mentioned by Iversen (1987).

Many projects in Africa have activities relating to animal-drawn carts and some of these are listed in GATE Animal Traction Directory: Africa (Starkey, 1988). Organizations outside Africa working on animal-drawn cart technology include Intermediate Technology Transport in UK.