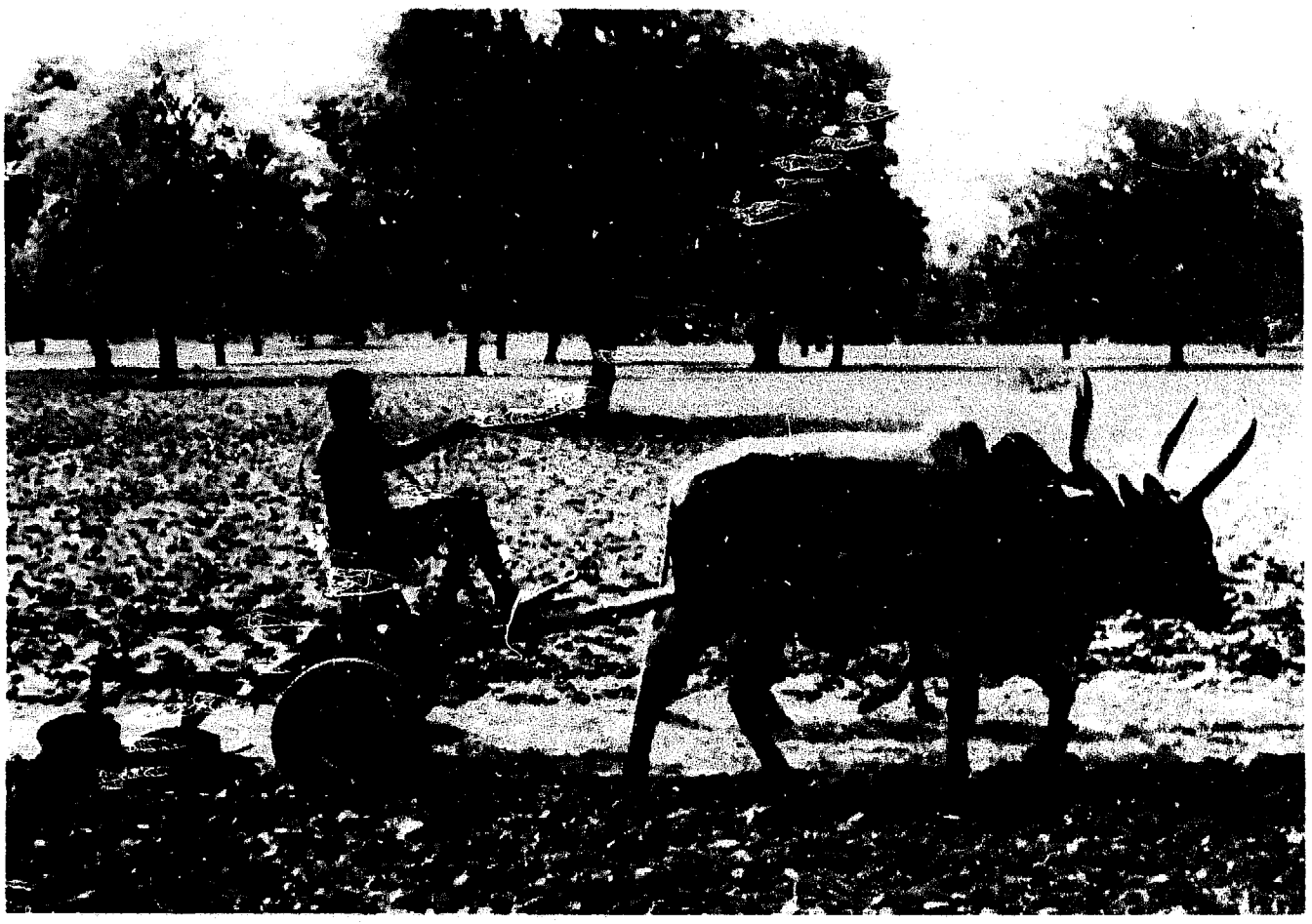
Paul Starkey

Animal-Drawn Wheeled Toolcarriers:

Perfected yet Rejected



Vieweg

3. Early Experience in Africa: 1955—1975

3.1 Senegal

Much of the pioneering work on wheeled toolcarriers was carried out by the Secteur Expérimental de Modernisation Agricole (SEMA) in the central groundnut basin area of Senegal. In 1954 SEMA employed the French agriculturalist Jean Nolle, who was charged with others with developing a modern, socially and economically acceptable system of farming using animal traction (Nolle, 1986). Nolle's first design of wheeled toolcarrier was developed in 1955. *Le Polyculteur Léger* comprised a metal chassis and drawbar supported on two wheels with pneumatic tyres. There was an operator's seat and a handle for raising or lowering the implements that included a mouldboard plow, up to three seeders, flexible tines, groundnut lifter, harrow and ridger. A platform could be fitted to make the toolcarrier into a cart. Nolle continued to work on his design and in 1956 he developed the *Polyculteur Lourd,* which used wheels of the same diameter as the local taxis, and which could be modified to become a water tanker or tipping cart. Nolle's Polyculteur design quickly passed from being a prototype to being manufactured commercially in France, and by 1958 a photograph of the Mouzon-

Fig. 3-1: Polyculteur "léger" with three seeders, Senegal, 1955. (Photo: Jean Nolle).

Nolle Polyculteur in action in Senegal had appeared in the journal Agronomie Tropical (Labrousse, 1958).

At the same time as this early work on wheeled toolcarriers, Nolle while working in Senegal also designed some cheaper intermediate type of toolframes known as the *Houe Saloum* and later the *Ariana*. These had two small wheels but unlike the Polyculteurs they were not designed for ride-on operation or for use as carts. More importantly Nolle also designed multipurpose toolbars such as the *Houe Sine* which were not based on two wheels. This work was extremely significant as simple longitudinal toolbars derived from these early designs have since been sold in tens of thousands in West Africa.

Nolle considered his designs would allow small farmers to improve rapidly the profitability of their enterprises, and described how in 1958 at Bambey in Senegal a display of ten toolcarriers each with a different implement was organised, with a sign indicating that the technology would bring new freedom to the peasants. He also describes how one farmer was able to make so much profit using the toolcarrier that he could buy a second-hand Landrover. It is clear that from his perspective as a designer of animal-drawn equipment, Nolle regarded his innovations as highly successful, as his toolcarriers allowed farmers to work greater areas with less drudgery than alternative implements (Nolle, 1986). Although there were some early reservations concerning the high cost and complexity of the wheeled toolcarriers (Nourrissat, 1965), economic models were developed at Bambey Research Station which illustrated how the wheeled toolcarriers could allow cultivated surfaces to double, relative to alternative equipment, while at the same time allowing returns to both area and labour to increase (Monnier, 1967).

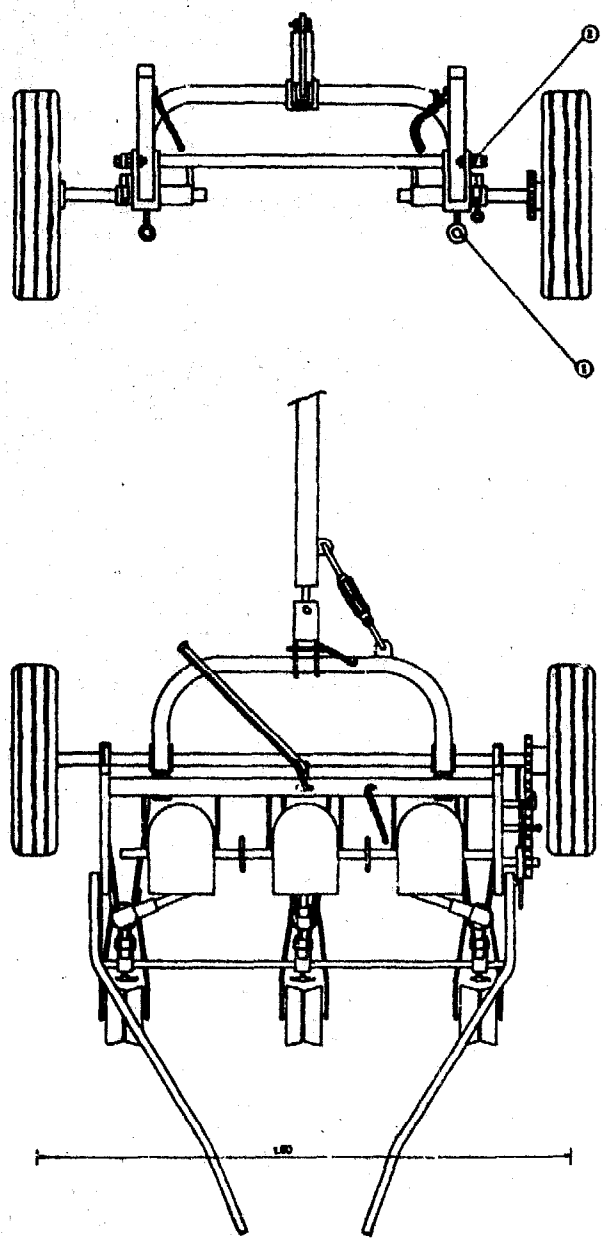


Fig. 3-2: Polyculteur à grand rendement developed at CNRA Bambey, Senegal (CEEMAT/Monnier and Plessard, 1973).

Nolle's innovations were further developed in Senegal, and the perceived benefits of the wheeled toolcarriers were made clear in the name of one model known as "Matériel à grand rendement", or high output machine. This was designed for use with two oxen and with its three row seeder it was recommended for the small proportion of the farms that were over 15 ha and which had destumped areas (Monnier, 1971; Monnier and Plessard, 1973).

Following the work of Nolle, Monnier and others, the toolcarriers were actively promoted and credit was made available to facilitate purchase. As early as 1958 toolcarriers had been commercially manufactured in France by Mouzon-Nolle and were imported into Senegal (Labrousse, 1958). The main importation and promotion was in the years 1961–1967. During these years the numbers of intermediate toolframes and wheeled toolcarriers distributed first rose and then fell dramatically as shown in Table 3.1.

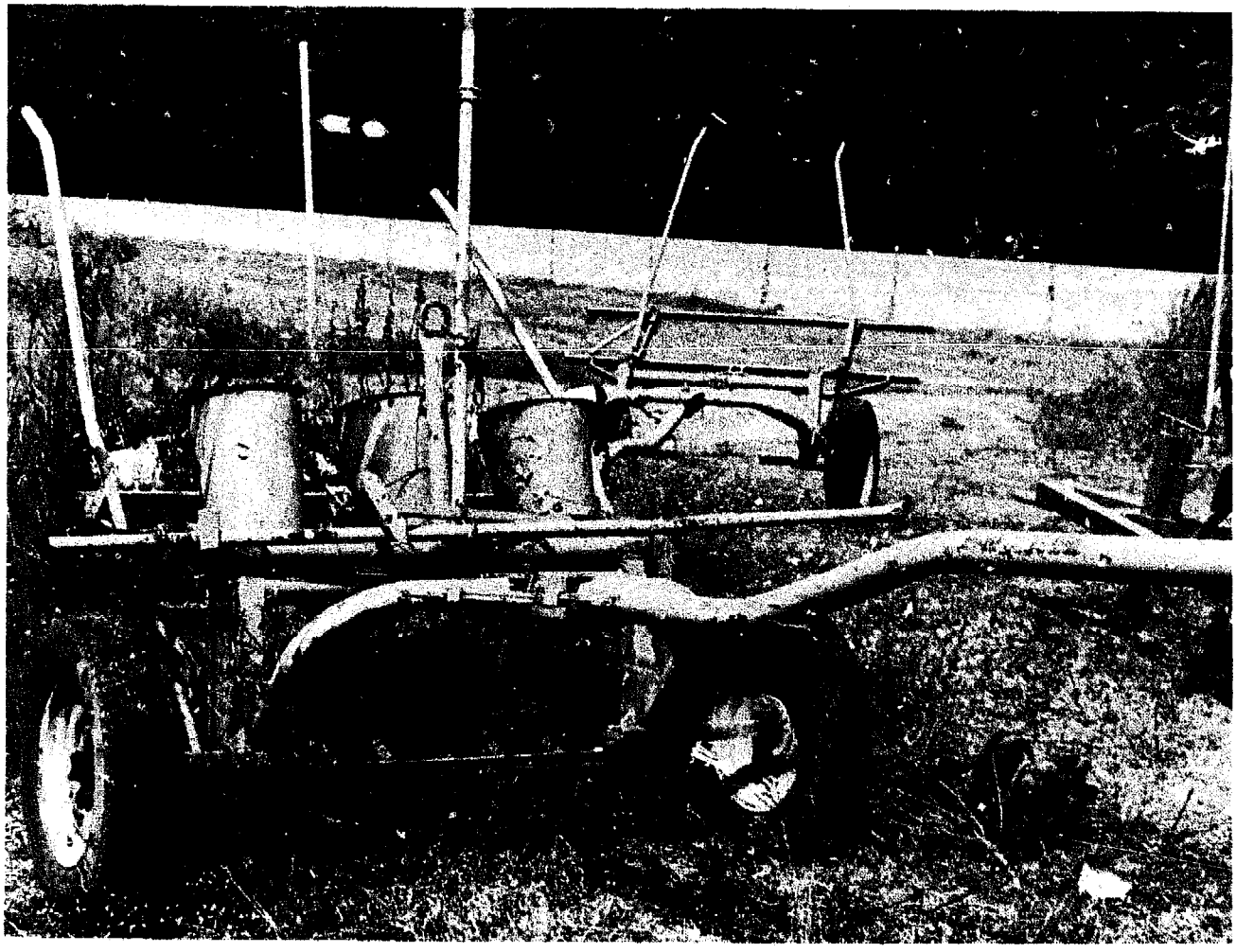
As a result of the promotion, numbers of intermediate toolframes and toolcarriers on farms in Senegal increased from 200 in 1958 to 700 in 1960, and to 7800 in 1968 (Havard, 1985a; Havard, 1985b). Of these, the majority were Ariana-type toolframes but about 500 were the more expensive

Table 3.1: Toolframes and toolcarriers distributed in Senegal, 1961–1967

Year	Toolframes distributed*
1961	83
1962	3 151
1963	2 026
1964	1 311
1965	291
1966	104
1967	72
Total for period 1961–1967	7 038

**Note:* These figures combine the intermediate type of toolframes such as the Houe Saloum and Ariana with wheeled toolcarriers such as the Polyculteur. Only about 500 implements (7% of this total) would be wheeled toolcarriers, but the pattern of rapid rise and fall was similar for both categories of implement.
Source: Havard, 1985a.

Fig. 3-3: SISCOMA/SISMAR Baol Polyculteur on research station in Senegal, 1987: foreground with seeders; background with steerable toolbar. (Photo: Fadel Ndiamé).



wheeled toolcarriers. However farmers mainly used both implements as multirow seeders as this operation imposed only a small draft on the animals and timeliness was all important. Since farmers were not making full use of the multipurpose potential of the Polyculteurs, as soon as the early promotional benefits were reduced, farmers found it preferable to purchase several cheaper and lighter implements to one wheeled toolcarrier and research attention turned to single purpose seeders.

While about 200 000 plows, seeders, simple (Houe Sine) toolbars and ordinary carts were sold in Senegal between 1968 and 1983, only about 100 wheeled toolcarriers were sold during this period, and numbers remaining in use declined rapidly. 1983 estimates of equipment in use put the numbers of simple toolbars (Houe Sine) at 100 000–150 000, the numbers of Houe Grecos (another simple toolbar design) were about 500, the numbers of Ariana (intermediate) toolframes were even lower at "very few", and the numbers of wheeled toolcarrier were neglected altogether, as they were considered of only marginal importance (Havard, 1985c).

The large SISCOMA (subsequently SISMAR) factory that had started toolcarrier production in 1961 continued to make and sell small numbers of wheeled toolcarriers during the 1970s, during which time the customers were increasingly aid projects and research stations rather than farmers. Total sales of wheeled toolcarriers in Senegal during the years 1976 to 1979 were only 51 in the Sine Saloum Region and three in the rest of the country (Havard, 1985a). After total sales of just three units were recorded for the year 1983 (representing 0.18% of production) the SISMAR factory decided that the routine manufacture and sale of wheeled toolcarriers would cease altogether, and production would be restricted to special orders (SISMAR, 1984 and 1985). Between 1983 and 1987 about thirty Polyculteurs were made to order, but the factory considered demand was practically nonexistent (SISMAR, 1987).

In present-day Senegal at least 30% of the farmers use animal traction employing a total of 430 000 oxen, horses and donkeys. In the SISMAR (formerly SISCOMA) factory, Senegal has one of the largest manufacturers of animal traction equipment in Africa, with a quarter of a century of experience in fabricating various toolcarriers within a free-market economy. Yet in Senegal, a country that could be considered the "home" of the modern toolcarrier concept, the wheeled toolcarrier that has been both known by and commercially available to farmers for thirty years, appears to have been rejected and forgotten.

3.2 Eastern Africa, 1960–1975

3.2.1 Tanzania

Animal traction was introduced into Tanganyika in the early years of the century, and about 600 000 of the country's 12 million zebu cattle are used for work. Early testing of wheeled toolcarriers was carried out in 1960 and 1961, in the context of cooperation between NIAE, TAMTU (Tanganyika – later Tanzania – Agricultural Machinery Testing Unit) and the colonial authorities. One objective of the toolcarrier research was to produce a gradual break from traditional methods that would help the farmers to become ready for mechanical cultivation.

The initial NIAE design work had been carried out between 1958 and 1960 in Silsoe, U.K. The toolcarrier comprised a tubular drawbar attached to a cranked axle carried on pneumatic tyres. A pivoted toolbar could be raised with handles that could also be used for steering. The prototype survived field trials, although it was noted that

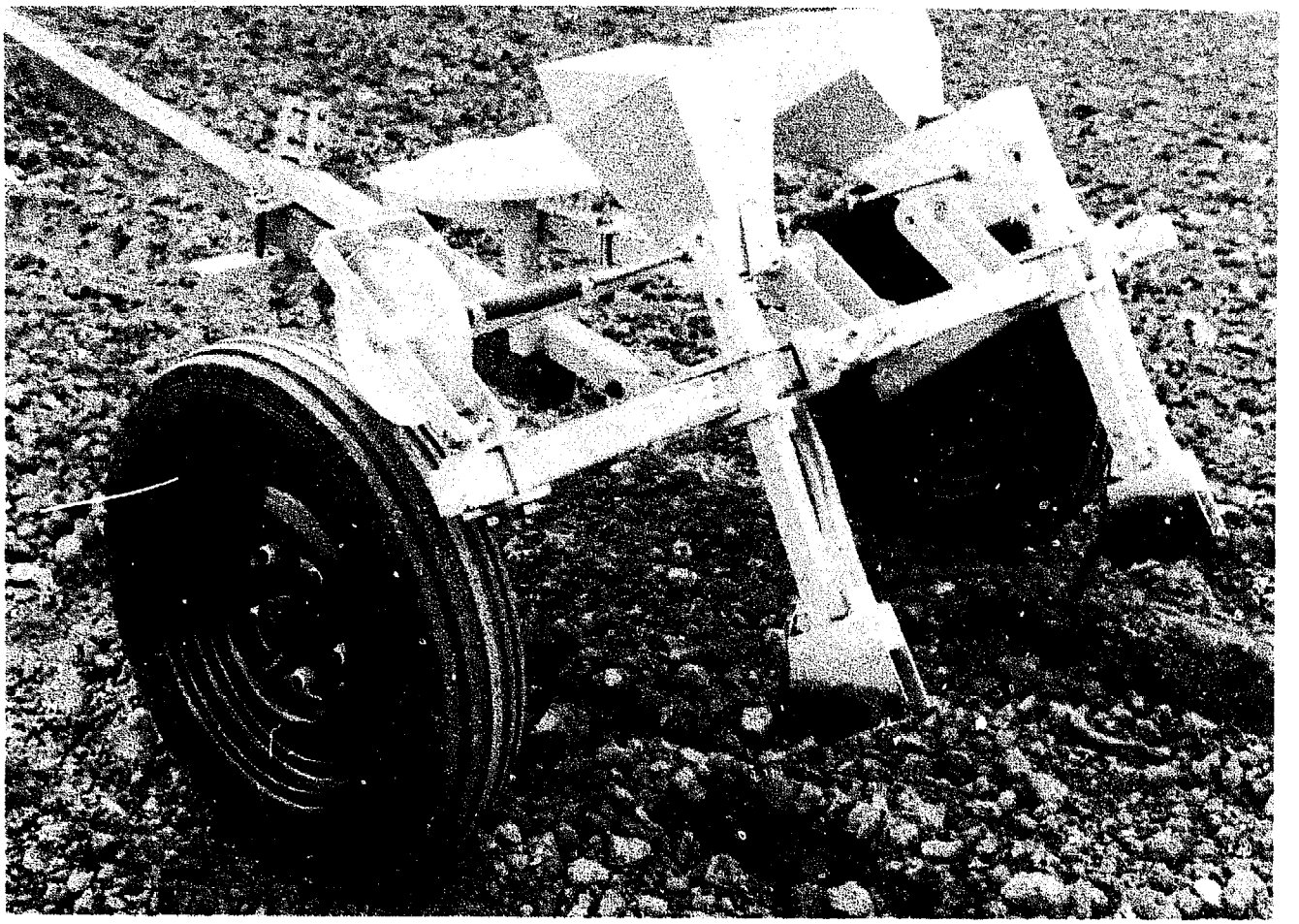
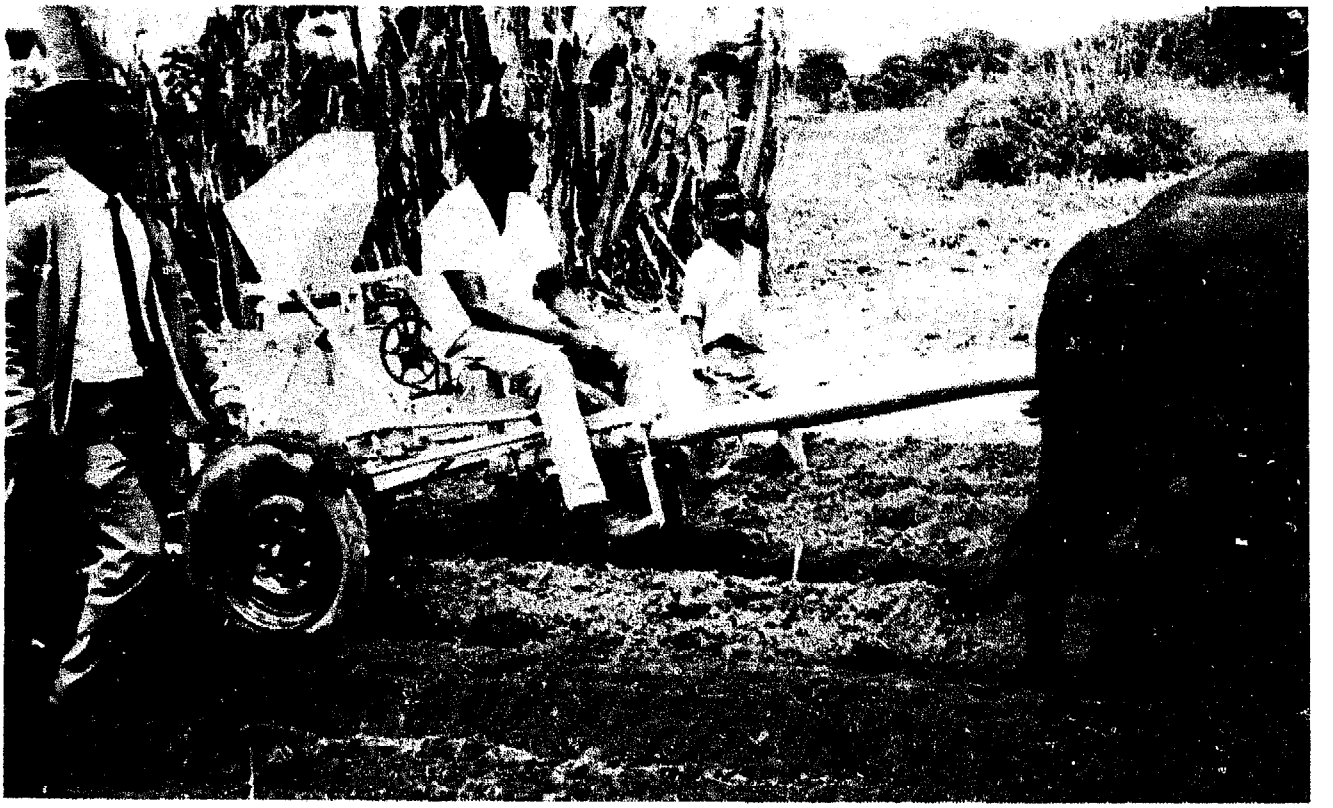


Fig. 3-4: NIAE ADT wheeled toolcarrier with simple friction drive seeder in the U.K., 1967. (Photo: AFRC-Engineering archives).

Fig. 3-5: NIAE wheeled toolcarrier with SISIS roller seeder being tested in Malawi, 1969. (Photo: AFRC-Engineering archives).



the equipment needed strengthening to withstand peak loads of up to 400 kg attributable to implements striking roots. Some nuts and bolts in the initial design were replaced with clamps with retained screws. The prototype was designed for use with one pair of animals, but TAMTU suggested that in order to work the recommended 0.9 metre ridge spacings a larger toolcarrier with a 1.8 metre wheel spacing would be useful. This it was suggested could be used with teams of four or more animals as found in some parts of the country. While there were distinct reservations over the additional weight and cost of a larger unit, a 1.8 metre prototype was developed and initial trials were considered very promising (Chalmers and Marsden, 1962). However the larger toolcarrier was heavy, requiring 4–6 animals, and difficult to manoeuvre and it was decided not to proceed with the design.

In 1962/1963 a 0.9 metre toolcarrier was developed, based on the lessons learned from the earlier models and from studies of European and Indian models. This incorporated a commercially available tractor toolbar, arched for crop clearance. The use of the existing International tractor toolbar was intended to make it easy to progress to motorized applications. The toolcarrier had an adjustable wheel track and a driver's seat and was used at TAMTU's Tengeru farm for plowing, harrowing, weeding, ridging, planting and as a cart (Constantinesco, 1964). It had been hoped that this model would be extensively tried out throughout East Africa, but it does not appear to have been manufactured in significant numbers and toolcarriers never spread in Tanzania.

Small numbers of commercially produced versions of the NIAE wheeled toolcarrier were evaluated in Malawi, Kenya and Ethiopia. In Malawi an Aplos toolcarrier was tested at Chitedze Research Station in 1969 with seeding and ridging attachments. It was shown to be effective, but it was not promoted. Instead emphasis was placed on the development of a simple toolbar (Kinsey, 1984). Similar decisions not to promote wheeled toolcarriers were taken positively, or by default, in most eastern African countries, and only Uganda attempted to subsidize and promote them. Wheeled toolcarriers were never adopted by more than a few farmers anywhere in the region (Ahmed and Kinsey, 1984).

3.2.2 Uganda

The development of animal traction in Uganda has been well documented and the equipment innovations in the cotton-millet farming systems in the northern and eastern areas of the country have been reviewed by Kinsey (1984). Ox-cultivation grew rapidly during the period 1900–1930, so that by 1930 the plow was becoming the universal implement for primary tillage in Teso District, and it was spreading into many nearby areas. During the period 1929–1960 there were several attempts to introduce harrows and cultivators but these were generally rejected by farmers as too heavy, too expensive or inappropriate to the local farming systems (Kinsey, 1984).

In 1960 and 1961 prototypes of the NIAE designed wheeled toolcarrier were tested in Uganda (Chalmers and Marsden, 1962) but these were considered heavy and difficult to adjust (A. Akou, personal communication, 1986). French manufactured Polyculteurs and later Tropiculteurs were also imported and, following two years of tests from 1960 to 1962, officers at the Serere Research Station in Teso concluded that the Polyculteur was the preferred design. The Tropiculteur designer Jean Nolle undertook a consultancy mission in Uganda in 1963 and redesigned a mouldboard plow for the Tropiculteur suitable for plowing land covered with the difficult grass *Imperata cylin-*

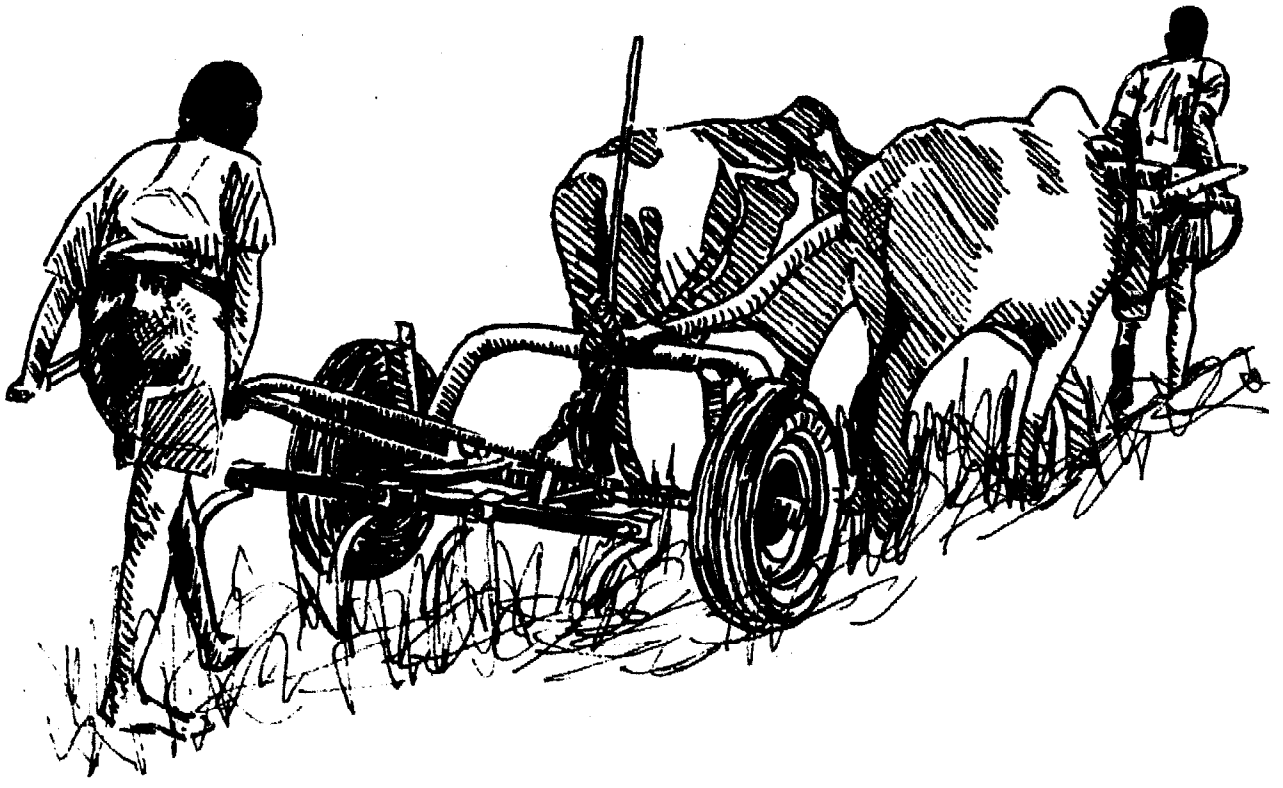


Fig. 3-6: Polyculteur being demonstrated to farmers in Uganda c. 1969. (Based on photo: A.D.R. Ker).

drica. Tropiculteurs were distributed to the sixteen district farm institutes. In 1965 some Aplos toolcarriers based on the NIAE design were imported, but they were still considered "heavy" (Akou, 1986).

From 1962 to 1968 comparative trials in which tractor operations were compared with a range of ox-powered implements were carried out on the farm of the Arapai Agricultural College near Soroti in eastern Uganda. For six years Polyculteurs were in use daily for cultivation (weeding and seeding) or transport on the college farm and in 1964 they were used to weed forty hectares of crops. A report concluded: "Despite this hard and continuous use over six years, apart from replacing the wooden cart bodies occasionally, maintaining tyre pressures, and mending a few punctures, the Polyculteurs are almost as good as new. Their designer should be congratulated on the success of this implement." (Ker, 1973).

The Polyculteur had a fixed 1.3 metre wheel track and was difficult to use for plowing and ridging. It was used mainly for weeding, seeding and transport and work at Serere led to the following observations on it: "One disadvantage is that it cannot plough. Secondly, as it has low clearance, it is limited to weeding only crops at early stages. But for transport alone this tool is much better than the Tropiculteur. It has the best toolbar for sowing with seeders attached, as it is a steerable toolbar." (Akou, 1975).

The Tropiculteur package was about twice the price of the Polyculteur and was tested in several locations. At Arapai it was concluded that its additional cost was not justified, while at Serere its versatility was particularly appreciated, for with its high-clearance chassis it could be used for the spraying of cotton. The cheaper intermediate Ariana toolframe was also assessed, but at Arapai it was found to be difficult to control for planting and inter-row weeding, and since it was expensive compared with single purpose implements, it was concluded that its usefulness was limited (Ker, 1973). Work at Serere led to the conclusion that while the Ariana was a versatile and relatively simple and cheap implement, a farmer beginning with animal traction should use a simple

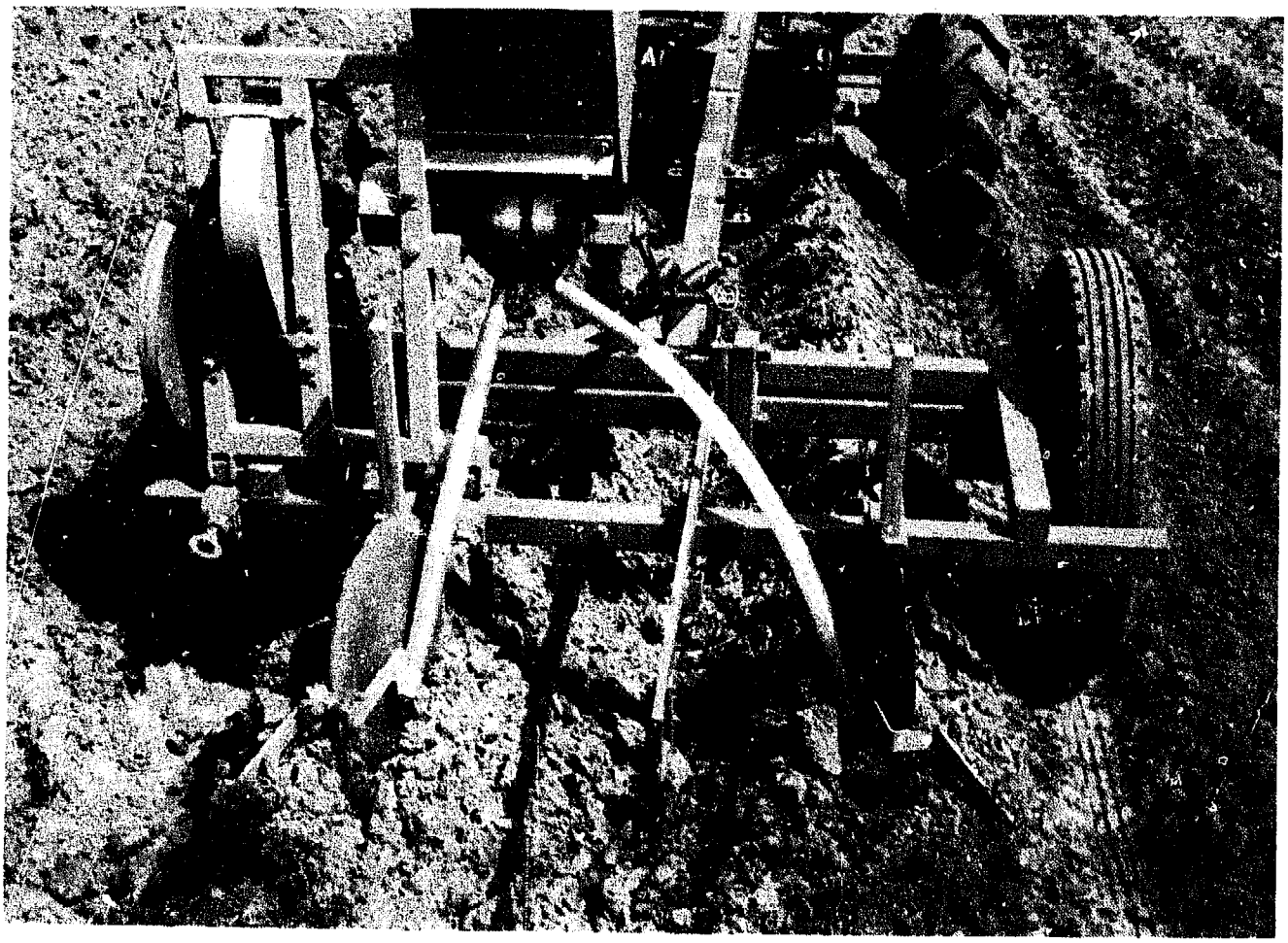
plow and cultivator and later progress to a Tropiculteur or Polyculteur (Akou, 1975).
From 1962, the Polyculteur and Tropicultor were actively promoted by the Department of Agriculture and were eligible for 50% price subsidies. Kinsey (1976) noted that the government subsidy element on each wheeled toolcarrier was equivalent in value to the cost of ten simple plows. The 50% subsidy continued for over a decade, and was still in operation in 1973/1974 (Akou, 1975). However, while single purpose implements, either unsubsidized or with a much lower rate of subsidy, continued to be purchased in significant numbers, very few toolcarriers were ever sold. Of the sixty implements purchased about thirty went to progressive farmers, while thirty went to local politicians and dignitaries (Akou, 1986). The 1965 Northern Region Annual Report put the number of privately owned Polyculteurs in the region at twenty. Hunt (1975) followed up the progress of five farmers who had received loans to buy Polyculteurs in 1963 and 1964 and found that by 1966 two were not in use at all, the reasons being given as lack of trained animals, difficulty in using the implements on land with some stumps, and lack of extension advice on how to assemble and operate the equipment. Three wheeled toolcarriers were still in use, but they were used for very few operations and they had made no obvious impact on timeliness, area cultivated or labour substitution of the farmers using them (Hunt, 1975). By 1971, when a survey was carried out of 67 farms selected by extension workers as "progressive", it was found that while there were an average of 1.7 conventional plows per farm in the survey, no wheeled toolcarriers were in use (Kinsey, 1984).
In the early 1970s the Department of Agricultural Engineering of the Makerere University made its own wheeled toolcarrier based on the NIAE design (Ker, 1973), but this did not progress beyond the prototype stage. Thus, while wheeled toolcarriers were proven to be very effective on-station in Uganda, and while they were promoted for many years with generous subsidies, they did not pass the test of farmer adoption in Uganda.

3.3 The Gambia

In the early 1960s, interest in the newly developed wheeled toolcarriers spread from neighbouring Senegal to The Gambia. Six French-manufactured "Polyculteur" units were tested at ox-plowing schools in the early 1960s (Davidson, 1964). At about the same time the British National Institute of Agricultural Engineering (NIAE) had been testing its own Animal-Drawn Toolbar in Tanzania and Uganda (Chalmers and Marsden, 1962; Willcocks, 1969). Britain was the major bilateral aid donor to The Gambia during the 1960s and from 1965 to 1975, with funding from the British Overseas Development Administration (ODA/ODM), there was close collaboration between NIAE and the Department of Agriculture in The Gambia. The history of this initiative has been well reviewed (Peacock et al., 1967; Matthews and Pullen, 1974; Mettrick, 1978; Kemp, 1978; Cham, 1979).
Between 1965 and 1973 the Gambian Department of Agriculture, with technical advice from NIAE, actively promoted the use of the NIAE Animal-Drawn Toolbar, manufactured under the name of *Aplos*, and its derivative the *Xplos*. These toolcarriers had a steel chassis, pneumatic tyres and a wooden drawbar. The models imported into The Gambia were relatively simple and had fixed axles without adjustments for height or width, although a more expensive adjustable version was available (Willcocks, 1969). As with the Nolle-designed equipment these toolcarriers could be converted for use as carts.

Fig. 3-7: NIAE wheeled toolcarriers being assembled in The Gambia, 1968. (Photo: AFRC-Engineering archives).

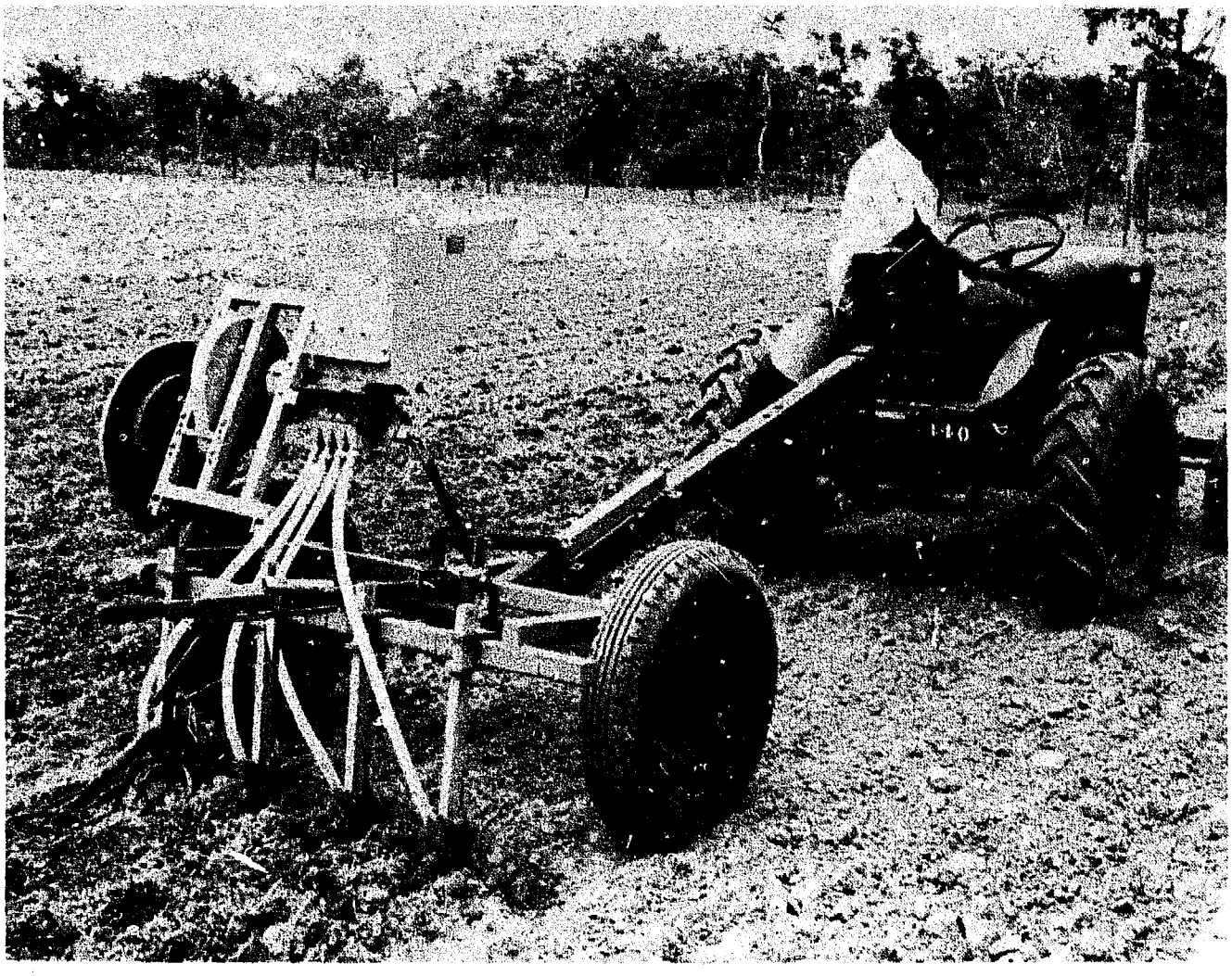
Fig. 3-8: NIAE wheeled toolcarrier with prototype roller planter and disc openers, The Gambia, 1968. (Photo: AFRC-Engineering archives).



It appears that few (if any) trials were conducted with these implements and no programmes were undertaken to identify suitable cultivation systems in which they could be employed (Kemp, 1978). The main justification for their introduction appears to have been the concept of a "mechanical ladder", in which they represented a stage between simple animal-powered implements and small tractors. However the logic of this ladder was subsequently questioned by Mettrick and his co-authors in their evaluation of the scheme (Mettrick, 1978).

By 1966, the Department of Agriculture had distributed 300 sets of Aplos wheeled toolcarriers throughout the country. The package comprised the toolcarrier complete with plow, weeder, ridger and cart body, and they were sold at the subsidized price of £ 66. Already by 1966 some problems were apparent and were identified during a survey carried out by Wye College (University of London) to gauge the effect of the work oxen training programme of the Mixed Farming Centres (Peacock et al., 1967). 24 out of the 49 compounds studied had bought Aplos wheeled toolcarriers. Of the compounds for which the Aplos was the only type of animal traction equipment, one third did not use it for plowing and two thirds did not use it for weeding. In compounds in which alternative implements were available, the utilization was much lower, with only 54% using the Aplos for plowing and only 20% using it for weeding. Problems with their use included insufficient farmer training in adjustments,

Fig. 3-9: NIAE wheeled toolcarrier with prototype planter being tested with a tractor as surrogate oxen, The Gambia, 1968. (Photo: AFRC-Engineering archives).



the heavy weight and draft of the equipment, and farm land in which the occurrence of stumps made the use of wheeled toolcarriers impracticable.

The observation was made that: "If the Aplos is to be introduced on a large scale throughout the country, then it is essential that the first examples in any area should be used successfully. Considerable damage is being done to the reputation of the Aplos by the *high proportion presently lying unused.* Every effort should be made to get the Aplos working efficiently so that farmers can see the advantages of this type of plough. This means that the Aplos should only be sold to trainees who have sufficient knowledge of how to use the plough properly and land suitable for cultivation by the Aplos. This will mean considerable reduction in the volume of sales over the next few years, but eventually a demand will be created *rather than sales being forced, as at present.*" (Peacock et al., 1967, *emphasis added.*)

It is not clear what influence, if any, this report had on the authorities in The Gambia. Apparently the British Ministry for Overseas Development (ODM/ODA) that had been assisting the Gambian Ministry of Agriculture was unhappy with the conclusions of the Wye College team and refused to assist in the publication of its report (J.M. Peacock, personal communication, 1986). Certainly the active promotion continued for several more years, and a total of 900 units (worth about one million US dollars at 1986 prices) were imported into The Gambia before it was concluded that the toolcarriers were inappropriate for Gambian farmers (Mettrick, 1978). Among the major problems was the unsuitability of the toolcarriers for use on land with stumps, due to their limited manoeuvrability, and farmers did not accept that full destumping was beneficial. The implements were too heavy for the N'Dama oxen, particularly if the farmer sat on the seat. Early models had plain steel bearings that rapidly wore out and were expensive to replace, although later models came with sealed roller bearings. Matthews and Pullen (1974) also cited that there had been an inadequate extension and training programme, while Mettrick (1978) noted that even at its subsidised price, it was too expensive. Adjustments to the Aplos required a spanner and were relatively difficult, while the later Xplos model was even more complicated. Although the toolcarriers could act as carts and implements, their cost was comparable to the combined price of a cart *and* a more simple toolbar, and farmers did not like the complication of converting, nor the added risk that one breakage could leave the farmer with neither cart nor plow.

Some of the toolcarriers remained in service for several years, but only as single purpose carts (Cham, 1979). Following the rejection of the wheeled toolcarriers, a range of other equipment was evaluated between 1973 and 1975, and it was recommended that the Gambian Department of Agriculture should standardize on the much cheaper and simpler Houe Sine implement from Senegal (Matthews and Pullen, 1974, 1975, 1976). Since 1974 there has been no further interest in wheeled toolcarriers for The Gambia.

3.4 Botswana

3.4.1 Background

Botswana is a sparsely populated country in southern Africa with a variable semi-arid climate which makes crop production risky and marginal. Since the introduction of animal traction in the nineteenth century, draft animals have become integral components of most farming systems. The combination of climate and soils results in only a few days each year that are suitable for land preparation so that farmers start cultivation as soon as the ground has been softened by the rains.

To achieve the necessary tillage in a short time they use wide mouldboard plows pulled by teams of 6–8 animals, and sometimes as many as 16 cattle (bulls, oxen and cows) are hitched into a single team.

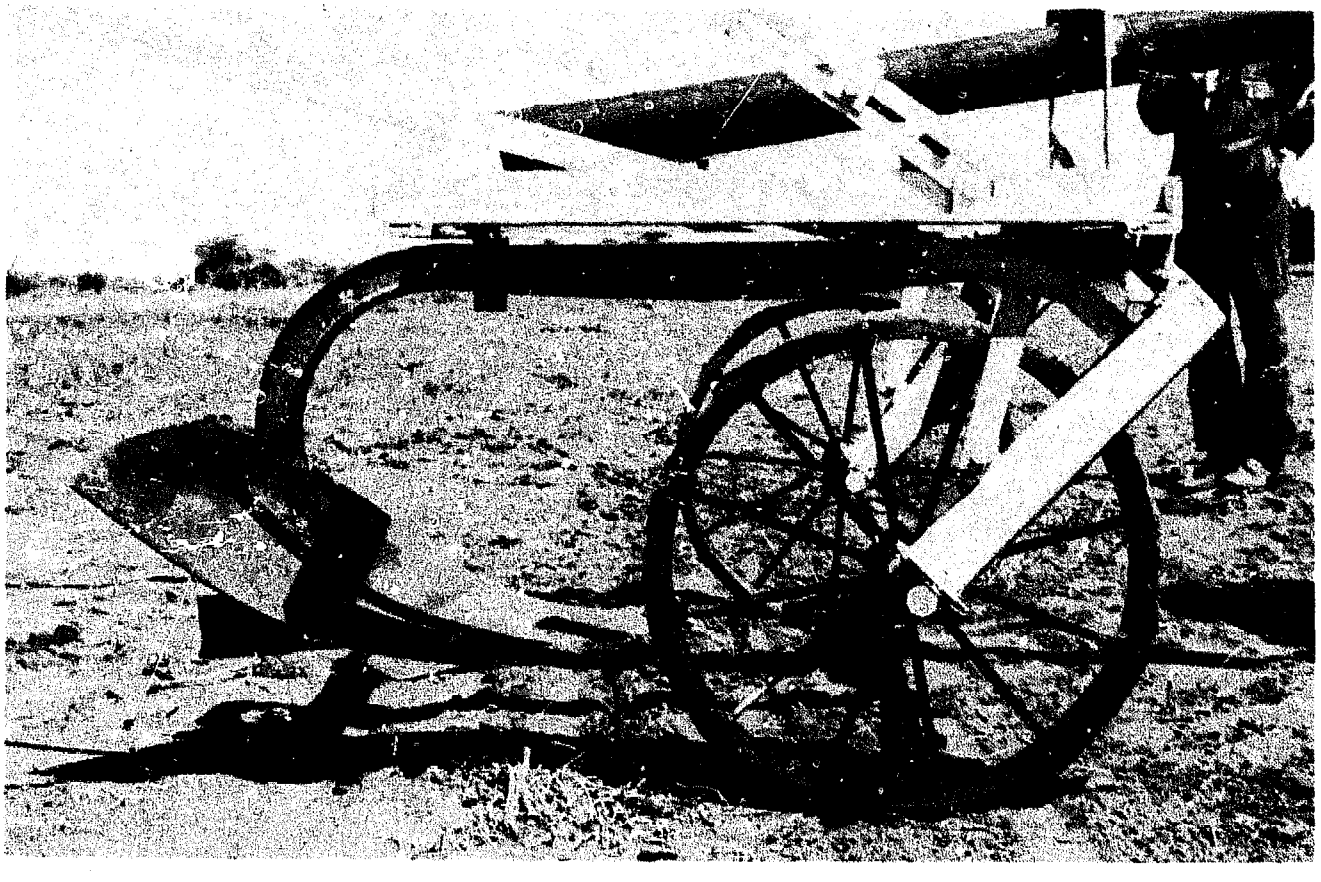
There has been considerable debate as to the necessity for such large teams of draft animals, with farmers arguing that they are technically essential, with additional value as a means of conveying social status. Several researchers over the years have suggested that a system using less power should be employed, particularly as many farmers have insufficient animals to make a full team. During the 1970s wheeled toolcarriers were proposed as the basis for low-draft and minimum tillage systems. However, as will be seen, the numbers of animals required to use wheeled toolcarriers in Botswana was progressively modified upwards from the intended single pair, to teams of 4–6 strong animals, equivalent to the 6–8 indifferent animals commonly used in the "traditional" systems.

The case history of wheeled toolcarrier development in Botswana spans several years, with an enthusiastic phase in the early 1970s, disillusionment in the late 1970s and a brief second period of evaluation in the 1980s. The case is also unusual in that two separate toolcarriers were developed in the same country, in the same period and only a few miles away. Although one project involved several British technical cooperation personnel, the new toolcarrier was not based on the earlier NIAE design.

3.4.2 The Makgonatsotlhe

The first, and more successful, toolcarrier initiative in Botswana was started by the Mochudi Farmers Brigade, a project of the Kgatleng Development Board, a non-govern-

Fig. 3-10: Early prototype of Mochudi toolcarrier "Makgonatsotlhe", Botswana c. 1971. (Photo: Eric Rempel).



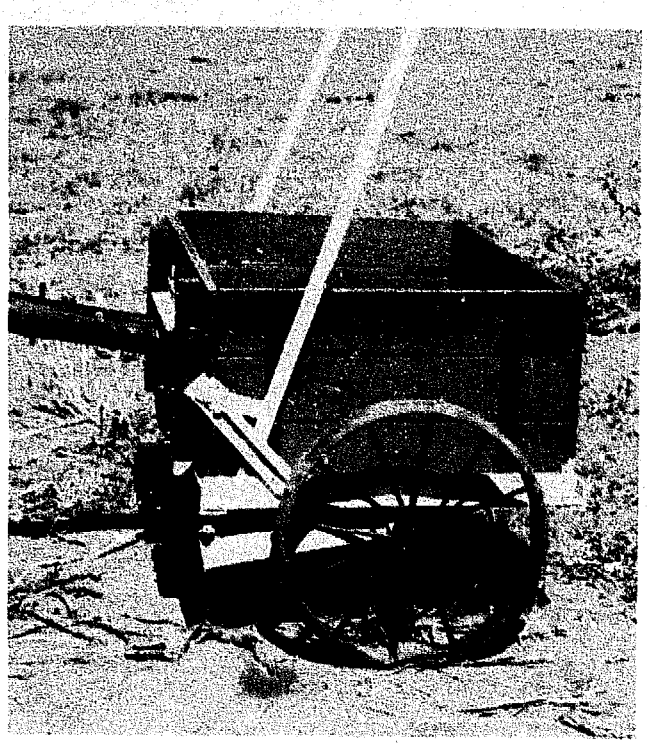
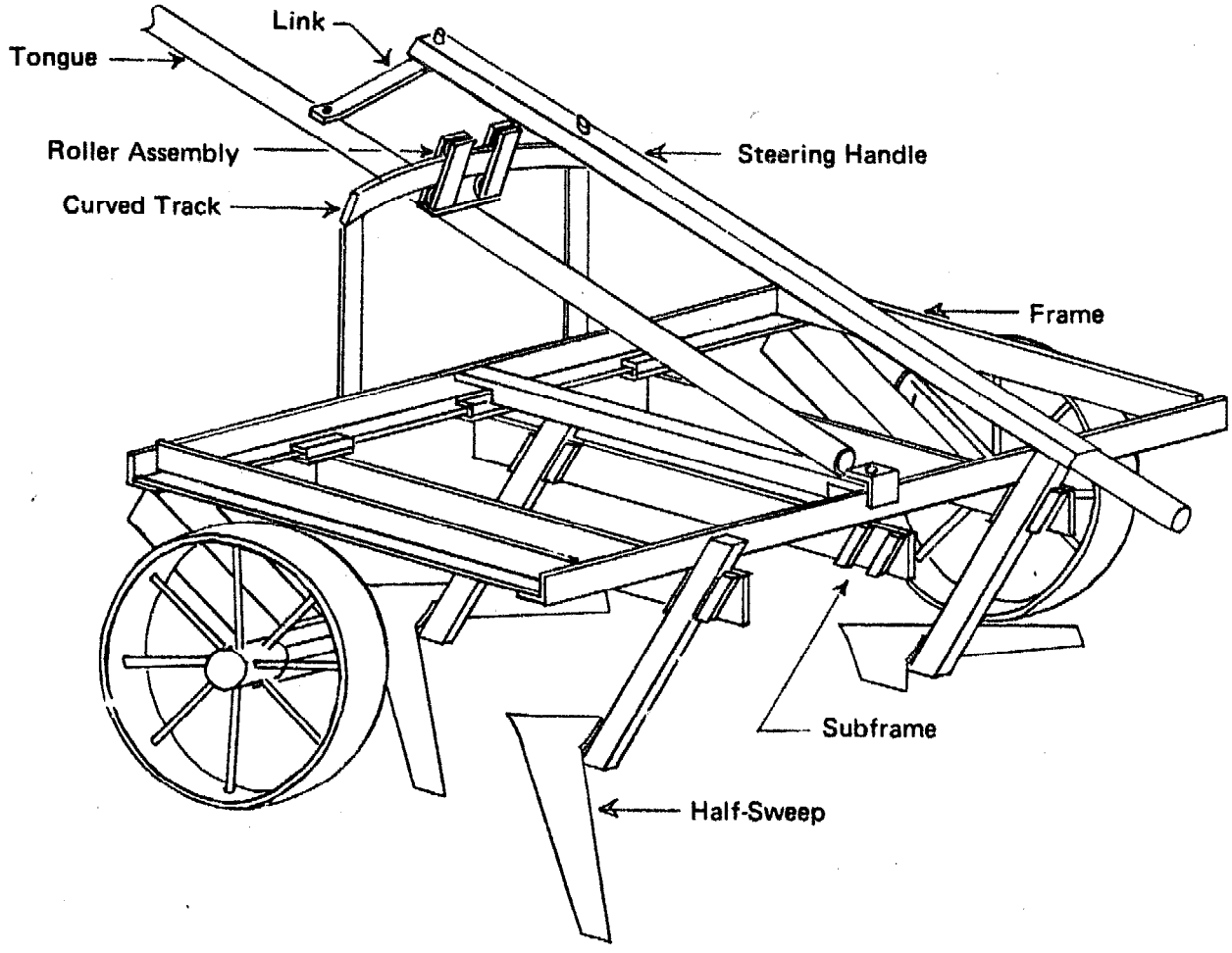


Fig. 3-11: Early prototype of Mochudi toolcarrier "Makgonatsotlhe", fitted with cart, Botswana c. 1971. (Photo: Eric Rempel).

mental development agency. Work began on the Mochudi toolcarrier in 1971 with assistance from Oxfam and the Mennonite Central Committee. The toolcarrier was intended as part of a drylands minimum tillage system, and the design concept was influenced by the till-plant system developed by the University of Nebraska for the southwestern United States. The minimum tillage was considered important to overcome the problem of draft power since less wealthy farmers owning only four cattle or a few donkeys sometimes did not cultivate at all due to their perceived shortage of draft power. Thus the Mochudi toolcarrier was designed to be pulled by just one pair of animals. The relatively high cost of the implement for such farmers was justified by the supposition that farmers owning a few cattle would be able to afford the implement by selling the oxen that would be made redun-

Fig. 3-12: Drawing of Mochudi toolcarrier "Makgonatsotlhe" (Eshleman, 1975).



dant by the low draft technology (E. Rempel, personal communication, 1986).

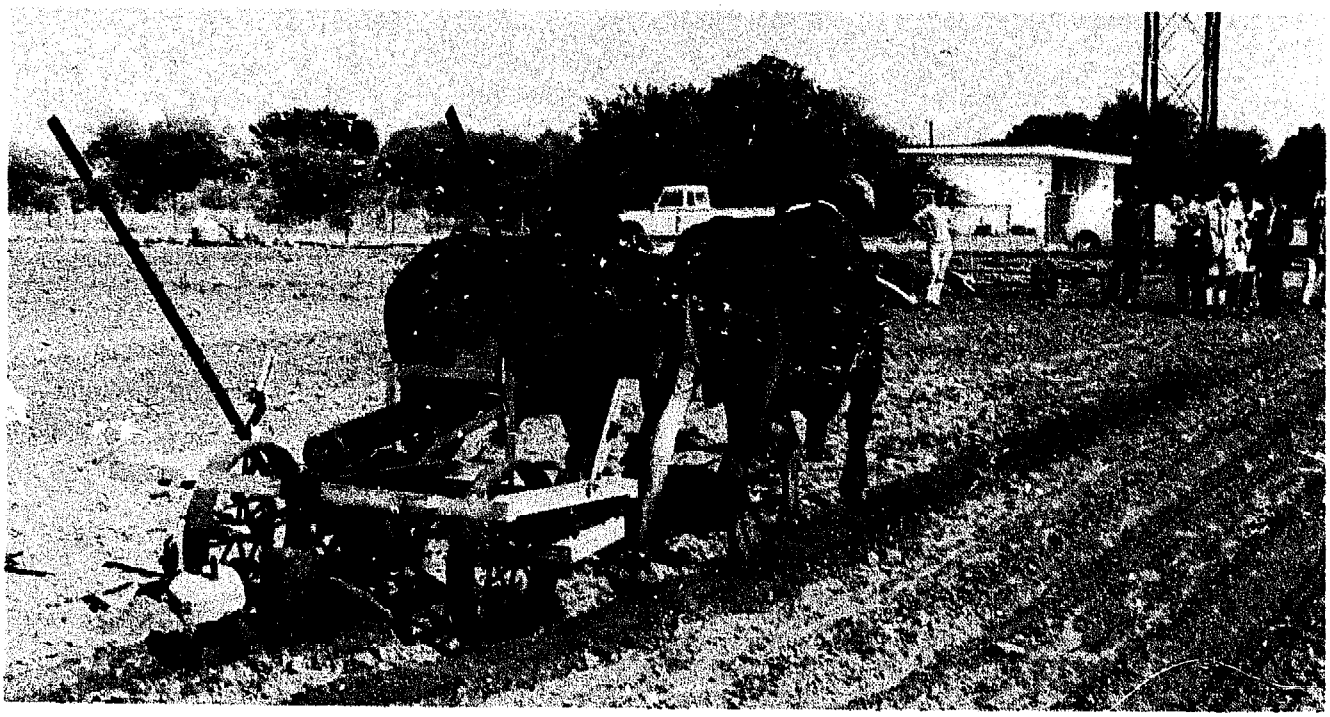
The Mochudi toolcarrier comprised a rectangular chassis of heavy angle iron, with independently mounted wheels. The stub axles were reversible so that the wheels could be mounted inwards (to give a narrow track) or outwards. In early prototypes metal wheels were used, but pneumatic tyres became standard. Onto the chassis was bolted a subframe that could take one or two seeders (of a design from Texas), fertilizer applicators, weeding sweeps, disc hillers for earthing maize, and subsoiling tines. The frame could also be used to support the standard mouldboard plows widely used by farmers, although plowing was not an element of the minimum tillage system for which the toolcarrier was initially designed. The chassis could hold two 200 litre drums for water transport, and an expanded metal cart body could also be bolted to the frame (Mochudi, 1975; EFSAIP, 1977).

The Mochudi toolcarrier was launched in 1973 with the name *Makgonatsotlhe* or *the machine that can do everything.* After further testing, the Makgonatsotlhe was "perfected" in 1975 and medium-scale production from imported components and steel was started at a special workshop at Mochudi (Eshleman, 1975). Using the toolbar and the tine cultivation system, it was claimed that erosion would be reduced and ground moisture would be conserved through mulching, that weeds would be better controlled with the sweeps and disc hillers, and that germination, seed survival and fertilizer effects would be higher through use of the seeder and fertilizer applicator.

From 1975 to 1978 some 125 toolcarriers were manufactured, of which 72 were bought for testing by various government agencies. The Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP) carried out both on-station and on-farm evaluation of the Makgonatsotlhe from 1977 to 1984, and monitored the progress of farmers and farmers' groups who had purchased the toolcarriers or to whom they had been lent by government agencies.

Some initial design problems were identified by EFSAIP including weak chassis and wheel arm construction, drawbar breakages, and

Fig. 3-13: On-station demonstration of Mochudi toolcarrier, Botswana c. 1974. (Photo: FMDU archives).



inaccurate operation of the seeders and fertilizer applicators, and the Mochudi workshop took action to rectify these problems (EFSAIP, 1977). The use of second-hand tyres was discontinued as repeated punctures made this a false economy (EFSAIP, 1980). While designed as an implement of low draft requirement, the number of animals actually used to pull the Makgonatsotlhe toolcarrier tended to increase. For row work it was initially suggested that no more than two oxen be used, in conjunction with a single seeder and fertilizer applicator. Double seeders and fertilizer applicators required the use of four oxen, but with four animals accurate control of row spacing become difficult (Eshleman, 1975). For mouldboard plowing with an 8" share the power of at least four oxen was required. However the EFSAIP team found that the power requirements of sweeping under field conditions were also much greater than first imagined. Blockages of the sweeps with weeds (notably *Ananthospermum hispidum* and *Cynodon dactylon*) became a major problem (D. Horspool, personal communication, 1986) and farmers had to use six animals to pull the toolcarriers fitted with tines. Farmers often found it necessary to pass more than once to obtain a satisfactory seedbed and observing increasing weed problems farmers owning toolcarriers returned to traditional mouldboard plowing using large teams of 6–8 animals and often single purpose implements (Farrington and Riches, 1983).

3.4.3 The Versatool

Another initiative involving both minimum tillage concepts and wheeled toolcarriers was carried out by staff of the Dryland Farming Research Project from 1971 to 1974. This was a Government of Botswana project, supported by the British Overseas Development Administration (ODA). The British National Institute of Agricultural Engineering (NIAE) had no direct involvement in this toolcarrier initiative (D. Kemp, personal communication, 1987). The project investigated options for improving systems of crop production and the research team concluded that the existing animal-drawn equipment was inadequate, often unsuitable for the conditions of Botswana and of poor design. The researchers found that the conventional mouldboard plows covered the ground slowly and encouraged excessive water loss, and considered that implements such as chisels, sweeps, planters with press wheels and flat-bladed, inter-row hoes were "an essential prerequisite for the successful introduction of an improved crop production system" (Gibbon, Harvey and Hubbard, 1974).

Although they were aware of the Mochudi toolcarrier development work, and there was close liaison with the Mochudi Farmers Brigade, the Dryland Farming Research team designed and constructed their own wheeled toolcarrier named *The Versatool* (Hubbard, Harvey and Gibbon, 1974). This comprised a rectangular chassis made of box section steel, to which were welded stub axles, adjustable for frame height but not track width. The wheels were fitted with pneumatic tyres. Inside the chassis was suspended a hinged angle iron frame on to which implements could be bolted. The hinging allowed the subframe and tools to be raised by a long lever, and this could be useful at the end of a row, or for transport to the field. The Versatool could carry chisel plows, cultivation sweeps, subsoiler tines, and twin seeders or fertilizer applicators. The implement was drawn by a pair of oxen, and the system was designed to allow contour cultivation. Like other toolcarriers it could be modified to carry water drums or a cart body, although, as with the Mochudi toolcarrier, there was no provision for a driver's seat.

Fig. 3-14: Versatool demonstration, Sebele Research Station, Botswana, 1973. (Photo: FMDU archives).

3.4.4 The Versatool minimum tillage system

Following the on-station development of the Dryland Farming Research Project, it was concluded that the use of the Versatool toolcarrier could overcome two major problems. The first was inadequate availability of draft animals to form the very large teams traditionally used to pull large mouldboard plows. The second problem that could be overcome was the difficulty that farmers experienced in efficiently weeding crops that had been broadcast. Economic analyses suggested that the Versatool could be used on farms of about 10 ha, while allowing farmers to cover all costs, and in most years leave a cash surplus. As the median area of cleared land per farmer in Botswana was 9 ha, it was felt that many farmers would be able to use their own units, but it was also considered feasible for two farmers each with 6 ha to share one Versatool (Gibbon et al., 1974).

At the end of this first research phase, a memorandum was drawn up in 1974 between the Botswana Government and the British ODA defining the objectives of a follow-up programme, the Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP). One of the major objectives was: "To establish the advantages of using an animal draught minimum tillage crop production system, including the DLFRS 1 toolcarrier, over present and alternative systems." (EFSAIP, 1981).

Consequently members of the research team that started the EFSAIP Animal Draught Systems Study in 1976 did not initially feel that they had been given an open ended re-

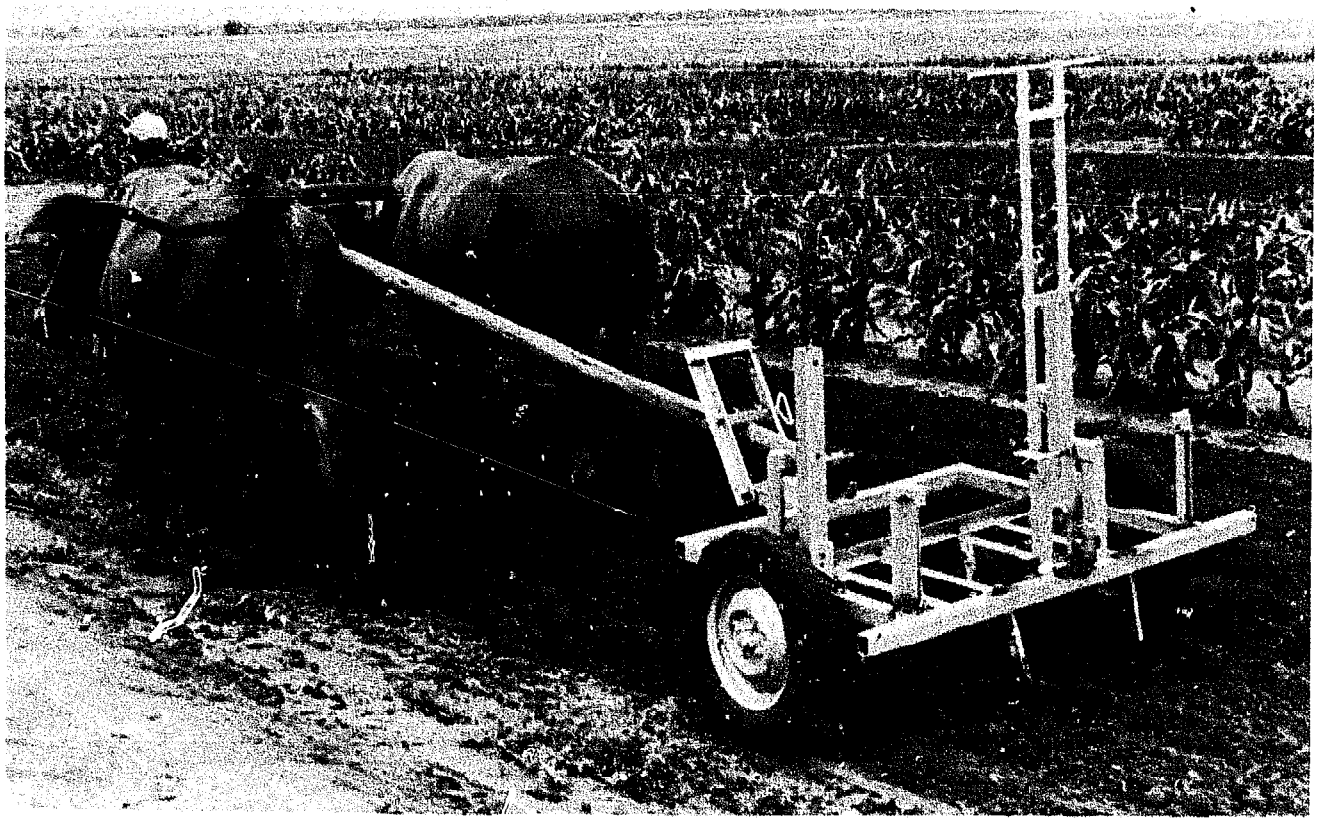
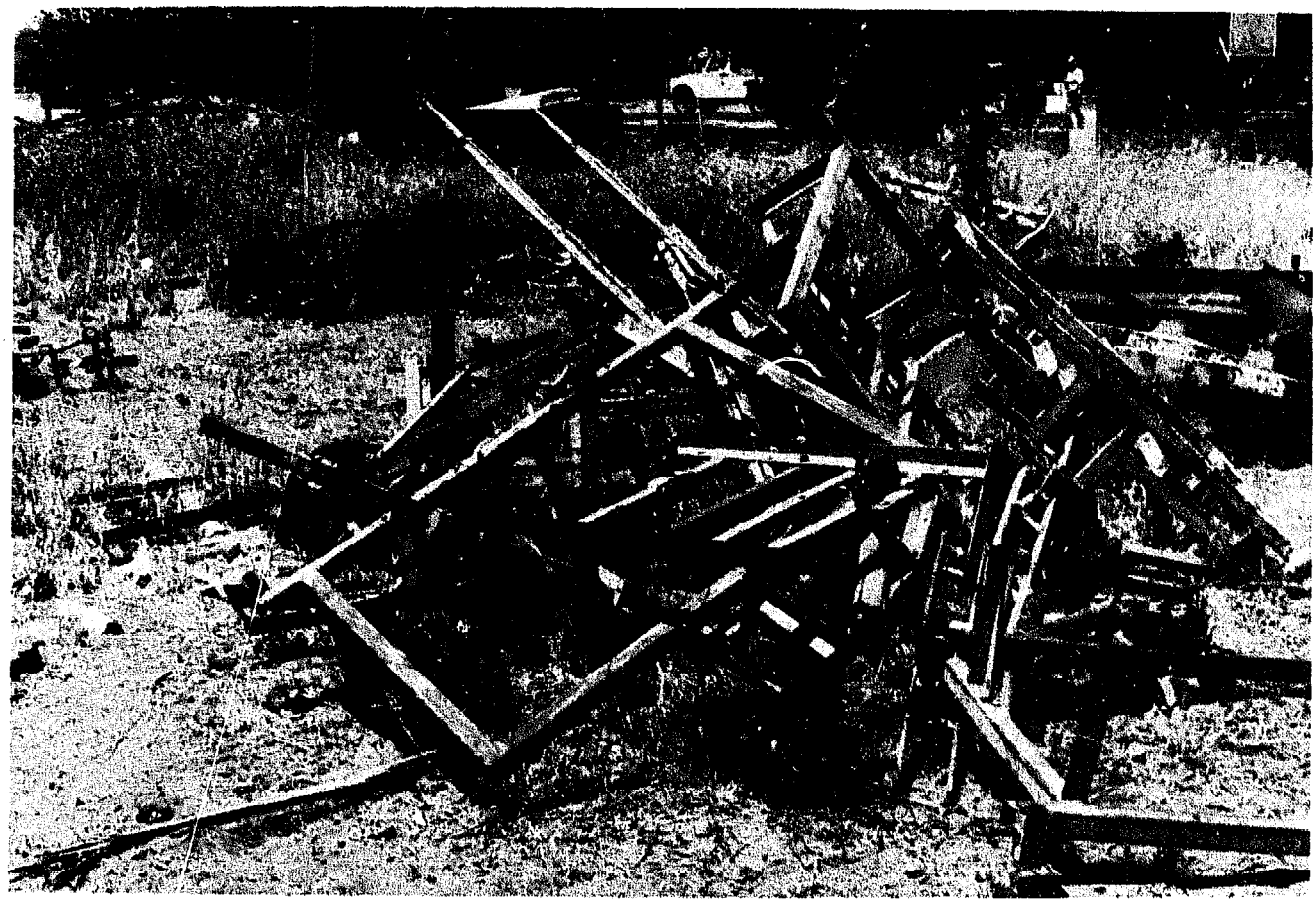


Fig. 3-15: Versatool with sweeping tines at Sebele Research Station, Botswana, 1973. (Photo: FMDU archives).

Fig. 3-16: Graveyard of Versatool frames and components at Sebele Research Station, Botswana, 1987. (Photo: FMDU).



search mandate. There was an apparent need to prove through on-farm trials that the DLFRS 1 (Versatool) system developed on station was indeed better than present and alternative systems.

In fact, despite the original project objectives, work with the Versatool was discontinued after just one season in favour of the Mochudi Makgonatsotlhe. At least ten Versatools had been made for evaluation, but once it had been decided to work only with the Mochudi toolcarrier they were naturally put to one side. Here they formed an example of what was to become an increasingly common sight in developing countries, a *toolcarrier graveyard*, which (like many others) could still be seen in 1987.

The Versatool was rejected owing to overall quality considerations, inferior performance of the sweeps, seeders and fertilizer applicators, and difficulties associated with trash clearance and in raising the tools (EFSAIP, 1977; EFSAIP, 1984). Through their programme of on-farm trials EFSAIP found the cultivation system devised in conjunction with the Versatool involved too many operations with high draft requirements and labour inputs, and that these were unacceptable in view of the associated low yields and poor crop stands. Post-harvest sweeping, an integral part of the system, was found impractical due to blockage by weeds and stover. Using the Versatool, three passes with 2–4 large oxen were required to achieve the post-harvest autumn chisel plowing, and combined subsoiling and fertilizer application was found impossible with small numbers of animals in hard soil. Great difficulty was experienced in getting oxen to follow the same indistinct lines for "precision strip" minimum tillage, planting and fertilizer placement operations before crop emergence (EFSAIP, 1977; 1981; 1984).

Essentially the new cultivation system had worked under the high management, research conditions in clean and relatively light soils of the research station, but was difficult to apply on the conditions of the small farms. The conclusion that on-station results may not be directly transferable to on-farm conditions is a common one. However in this case a compounding factor was the short-term horizon of the initial project. The highly variable climate that makes crop cultivation itself problematic, also makes short-term research difficult. For example the weed control techniques with sweeps that were found effective in a relatively dry year proved unsuitable the following year when rainfall stimulated additional weed growth causing implement clogging. It was fortunate that the EFSAIP was of longer duration and was able to gain from the lessons of methodology and timeframe taught by the earlier DLFSR Project.

3.4.5 Toolcarriers, mouldboard plows and plow-planters

Since the various tine-cultivation minimum tillage systems that had been developed had proved inappropriate in on-farm conditions, from 1978 onwards all "improved" systems tested on-farm by EFSAIP were based on mouldboard plowing rather than tine cultivation (EFSAIP, 1978; 1979; 1980). When fitted with a mouldboard plow and improved planter, the Mochudi toolcarrier performed well in on-farm trials, and although its routine production had stopped at this time, estimates of replacement costs were made to allow economic comparisons of its use. This showed that average returns to the toolcarrier use were high, particularly for growing sorghum, and could be very high, but some of the lowest returns also came from the toolcarrier users. The single purpose planters and the combined plow-planter also performed well, and these were much cheaper and simpler to set up and adjust. The overall conclusion was that farmers could substanti-

Fig. 3-17: Mochudi toolcarrier "Makgonatsotlhe" pulled by six oxen in an attempt at post-harvest sweeping during on-farm evaluation, Botswana, 1977. (Photo: FMDU archives).

ally improve yields and income over traditional methods using a plow-planter that required much lower capital investment and lower overall risk than that of the Mochudi toolcarrier. Thus it was the lack of clear economic benefits to justify the very high costs and the complexity that led the research team and Ministry to reject the toolcarrier (EFSAIP, 1981; 1982; 1984).

Despite the obvious enthusiasm of the Mochudi Farmers Brigade, displays at agricultural shows and promotion through on-farm demonstrations in which over seventy units were placed in farmer service and maintained by the Ministry of Agriculture, the Mochudi toolcarrier had not been adopted by farmers on any large scale. Notwithstanding the existence of subsidies and credit only 24 toolcarriers were ever sold to farmers. Routine production ceased in 1978 and was finally terminated in 1982, leaving significant stocks of components unused, and an operational deficit that made subsequent workshop diversification into other operations difficult. In 1982, the government finally decided to discontinue its toolcarrier extension programme (EFSAIP, 1984). Most toolcarriers loaned to farmers for evaluation were written off the government books and handed over without charge to the farmers. Although showing their age, the majority of the fifteen Mochudi Makgonatsotlhe toolcarriers left with farmers after the EFSAIP on-farm evaluation programme were still in service in 1987. However they were used only as ox-carts or donkey carts and never for cultivation (D. Horspool, personal communication, 1987).

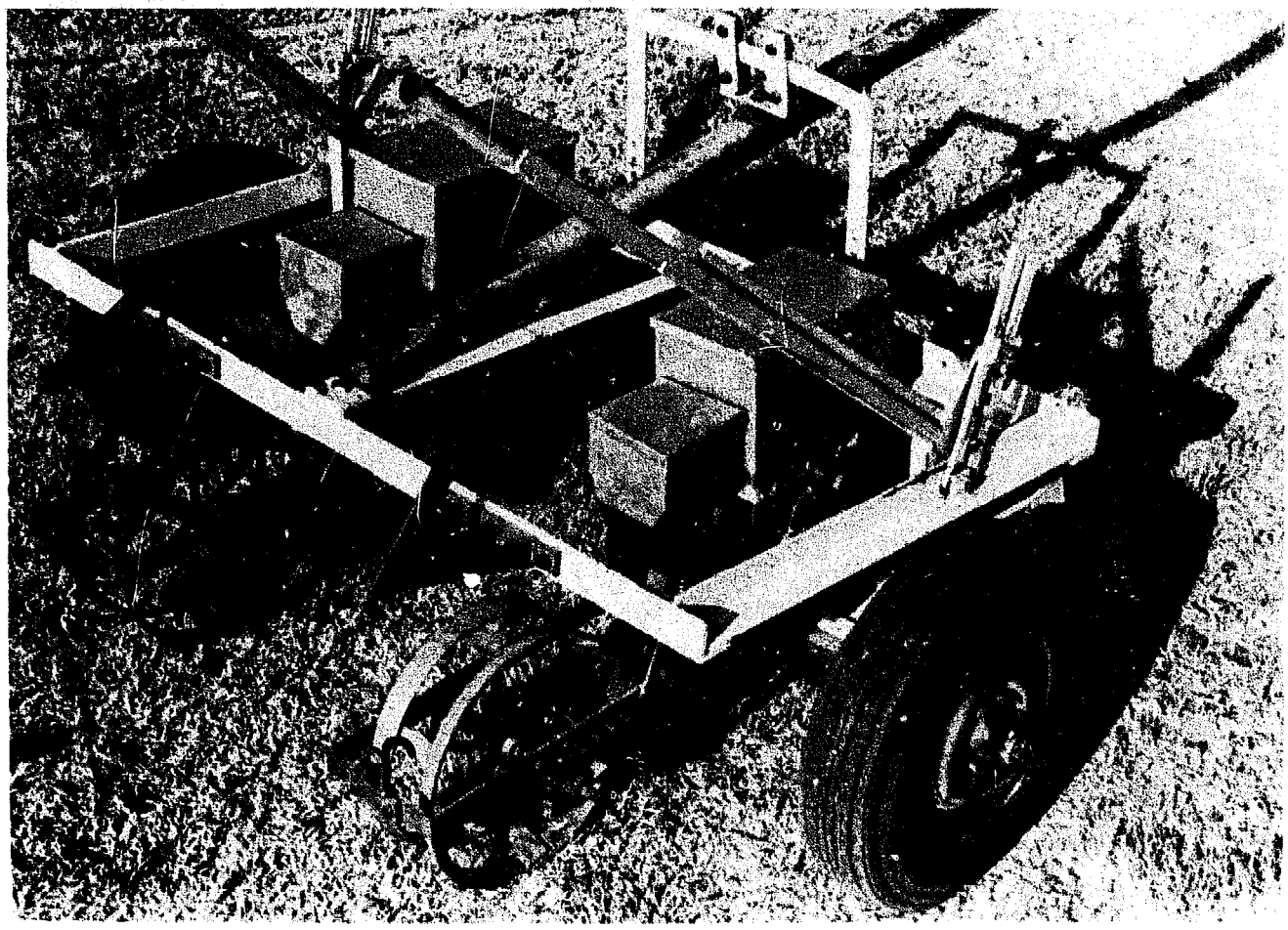


Fig. 3-18: Mochudi toolcarrier fitted with EFSAIP planter and fertilizer units, Botswana, 1980. (Photo: FMDU archives).

3.4.6 Further on-station trials

As will be briefly described in Chapter 5, subsequent research on toolcarriers in Botswana has involved only small-scale on-station trials to evaluate cultivation systems developed at ICRISAT in India. A modified Mochudi toolcarrier and very small numbers of British-manufactured GOM Toolcarriers (Nikart type) and French-manufactured Tropicultors have been used and have given variable results (EFSAIP, 1984). Toolcarrier performance has been generally acceptable, although for technical or traditional reasons four or six oxen were used for plowing and cultivation with toolcarriers. It was concluded that the broadbed system using wheeled toolcarriers had not been proved appropriate to needs and conditions of the small farms in Botswana.

Thus there have now been fifteen years of well-documented research and development on wheeled toolcarriers in Botswana, during which time several different designs have been proved capable of working on station. However the toolcarriers have been rejected by both farmers and research workers due to their cost, their heavy weight, and the inconvenience of changing operational modes. Most importantly for each operation that could be performed by the toolcarriers there were simpler implements capable of performing the operation at least as well as wheeled toolcarriers. Thus future animal traction equipment research and development will concentrate on less costly imple-

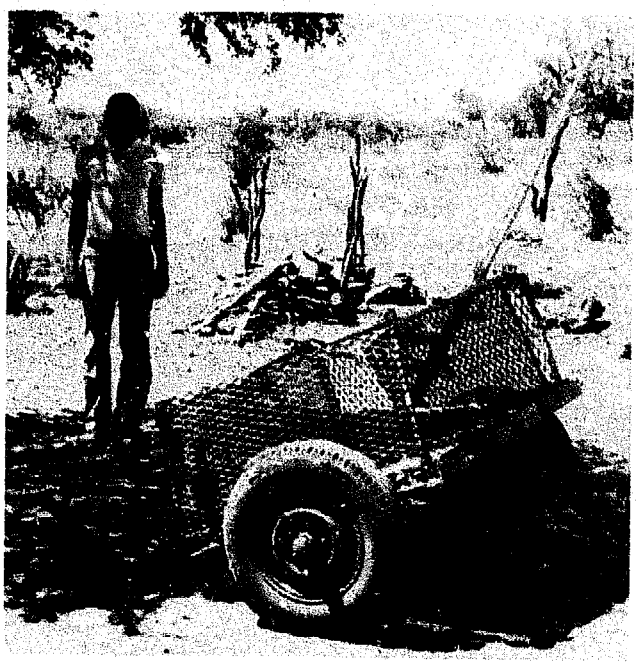


Fig. 3-19: One of the remaining Mochudi toolcarriers, now used only as a cart in Botswana, 1987. (Photo: FMDU).

ments such as a seeder attached to a simple mouldboard plow and there are no further plans to promote wheeled toolcarriers in Botswana (D. Horspool, personal communication, 1986).

3.4.7 Sudan

As a footnote to the Botswana experience it can be recorded that two of the team that had designed the Versatool subsequently worked in an agricultural development project in the Sudan. In 1975 and 1976 they and their colleagues worked on another toolcarrier, the *Atulba Toolbar* (Gibbon, Heslop and Harvey, 1983). The Atulba toolbar was a derivative of the Versatool experience but

Fig. 3-20: Atulba toolframe (a derivative of the Versatool), Sudan, 1975. (Photo: David Gibbon).

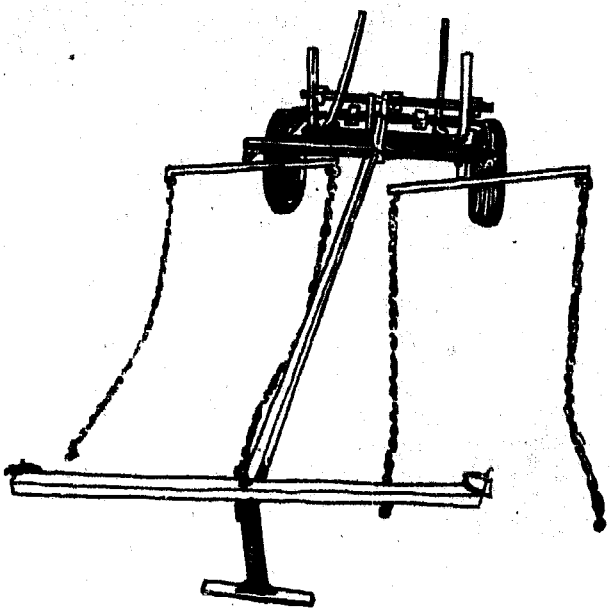


Fig. 3-21: Drawing of University of East Anglia toolcarrier (based on Atulba), with swingle-trees for harnessing.

differed significantly from the Versatool in that it used skids rather than wheels. It was not designed for adaptation for transport use. It had some of the features of an intermediate toolframe but it was heavier than the Ariana intermediate toolframe and was pulled by a draw-pole rather than a chain. The Atulba development did not pass the prototype stage in Sudan, but the design was further developed at the University of East Anglia (UEA) in Britain. On the UEA toolcarrier the skids were replaced with wheels. It was envisaged that the UEA toolcarrier might have applications for small farms in Britain or the tropics but it has not been commercially developed (Barton, Jeanrenaud and Gibbon, 1982).

3.5 Summary of experience in Africa: 1955–1975

The first twenty years of work with wheeled toolcarriers in Africa had been dominated by two designs: Jean Nolle's Polyculteur and the NIAE's animal-drawn toolcarrier. Derivatives of Nolle's designs of wheeled toolcarrier had been promoted in Senegal and several hundred were used by farmers in the 1960s. However it was soon clear to both farmers and the authorities that lighter, cheaper and simpler implements were preferable. Small numbers of Polyculteurs and Tropiculteurs were tested in several African countries, but only in Madagascar and Uganda were they actively promoted. Here also the farmers opted for simpler implements even when they carried lower rates of subsidy. The NIAE toolcarrier had been designed in the U.K. and tested in at least eight African countries, but only in The Gambia was it actively promoted. Large numbers were imported and through credit and subsidies distributed to farmers. However utilization rates were always very low and it was concluded that simpler implements were more appropriate. Several other toolcarrier designs were produced by projects, universities and agricultural engineering units in several parts of Africa. Of two designs produced in Botswana, one was actively promoted, but rejected by farmers in favour of lighter, simpler implements.

In the first twenty years project initiatives had been mainly sponsored by the bilateral aid agencies of France and Britain, with technical support from their agricultural engineers from CEEMAT and NIAE. Experiences were beginning to form a clear pattern of enthusiastic promotion followed by unequivocal rejection in favour of lighter, cheaper and simpler implements. However before the trends emerging in this first phase are discussed it will be interesting to go on to look at the second main phase – the internationalization of wheeled toolcarrier research, development and promotion.