

Rural transport in Zambia: the design of an ox cart which can be produced in rural areas

by

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Abstract

Ox carts can be regarded as the most suitable means of transport in rural areas. The problem with the ox carts manufactured in Zambia is that they are too expensive and are not available in the (remote) rural areas. Ox carts should therefore be produced in the rural areas using, as much as possible, locally available materials; this will also facilitate repair and maintenance.

The University of Zambia's Technology Development and Advisory Unit has designed an ox cart especially for rural production. The design uses wood as the basic raw material wherever possible, and has no imported parts. The cart has wooden bearings, which can be manufactured easily and have surprisingly low friction and wear rates. Flexi-wheels use the flexibility of rubber to provide good shock-absorbing characteristics. They cannot be punctured. The process of testing and improving the present design is continuing, based on the experience gained from carts already produced.

Introduction

Zambia's rural areas could easily grow enough food to feed the whole country. A major constraint to achieving such self-sufficiency is the shortage of transport to bring agricultural produce from remote rural areas to the urban centres, as well as to supply the rural areas with farm inputs and other basic needs.

Although motor vehicles can be used for transport between collection points and towns, their use in the rural areas is not economical. They are very expensive to buy and maintain because they, and their spare parts, have to be imported and paid for with foreign exchange. Also, roads in the rural areas are very poor, so breakdowns are frequent, and repairs are extremely costly and time-consuming.

Animal power can provide the solution to the transport problem in the rural areas. Sledges are useful for short-range transport, but for transport over longer distances—between the agricultural areas and the collection points—ox or donkey carts are the only viable answer.

Carts for rural areas

Carts are not readily available in the rural areas of Zambia, for several reasons. Components such as axles, bearings, rims and tyres have to be imported and are in short supply, so few manufacturers are able to produce carts on a regular basis, and the ones that are made are very expensive. Moreover, manufacturers of ox carts are concentrated in Lusaka and other cities, and transporting assembled carts to the rural areas is expensive because they take a lot of space. Thus only commercial and progressive emergent farmers can afford to buy carts. Another problem is that spare parts are not readily available, and difficult repair jobs can only be done by the manufacturers or by well-equipped workshops; this makes maintenance difficult, and so the reliability of carts is rather low.

The high demand for ox carts can therefore only be partially met. Only people in the areas close to the manufacturers and a few distribution points can obtain ox carts, while those in the more remote areas, where the need for this kind of transport is much more urgent, have to do without.

Producing ox carts locally, in the areas where they are needed, could provide an answer to the supply problem. This is already being done by some local artisans who use old car suspensions and/or pick-up bodies to build ox carts (Photo 1). However, there are very few broken-down cars available in the rural areas—not nearly enough to cater for the demand for ox carts. Furthermore, such local carts may be poorly designed and badly balanced, which places a considerable burden on the oxen. In addition, repair jobs to carts based on pick-ups often require welding and spare parts which are not available in the rural areas—the high costs and the hassle of repair work result in many carts being abandoned.

What is required is a more systematic approach to the design and local production of ox carts. The Technology Development and Advisory Unit (TDAU), an autonomous unit of the Department of Mechanical Engineering of the University of



Photo: H Vroom

Photo 1: Ox cart made locally from an old pick-up

Zambia, works in partnership with aid organisations to give technical assistance in the testing and redesigning of equipment to suit Zambian conditions. TDAU has designed a basic cart that can be made with locally available materials and parts (Figure 1).

The advantages of the type of local manufacture required for the TDAU cart are clear: the cart will be cheap to produce, easy to maintain and repair, and available where the demand for this kind of transport is the greatest. Furthermore, carts can, to some extent, be custom-made according to the particular requirements of the local farmers.

TDAU is also providing support and training to local workshops and craftsmen who will make these carts. In its Rural Workshop Programme, TDAU is helping carpenters and blacksmiths to equip their workshops and upgrade their skills by offering tools on a hire-purchase basis, giving advice on technical and managerial matters and organising training courses. TDAU may enter into joint cart production arrangements with local manufacturers.

Design of the TDAU ox cart

The TDAU ox cart has been designed to be:

- affordable for the small-scale farmer
- highly reliable and durable
- easy to maintain and repair with locally available materials and limited tools and spares
- easily manoeuvrable, with low draft force requirements

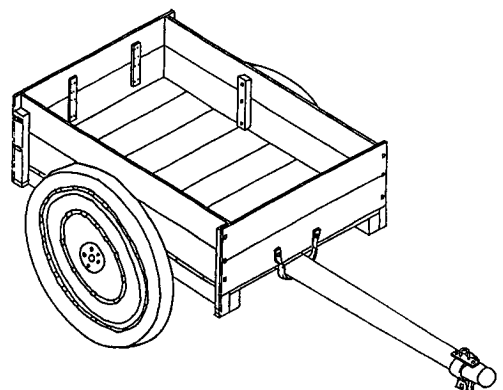
The cart has three main functional parts—the cart body, the suspension and the wheels—and the design choices for each of these parts are discussed in the following sections.

Cart body

A cart body can be made entirely of steel, of a steel frame with wooden boards or entirely of wood. The choice of material for the TDAU cart body was dictated by local availability: very little scrap metal is available in the rural areas, while wood is plentiful. Wood was therefore chosen as the basic material, with steel being used only to reinforce critical joints.

The body of the TDAU ox cart is made of thick boards of local timber, which are strong and durable although rather heavy. The boards are painted with old engine oil, to protect them against water and attack by ants, and hence to ensure a long life-span. Very few steel parts are used, so the cart body can be made by any capable carpenter. Experience to date with this cart body has been good.

Figure 1: The TDAU ox cart with flexi-wheels



Suspension

A two-wheeled ox cart is more suitable for use in rural areas than a four-wheeled version, because of simplicity of construction, manoeuvrability and price.

A suspension comprises a shaft and bearings mounted on some sort of subframe. For the bearings, a choice had to be made between roller bearings or plain bearings.

Roller bearings are the common choice for ox carts produced in a factory. They have a low friction coefficient (0.005 unsealed) and, if properly greased and sealed, can have a long life-span in a harsh environment. Their life-span is, however, affected by their sensitivity to impact loads which are quite heavy on ox carts. The roller bearings produced in Zambia (with imported, expensive steel) are of questionable quality; satisfactory bearings must therefore be imported ready made, so they are expensive and not readily available as spare parts. For all these reasons, roller bearings are not the best choice for an ox cart produced and used in the rural areas.

Plain bearings are less sensitive to impact loads, but have higher friction coefficients and need a lubrication system. They can be made of various materials, most of which are not very satisfactory for use in rural areas: PVC or bronze bearings wear too fast in harsh environments, and metallic bearings running against a mild steel shaft cause excessive wear on the shaft. Furthermore, bearings made of these materials cannot be repaired, but have to be replaced as a unit. So none of these bearings is a suitable choice for a rural ox cart.

TDAU chose plain wooden bearings (Photo 2) made of local Mukwa (hardwood) timber. The bearing blocks can be easily manufactured by any carpenter, with little training, so they are cheap. Fitted with grease-pots, their friction coefficients and wear rates

Figure 2: Friction coefficient in relation to bearing pressure (ie, bearing load/bearing area) for dry and lubricated wooden bearings

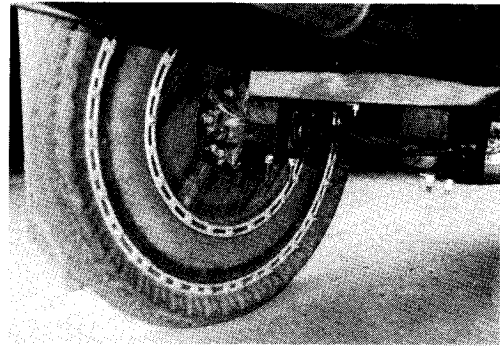
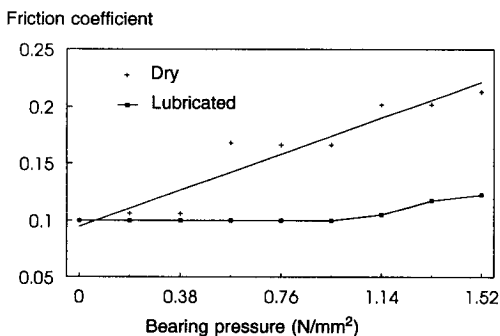


Photo: Paul Starkey

Photo 2: Plain wooden bearing used on the TDAU ox cart

are surprisingly low (friction coefficient < 0.2 , see Figure 2). Split bearing blocks were chosen because, when these get worn, they can be restored to almost new condition simply by replanning.

A shaft could also be made of wood, but TDAU's experience with wooden shafts have not been good: they are not capable of absorbing the impact loads typical of ox carts, and because they run in a wooden bearing block they wear rather fast, and then break. So TDAU chose mild steel as the shaft material, this being the cheapest alternative. Mild steel is strong and, in combination with the wooden bearings, has a long life-span. TDAU decided to use a "live shaft" system construction (Photo 2) as this facilitates manoeuvring. However, production of these shafts requires jigs and welding, so regrettably they will probably have to be manufactured in an urban workshop and supplied to the small rural workshops together with the grease-pots for the bearings.

Wheels

Land Rover rims and tires are the common choice for ox cart wheels. Pneumatic tyres have low draft requirements (if properly inflated) and excellent shock absorbency, but they puncture easily, and in rural areas a puncture can keep a cart out of use for days.

Wooden or metal disc wheels (spoked or solid) could be made locally. However, they are heavier and their lack of shock-absorbency results in frequent breakages of wheels and other cart parts, and discomfort for the oxen.

TDAU has designed a compromise solution, the flexi-wheel, which consists of an old rubber tyre clamped on a wooden disk. Rubber has good shock-absorbing characteristics, but the great advantage of these wheels is that they cannot be punctured. Old truck-tyres are the best choice

Rolling resistance
(kgf/kg)

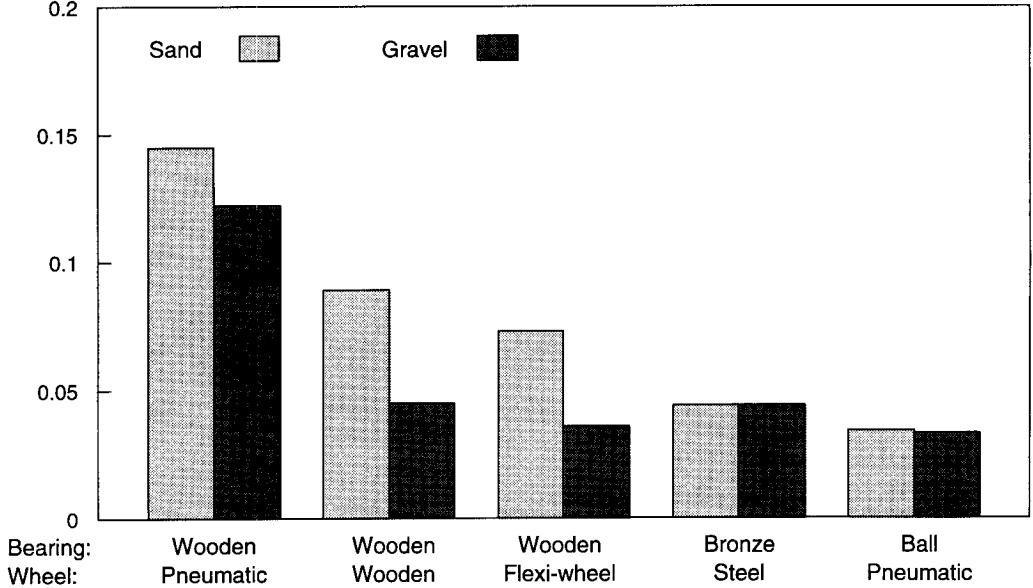


Figure 3: Rolling resistance for different wheels and bearings
(rolling resistance was calculated as draft force in kgf divided by load in kg)

because their size creates good roll-over characteristics: the cart rolls over uneven places in the road instead of bumping into all the holes and depressions. This reduces the necessary pulling force and the burden on the oxen. The major disadvantage, however, is the high weight of these wheels which can be 65–100 kg each depending on the diameter, materials used and configuration.

The results produced so far with the flexi-wheels have been very encouraging: there have been no punctures, and the shock absorbency and rolling characteristics have been good. In comparative tests on a sandy surface, the rolling resistance (draft force/total load) for the combination of flexi-wheels with wooden bearings was 0.075 kgf/kg compared with 0.030 kgf/kg for the combination of pneumatic tyres with roller (ball) bearings (Figure 3). The good rolling characteristics of the big flexi-wheels largely compensates for their extra weight and the friction of wooden bearing blocks.

As yet insufficient data are available to predict the life-span of these flexi-wheels, but it is hoped to study several different flexi-wheel designs in the near future.

Adaptability of the TDAU ox cart

The standard design of the TDAU ox cart, with a hardwood body, wooden bearings and flexi-wheels, can easily be adapted to suit locally available materials and manufacturing possibilities, the particular local conditions and customers' specific requirements. For example, the body could be made from another kind of wood or have different dimensions. Land Rover wheels could be used instead of the flexi-wheels.

Conclusion

The design of the TDAU ox cart is still being improved, but it can already be produced mainly with locally available materials by a carpenter and blacksmith in a rural area. Only a few parts, such as shafts, grease-pots and some wheel parts, would have to be supplied by a better equipped (urban) workshop.

Therefore the TDAU ox cart can be part of the solution to the transport problem in the rural areas of Zambia.