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Animal Traction in Africa

by Peter Munzinger

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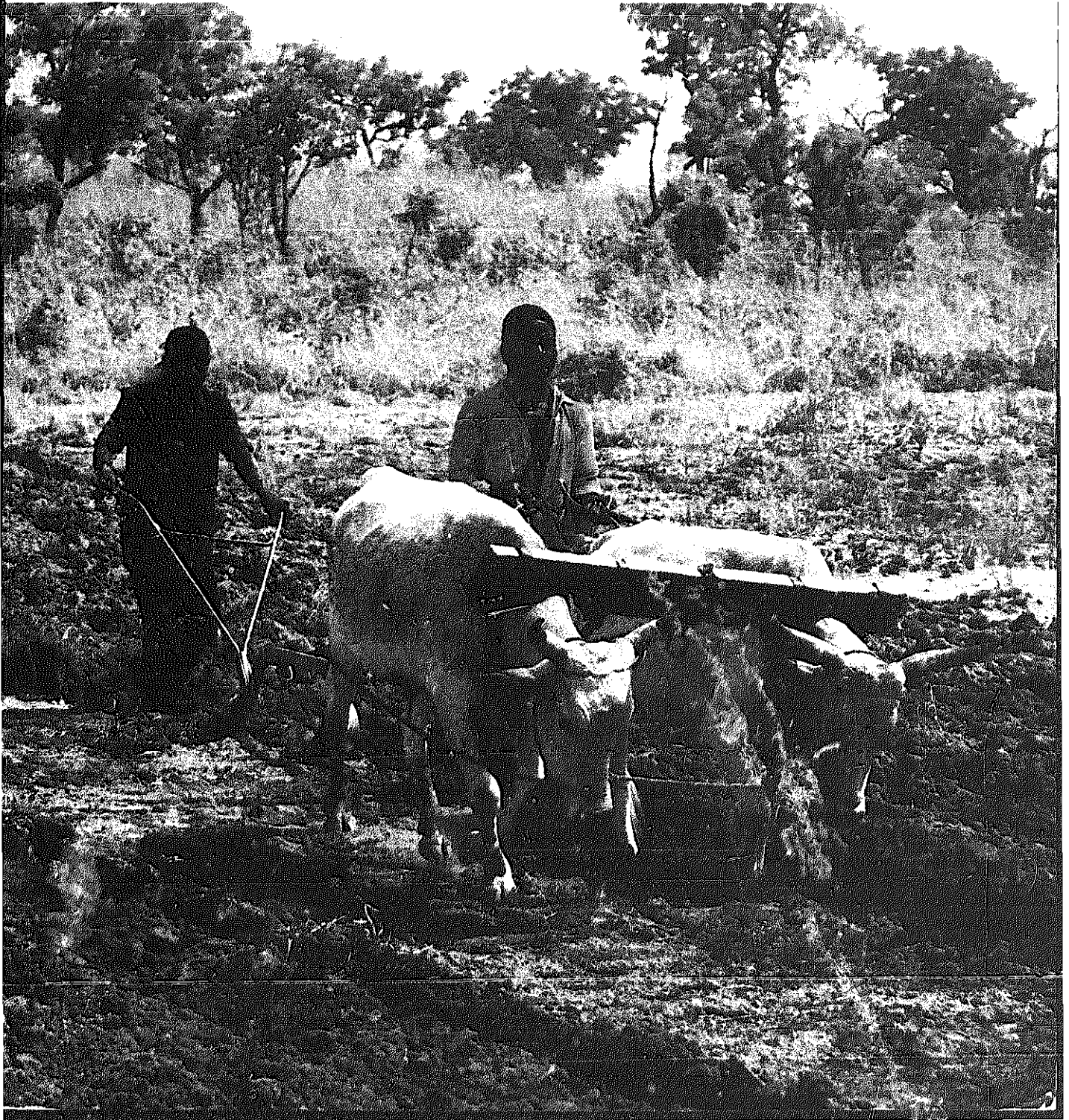
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Animal Traction in Africa



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Compiled and prepared
by Peter Munzinger

Eschborn 1982

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Compiled and
prepared by Peter Munzinger

Technical
editing Christel Rejholec

Translated by Hilary Burgess (Ingenieurbüro für Übersetzungen Dr. W. D. Haehl, Dipl. Ing.)

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CEEMAT, Parc de Tourvoie,
92160 Antony France

Mr. R. L. Bell
Mr. M. D. P. Matthews

National Institute of Agricultural
Engineering (NIAE), Wrest Park, Silsoe,
Bedford MK 45, 4 HS

The authors were assisted and supervised on technical matters principally by:

Prof. Dr. N. Atanasiu

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Finally the authors would like to thank all GTZ staff members both at the head-office and in the field who made a considerable contribution towards the success of this manual with their suggestions, reports and in some cases active assistance.

Preface

Long neglected as a relic of bygone days, animal traction has in recent years gradually reemerged as a topic in development policy and technical discussions.

Since the early sixties, the German Technical Assistance scheme has supported not only the use of draft animals but also the testing, manufacturing and promotion of suitable implements and equipment.

As one of the spiritual fathers of this field, B.H. Doormann (Dipl. Ing.) played an essential part in initiating the production of this manual. However, Mr. Doormann, who died in August 1980, was not able to witness the publication and rebirth of the ideas he so passionately advocated.

Nevertheless, he did live to observe the increasing momentum of his ideas and the willingness of a new generation to provide more than just vocal support for the use of draft animals – this generation was prepared to become actively involved in its promotion wherever feasible.

As a representative of this group, Peter Munzinger invested a great deal of patience, determination, critical expertise and enthusiasm into compiling and editing this manual. We would like to express our special thanks to him and all his co-authors.

There are few tasks more fascinating and rewarding than to contribute to developing and safeguarding an appropriate energy supply to farmers in the Third World.

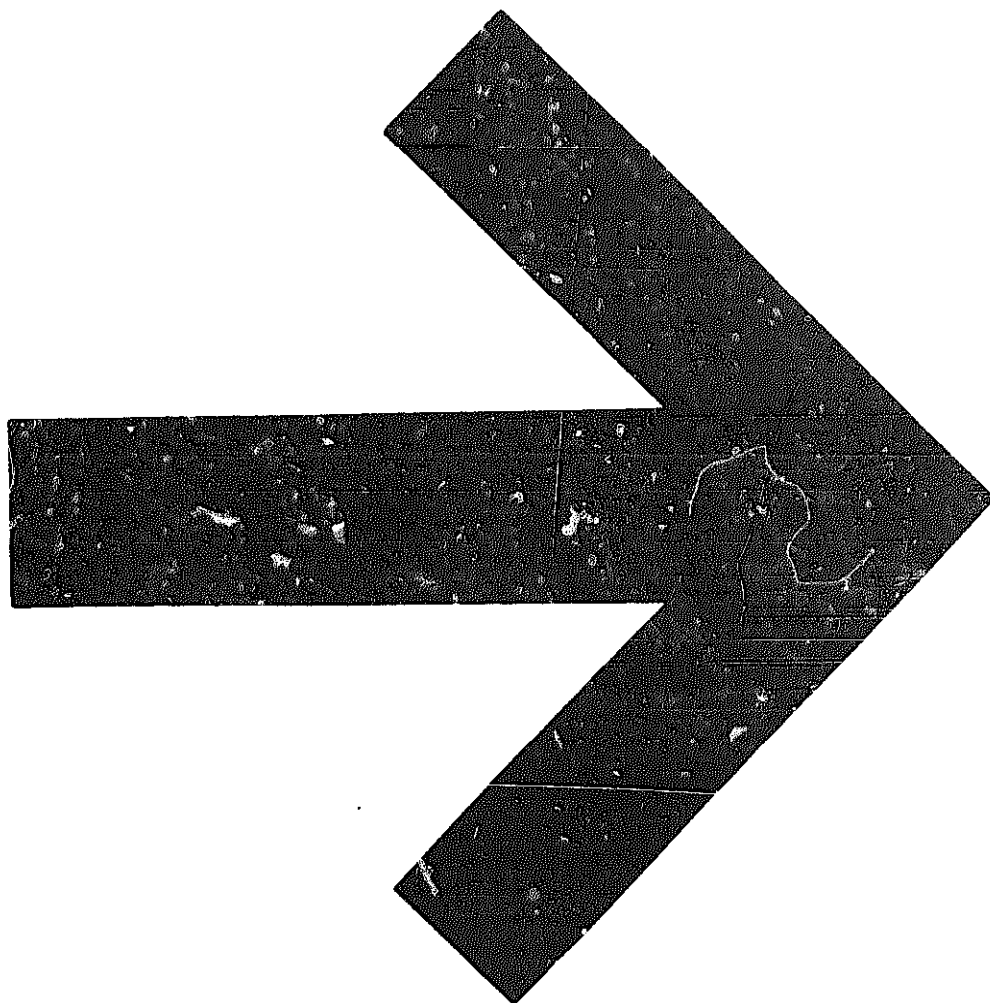
The GTZ series has rarely featured a publication which tackles a long-standing problem in such an up-to-date fashion as this joint venture of the Max-Eyth-Gesellschaft and the GTZ:

The German edition was first published in February 1981, in time for the 75th anniversary of the Max-Eyth-Gesellschaft für Agrartechnik e. V. (MEG) and 145 years after the birth of Max Eyth, the founder of the German Agricultural Society and also the first German promoter of mechanised farming in Africa from 1862 to 1866.

Max Eyth could not anticipate future developments. However, analyzing the past should give us more insight and foresight and oblige us to plan for a future which is not geared to the ruthless exploitation of resources but fosters their sustained equilibrium.

February 1982

Klaus J. Lampe



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Preliminary remarks

The use of animal traction power – which is to a very large extent a renewable energy source – will in the future continue to be of enormous importance for many agricultural holdings in Africa and its significance will probably increase still further. This hypothesis is supported in particular by the permanent worldwide shortage of fossil energies, for the resultant increase in the cost of conventional types of energy is already having disastrous consequences for some African countries.

The severe population pressure means that there is a need for measures to intensify agricultural production and the spread of the use of draught animals, in combination with suitable implements, must be regarded as an entirely suitable form of modernization. In many cases it is this which facilitates the only economically practical form of agricultural mechanization.

The major objective of this book is therefore to provide information on questions concerning the use of draught animals under African conditions. It is aimed at the specialists and development planners working for national and international development cooperation organizations and dealing with the use of draught animals in Africa or other parts of the world. The handbook is also intended for decision-makers within national authorities.

The book consists of three parts, the major elements of which are closely related to one another¹⁾:

1. **Part A** gives a brief survey on the development of animal traction to date in the various African countries. Among other things, a list is given of the most important national and international organizations which have already become involved in the spread and support of the use of draught animals. The references to further literature, reports and project information give the reader, i.e. in particular the planner of new development projects involving promotion of the use of draught animals, the basic information necessary for intensive preparation.

¹⁾ The handbook contains a number of gaps, particularly in the area of empirical research, since it was not based on independent surveys by the authors. The entire work is instead founded on the analysis of various sources of literature, project reports and individual studies, which not only constitute a random selection but which also in some cases contain inadequate and insufficiently detailed information on the topics under discussion here. Nor can the authors claim to have included all reports on the topic "Use of draught animals in Africa" produced both nationally and internationally.

The authors request that these limitations be borne in mind when the handbook is used.

The discussion of the conditions limiting and factors influencing the use of draught animals will serve to increase awareness of the special problems, while the checklist (Section 4.4) is intended for detailed data collection and preparation of the plans for corresponding development projects or project measures.

2. **Part B** deals with detailed questions and individual aspects of the use of draught animals, i.e. it contains the real basic information. In addition to discussing livestock husbandry and animal health (specially related to the use of draught cattle), together with a description and discussion of the various types of harness and implements, it contains the most important comments on the topic viewed from the point of crop-growing ecology, economics, technical aspects and socioethnological factors.

The aim of this part of the handbook is to provide comprehensive specialized knowledge for the actual project planning process.

3. **Part C** uses four case studies to document suitable promotional approaches for the use of draught animals in Africa. It is shown how the development of the use of draught animals can be supported in a variety of different ways on the basis of given preconditions. Problems of implementation are included to a large extent in the discussion and descriptions.

P. Munzinger

PART A

**Development and situation
of animal traction in Africa
and conditions limiting
further promotion**

Part A: DEVELOPMENT AND SITUATION OF ANIMAL TRACTION IN AFRICA
AND CONDITIONS LIMITING FURTHER PROMOTION

(P. Munzinger)

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1. Introduction

Problems in the mechanization of agricultural production in developing African nations have been the cause of major controversy for many years. Differing opinions on agricultural mechanization strategies have to date had a not inconsiderable influence on the development plans of the countries in question, and this not always to their advantage. In some cases - and there are numerous examples of this - the choice of a too highly advanced and therefore complicated form of mechanization led to misdirected developments or to uneconomical development projects which above all failed to take actual needs into account.

In developing African nations development planners are confronted with the fact that widely varying levels of mechanization are to be found there in the agricultural production process. To simplify matters three levels as described below can be distinguished and this classification is used throughout almost the entire handbook¹⁾:

- a) The manual labour level, which in actual fact involves no "mechanization" at all, is characterized by the use of simple tools and implements in manual labour only. Even today this is still the most frequently encountered form of land cultivation in Africa, particularly in the case of smallholdings.
- b) The draught animal stage is the beginning of "intermediate" or "appropriate" agricultural mechanization, whereby it should be borne in mind that in some areas (e.g. North Africa and Ethiopia) the use of draught animals has been traditional for centuries.
- c) Tractorization is a modern, highly advanced form of agricultural mechanization and involves a wide variety of designs and types of tractors and implements.

In accordance with the aim of the handbook this part will firstly provide a certain amount of basic information on the use of draught animals in Africa. Following a more general assessment of animal

1) Based on CARRILLION, R./LE MOIGNE, M. (1975), who suggest this simple way of distinguishing different levels of mechanization. The breakdown could of course be made in still greater detail.

traction in comparison with other forms of agricultural mechanization (Section 2), Section 3 gives detailed information, in the form of country-by-country tables, on the use of draught animals as regards¹⁾

- the historical development and the main types of animals used;
- the regional spread and relative importance;
- important national and international organizations which have provided or are still providing appropriate support;
- local production opportunities for animal-drawn implements and spare parts (including export possibilities);
- further literature, reports and research studies.

In conjunction with the subsequent brief discussion of framework conditions and influencing factors (the discussion is continued in more detail in Part B) this thereby creates an initial basis which can already be of assistance when a decision is to be taken for or against the use of draught animals.

The "checklist" is intended for detailed data collection and preparation of the plans for corresponding development projects or project measures; however, the basic prerequisites detailed in Part B are essential before meaningful use can be made of this list.

2. Importance of draught animals

The following statements can be made concerning the present position of animal traction within the framework of the development of agricultural mechanization:

- a) In most industrialized nations consideration of the relative advantages of motorized traction power in comparison with animal traction power has led to gradual replacement of draught animals. Emphasis today in the USA, in most European countries and on many farms in Asian countries is on the use of tractors (including small tractors). The continued advance of motorization in agri-

1) Despite a shortage of information in some cases (e.g. North Africa), which can be attributed to a lack of corresponding project reports and general documents, these tables are intended to give planners, appraisers and project personnel the opportunity to establish suitable contacts and obtain more detailed information.

culture is in this case being curbed only by the recent energy crisis and reconsideration of the growth ideology.

- b) In areas which are less developed in economic terms, such as many African countries, a number of attempts to motorize local agriculture have failed. For this reason, and for those already mentioned in the preliminary remarks, the use of animal traction power is or will become a greater possibility here as an alternative form of agricultural mechanization - only, of course, as far as the framework conditions permit.

The selection and promotion of suitable "situation-related" or "appropriate" agricultural technologies¹⁾ with a view to solving the agricultural production problems in developing countries is now being increasingly demanded in view of the fact that experience with development policy over the past two decades has shown that there have been repeated failures in this area. For the greater part of African agriculture, at least for that part of it based on arable farming, the provision and use of sufficient traction power (=energy sources) is still a crucial problem determining the sector's general development efforts on the part of national and international sources of development aid.

A number of major problems limit the use of "modern" agricultural mechanization procedures and thus provide a certain amount of scope for the keeping of draught animals and its promotion in this area. Particular mention must be made of the following problems:

- The acute shortage of capital, both on the individual farms and at the level of the national economy
- The mostly fairly small holdings and their in some cases still marginal market production

1) Definitions: The terms increasingly used in the discussion of development policy in recent years, such as "low-cost technology", "intermediate technology" or "appropriate technology", are also applied to the use of animal traction. In most cases they are intended by analogy to express the same meaning although it may be the cost aspect, the development level or the appropriateness to local framework conditions which is in the foreground depending on the starting point of the person doing the assessing. All these terms are relatively controversial, since unconsidered use of them can lead to confusion and misinterpretation.

- 3 The comparatively low standard of training of the farmers
- The continued lack of an infrastructure in most areas (e.g. maintenance and repair workshops).

Moreover, the technology involved in tractor use, combined with modern soil tillage, is not only too expensive for the majority of smallholders, but has in the meantime also become too costly in the long term for the economic strength of some developing countries in Africa. The latter applies in particular to the countries which, for want of domestic energy resources, are hit by the increasing cost of modern technologies and cannot compensate for this cost increase by means of appropriate measures at national-economy level (e.g. increased production in other sectors of the economy).

Technologies such as the use of draught animals are frequently regarded as an intermediate stage on the way to "more ambitious" agricultural mechanization. It is precisely the use of the term "intermediate technology" which reinforces the view that a form of technology located somewhere between the "traditional" and "modern" levels is appropriate for many developing countries. Why, however, should the development generally lead from the manual labour level to the use of draught oxen and from there to the use of tractors?

The criterion for a decision for or against a specific form of agricultural mechanization cannot be the development phase to which it belongs, for in many cases the hand hoe is still the most suitable tool, whereas in other cases the use of draught animals deserves particular promotion and can be regarded for technical and economic reasons as the only suitable form of mechanization practicable in the long term. In still other cases a direct transition from manual labour to tractors may be economical and therefore advisable.

It is therefore impossible to give a generally valid answer to the question of whether the introduction of animal traction in certain countries and regions of Africa is to be regarded only as an intermediate stage. Far more decisive elements are the regional and situation-related framework conditions and influencing factors in each case. These may be subject - and this must be given particular consideration when a decision is being taken for or against a specific mechanization alternative - to substantial changes through the use of the technology finally selected. A comprehensive situation analysis, combined with a correspondingly based assessment of long-term

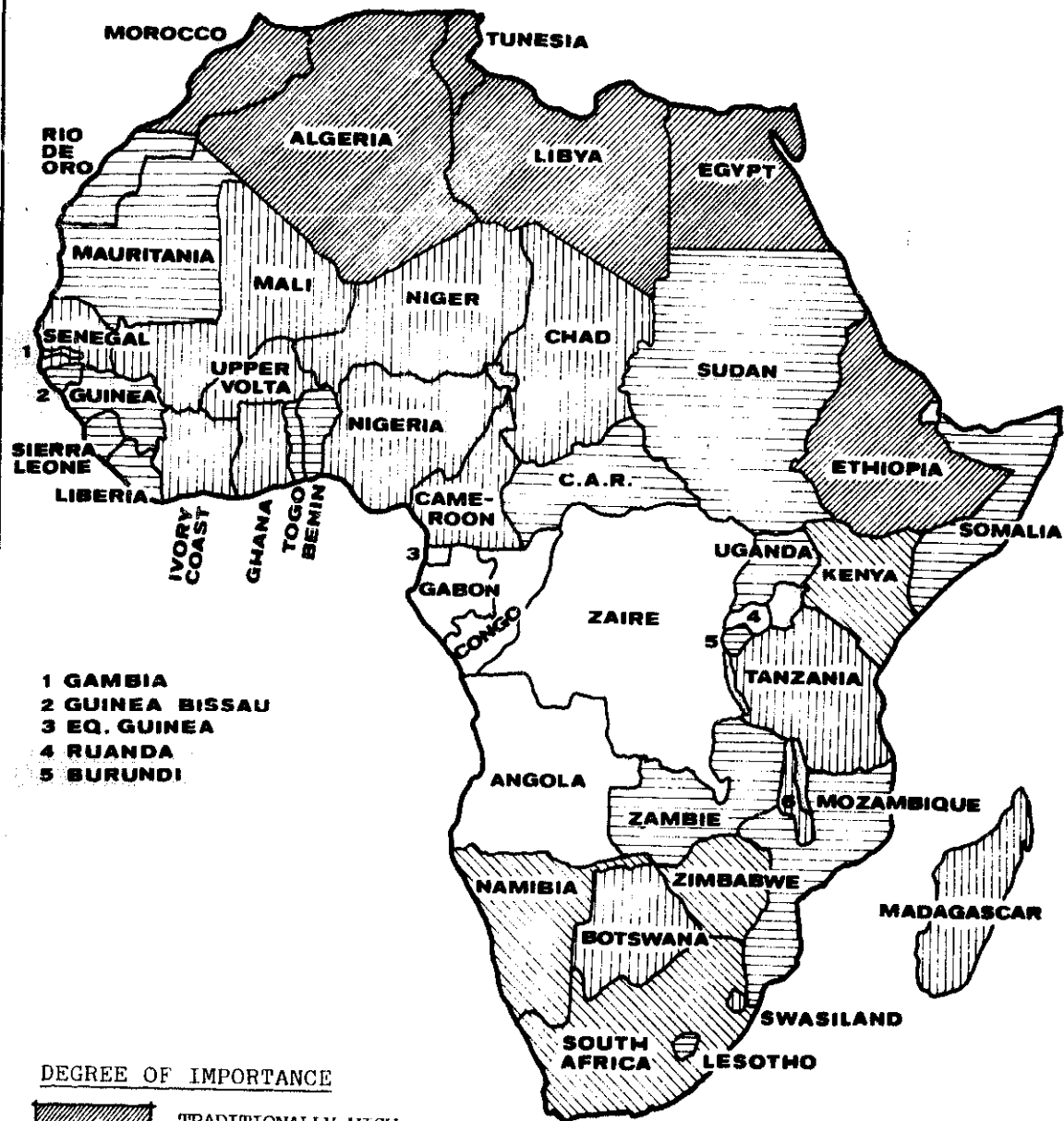
effects, must therefore be carried out before any form of agricultural mechanization is supported.

The fact that animal traction undoubtedly fits into the concept of "appropriate technology" is illustrated, for example, by the nature of the effects it produces (cf. e.g. Part B/IV). Negative effects of increased tractor-based mechanization are sufficiently well known and have been amply discussed, even though they are not always admitted.

By way of an example it should be simply pointed out here that intense use of tractors may not just release members of the agricultural labour force who can then find no alternative employment. It can also lead to an increase in the number of large farms, usually on account of certain competitive advantages, a process which is frequently to the detriment of many small and medium-sized farms which are undoubtedly viable. The differences in available income resulting from this development have severe negative effects in the long term, particularly in the social sphere.






Whereas many western industrialized nations and their national and international development organizations have in the meantime supported and further developed the concept of appropriate technologies - and thereby also the use of animal traction power - socialist industrialized nations are still for the most part continuing to reject such promotion measures (cf. e.g. MICHALSKI, 1974). The socialist belief is that priority should be given to agricultural development, in Africa as well, through the establishment of state farms with modern technology, state-run machinery-hiring stations and agricultural cooperatives. The support of smallholdings, which would undoubtedly result from the promotion of the use of draught animals, is regarded as an obstacle to overall economic and political development. In the African countries which are aiming to achieve a socialistic economic system or maintain relatively close ties with socialist and communist industrialized nations this view has in the meantime led to a sharp reduction in the use of draught animals and the respective attempts at promotion in this field.

IMPORTANCE OF DRAUGHT ANIMALS IN AFRICA



- 1 GAMBIA
- 2 GUINEA BISSAU
- 3 EQ. GUINEA
- 4 RUANDA
- 5 BURUNDI

DEGREE OF IMPORTANCE

	TRADITIONALLY HIGH (DECREASING TENDENCY)		MARGINAL, WITH DEVELOPMENT POTENTIAL (5% OF HOLDINGS)
	DURING COLONIAL DAYS (NOW REDUCED)		NONE; SEVERE LIMITING FACTORS
	INCREASING DUE TO DEVELOPMENT MEASURES (5 - 10% OF HOLDINGS)		

3. Development and situation

3.1 North Africa¹⁾

The use of draught animals for agricultural and non-agricultural work has been traditional for centuries over much of North Africa. Domestic animals (in particular also water buffalo) have been used in this way for more than 3000 years, especially in Egypt in the flood areas along the Nile.

In other North African countries cows, oxen, horses, donkeys, mules and camels (mainly used as pack-animals) are still important sources of energy for soil tillage, transportation, operation of irrigation systems, threshing work etc.

As far as the historical development of the use of draught animals is concerned, North Africa thus differs quite substantially from the rest of the continent, where the use of draught animals has comparatively little tradition and did not start - it at all - until colonial days, although Ethiopia is an exception to this rule.

In Algeria and Libya (in part also in Morocco) the use of animal traction has been severely reduced as a result of intensive tractor-based mechanization on large private and state-run farms. It was not only the large quantities of available energy resources (particularly petroleum) and the related foreign exchange earnings which initiated this development; it was also founded largely on political decisions. In line with the aims of agricultural policy this trend will probably continue in these countries, although it is highly unlikely that draught animals can be replaced altogether, for animal-drawn implements are still used to a certain extent even on large farms; this can frequently be attributed to the lack of trained personnel and the shortage of spare parts and repair workshops for the existing tractors and implements.

Tunesia and Egypt have not yet witnessed this degree of development in the direction of large-scale mechanization, although a variety of approaches have been tried in this area.

1) It was impossible to produce a country-by-country table for North Africa on account of the generally poor information basis, i.e. inadequate data on number of draught animals and implements, local production facilities for machines and implements and a general lack of literature and reports on this topic.



Fig. A/1: Mixed team comprising camel and mule
in North Africa. (Photo: GTZ Archives)

National and international development cooperation organizations have implemented almost no promotion projects aimed at improving the use of draught animals in North Africa. Earlier efforts in this direction are known from colonial days and there are still some local production centres for animal-drawn implements which were the result of this work. The importance of the old promotion efforts decreased relatively sharply once the countries gained independence, since the states, now largely autonomous, mostly turned their attention to developing and supporting other agricultural technologies which did not involve animal traction.

In many parts of North Africa, however, there is still a major potential for the "rediscovery" and further development of the use of draught animals on account of the relatively favourable framework conditions in terms of available animals, animal diseases and climatic conditions. This potential involves in particular the introduction of improved animal-drawn implements for smallholdings.

3.2 West Africa

Animal traction is less important in West Africa than in the northern part of the continent. Although the use of draught animals has to a certain extent become traditional in some areas over the past three decades and is continuing to spread, the initial situation is nevertheless totally different from that in North Africa, since arable farming and livestock husbandry have by tradition been kept largely separate in West Africa and this is for the most part still the case today.

Livestock-owning nomads cover the extensive steppe or savannah regions grazing their large herds of cattle and camels and mainly derive their living from these herds and related bartering. The tribes engaged in arable farming, on the other hand, have until recently for the most part remained unfamiliar with the keeping of heavy livestock, which was also restricted by the spread of the tsetse-fly (vector for trypanosomiasis, see Part B/I) in the more humid regions. Most of the small farmers therefore tilled their fields in the traditional manner in shifting cultivation using hand hoes and relatively simple implements.

This initial situation also remains relatively unchanged today, although control measures have helped to restrict the habitat of the tsetse-fly. Seen in terms of the use of draught animals in agriculture, changes have only been initiated in a few countries, a move which is today being documented there, for example, by increasing demand for draught animals and drawn implements (see Table A/1). This turn of events was for the most part brought about by various promotional measures implemented by a number of organizations. As far back as the fifties and sixties various colonial administration companies were devoting their attention to the introduction of animal traction (mainly draught oxen), which was simultaneously combined with the spread and promotion of specific crops for export or marketing (cotton, groundnuts, rice etc.). For the target group - farmers with small and medium-sized holdings - this frequently involved the allocation of substantial credits for the procurement of animals and implements.

In some cases these measures were accompanied by further development and research in the area of animal-drawn implements and the selection,

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keeping and feeding of draught animals under the specific conditions of the region in question.¹⁾

With its usually fairly light soils to be found over extensive flat areas, its large cattle population and its fairly low incidence of the tsetse-fly (in comparison with Central and East Africa), West Africa offers relatively good prerequisites for the spread of animal traction. This fact was realized at an early stage by some countries (e.g. Senegal, Mali, Upper Volta, Chad) and was accordingly included in the overall aims of their agricultural policy. Table A/1 shows that the use of draught animals has been particularly successful in the countries accounting for major proportions of the semi-arid savannah belt of the Sahara.



Fig. A/2: Harnesses being used to plough a millet field in Senegal, West Africa. (Photo: GTZ Archives)

1) cf. documentation produced by the French research institutions B.D.P.A., C.E.E.M.A.T., I.R.A.T. etc. (addresses in Section 3.6). Important reports are included in the bibliography in this handbook.

TABLE A/1: SITUATION AND DEVELOPMENT AS REGARDS USE OF DRAUGHT ANIMALS IN WEST AFRICA¹⁾

COUNTRY	START/MOST COMMONLY USED ANIMALS	REGIONS WITH RELATIVELY LARGE-SCALE USE	PROMOTIONAL ORGANIZATIONS	PRODUCTION OF DRAWN IMPLEMENTS	DETAILED INFORMATION ²⁾
BENIN	STILL RELATIVELY UNIMPORTANT; OXEN FROM WEST AFRICAN ZEBU BREEDS	MAINLY NORTHERN REGION (APPROX. 10 000 TEAMS) IMPLEMENTS IN 1977: 7 500 PLOUGHS	UNDP IN CONJUNCTION WITH B.D.P.A. FURTHER PROMOTION PLANNED BY FAO AND GTZ	1) COBEMAG 2) MFCANELEC	CASSE ET AL. (1965) D'INFIR, B. (1976) MORTIERES, G. AGROPROGRESS (1980)
CHAD	END OF 1950, BEGINNINGS IN COLONIAL DAYS; OXEN, A FEW HORSES OR DONKEYS	TSETSE-FREE AREAS. IMPLEMENTS IN 1977: 58 000 PLOUGHS 1 800 HOES AND MULTI-PURPOSE IMPLEMENTS 14 000 CARTS 3 900 RIDGERS	C.F.D.T., FED. GTZ.	SOMAT (SOCIETE DE MACHINISME AGRICOLE DE TSCHAD/NJAMENA)	CASSE ET AL. (1965) DRONNE, M. (1969) LE HASIF, J. (1976) TACHER, G. ET AL. (1969) LE MOIGNE/ZERBO (1977)
GAMBIA	PROMOTED BY GOVERNMENT SINCE 1955; HORSES, DONKEYS, OXEN	ALONG GAMBIA RIVER, HEAVILY INFLUENCED BY SENEGAL	N.I.A.E.; MINISTRY OF OVERSEAS DEVELOPMENT, LONDON	IMPLEMENTS MOSTLY IMPORTED FROM SISCOMA, SENEGAL.	MATHEWS, M.D.P. (1976) PULLEN, D.W.M. (1976) METTRICK, H. (1978)
GHANA	SINCE EARLY COLONIAL DAYS; OXEN, DONKEYS	UPPER REGION (NORTH-EAST AND NORTH); 4 - 8% OF ALL FARMS USE DRAUGHT OXEN.	GTZ, VARIOUS MISSIONS, GOVERNMENT SUPPORT	NEW FACTORY BEING SET UP IN TAMALE (SEE 3,7)	KLINE, C.K. ET AL. (1969) WATZMANN, W. (1978) CASE STUDY C/IV
IVORY COAST	N'DAMA INTRODUCED AS DRAUGHT ANIMALS IN 1954, PROMOTION IN CONJUNCTION WITH COTTON GROWING; BOVINES (ZEBU, BAOLE)	NORTHERN REGIONS (APPROX. 6 000 - 7 000 TEAMS).	FED; GTZ; C.I.D.T.; SODEPRA.	1) ABIDJAN INDUSTRIES 2) IVOIRE-OUTILS, ABIDJAN	BIGOT, Y. (1976) RENAUT, G. (1966) RUTHENBERG, H. (1969) MENSAH, M. (1967) SCHERRER, J. (1966)
MALI	AROUND 1925; OXEN, DONKEYS, HORSES, TSETSE-FREE AREAS; ZEBUS; TSETSE-INFESTED AREAS; N'DAMA CATTLE	WHOLE OF MALI EXCEPT SAHARA REGION. 1980: APPROX. 280 000 DRAUGHT OXEN. IMPLEMENTS IN 1977: 100 700 PLOUGHS 40 600 MULTI-PURPOSE IMPLEMENTS 54 700 HOES 10 800 HARROWS 9 800 SEED DRILLS 52 300 CARTS	C.M.D.T., GTZ, OFFICE NIGER, FED. FAO/UNDP; INTENSIVE STATE PROMOTION, DNFAF (DIRECTION NATIONALE DE FORMATION ET D'ANIMATION RURALE); DMA (DIV. DU MACHINISME AGRICOLE).	S.M.E.C.M.A., LOCAL CRAFT INDUSTRY UNDERGOING DEVELOPMENT	BOSUNER, M. (1976) LAGEMANN, J. (1977) MACK, C. (1968) N'DIAYE, A.D. (1973) VALLEE, G. ET AL. (1975-76) CASE STUDY C/II
NIGER	SINCE AROUND 1960 STILL RELATIVELY UNIMPORTANT; OXEN (ZEBU, AZAWAK) SOME CAMELS	NO MAIN AREAS; IN ARABIC FARMING REGIONS. IMPLEMENTS IN 1977: 3000 PLOUGHS 5200 HOES AND MULTI-PURPOSE IMPLEMENTS 900 SEED DRILLS 3300 CARTS 1500 RIDGERS 3300 GROUNDNUT LIFTERS	FAC; FAO/UNDP; U.N.C.C. (UNION NIGERIEENNE DE COOPERATION ET DE CREDITS) MAINLY TRIALS.	SONIFAME ET SEFAMAG (SOCIETE NIGERIEENNE DE FABRICATION DE MATERIELS AGRICOLES)	CASSE ET AL. (1965) FORT, J. (1975) BRAUN, H.J. (1963) LE MOIGNE/ZERBO, J. (1977)
NIGERIA	END OF 1950; RELATIVELY RAPID SPREAD; OXEN (WHITE FULANI)	NORTHERN REGIONS; ONLY IN TSETSE-FREE AREAS	USAID, FAO	VARIOUS LOCAL MANUFACTURERS	LAURENT, C.K. (1968) RENAUT, G. (1974) KLINE, C.K. ET AL. (1969) BOYD, J.E.L. (1973)
SENEGAL	SEED DRILLS INTRODUCED AS FAR BACK AS 1935; HORSES, DONKEYS, OXEN, COWS (N'DAMA)	WHOLE OF COUNTRY. IMPLEMENTS IN 1977: 8000 PLOUGHS 204000 HOES 220000 SEED DRILLS 90000 CARTS 5000 RIDGERS 88000 GROUNDNUT LIFTERS	FAC, C.N.R.A.; INTENSIVE STATE PROMOTION DURING 60s AND 70s	SISCOMA, INTENSIVE RESEARCH ON ANIMAL TRACTION IN BAMBEY NEAR DAKAR	BAIARD, C. (1977) CASSE ET AL. (1965) FAYE, J. (1977) GARIN, M. (1966) HARON, M. (1969) M'BODY, M. (1973/74) MONNIER, J. (1974)
TOGO	1910, LITTLE BROAD-BASED EFFECT SINCE; OXEN, DONKEYS	NORTHERN REGION, OTHERWISE UNIMPORTANT	FED, GTZ, BOPA (1963); LITTLE PROMOTION ON THE WHOLE	IMPLEMENTS AND CARTS ARE IMPORTED	CASSE, ET AL. (1965) I.R.A.T. (1977) LERUTH, A. (1978)
UPPER VOLTA	OXEN (APPROX. 10 000 TEAMS); DONKEYS FOR TRANSPORT	SOUTHERN AND CENTRAL REGIONS. IMPLEMENTS IN 1977: APPROX. 16500 PLOUGHS 2500 MULTI-PURPOSE IMPL. 23000 HOES	IBRD, FAO, FED, UNDP, B.D.P.A., MINISTRY OF OVERSEAS DEVELOPMENT, LONDON. INCREASING IMPORTANCE, INTENSIVE STATE PROMOTION	PROMOTED BY FAO SINCE 1978, CENTRAL FACTORY WITH FIELD STATIONS FOR ASSEMBLY	BINSBERGEN, H. (1973) GERADIN, M. (1964) FAO (1978) MALCOITTE, C. (1974) MENSAH, M. (1967) REMY, G. (1972)

1) IN GUINEA, GUINEA-BISSAU, LIBERIA, MAURETANIA AND SIERRA LEONE THE USE OF DRAUGHT ANIMALS HAS BEEN OF ALMOST NO SIGNIFICANCE TO DATE, NOR ARE THERE KNOWN TO BE ANY PROMOTION MEASURES IN THESE COUNTRIES.

2) SEE BIBLIOGRAPHY FOR THE HANDBOOK.

As far as future use of draught animals in West Africa is concerned, the essential task will be to stabilize this form of agricultural mechanization through

- credits and subsidies for smallholders
- improvement of veterinary services and general extension services
- intensification of fodder growing and fodder harvesting
- provision of an adequate number of implements and the necessary spare parts etc.

These measures are particularly necessary because many West African countries can employ complex technologies in their agriculture to only a limited extent or not at all on account of conditions concerning the individual farms, the economy and the natural environment (in particular a shortage of appropriate resources).

3.3 East Africa

In contrast to West Africa, the use of draught animals was given far less promotion in the past in East Africa and is therefore not so widespread in this area. One exception, however, is Ethiopia, where simple hook ploughs ("maresha") have been used for centuries (Fig. A/3).

Although oxen, mules, horses and camels were used for a variety of purposes (e.g. railway construction, pulling trucks on plantations etc.) during colonial days in other East African countries under the various colonial administrations, the use of draught animals as a whole failed to become popular on the local smallholdings.

The major reasons for this are as follows:

1. The relatively high incidence of serious infectious diseases (e.g. East Coast fever, anaplasmosis, trypanosomiasis etc.) led to a high mortality rate among heavy livestock. The less seriously infected areas are generally not suitable.
2. The extensive separation of arable farming and animal husbandry (the latter mostly only among nomadic tribes) in local agriculture

acted as a major obstacle. There were often also armed conflicts between various ethnic groups.

3. The concentration of agricultural market production on plantations, i.e. large farms which either employed a substantial amount of usually local hired labour or used other forms of agricultural mechanization at a relatively early stage, was a process which had been initiated during colonial days and not only prevented local smallholders from forming the necessary capital but also kept them largely at subsistence level.
4. In spite of a relatively low population density in much of East Africa adequate labour for the necessary subsistence production of food was usually available and there was therefore no urgent need to make the work easier through use of draught animals.

Although the situation has now changed substantially, animal traction is still little used on the whole, except in a few regions. It is true that promotional measures aimed at spreading the use of draught animals were initiated by national or international development co-operation organizations once the countries had gained independence, but these have to date enjoyed only limited success on the whole. However, it was possible to convince some East African nations of the need for further support measures and this is today being partly reflected in the targets of these countries' agricultural policy as regards mechanization.

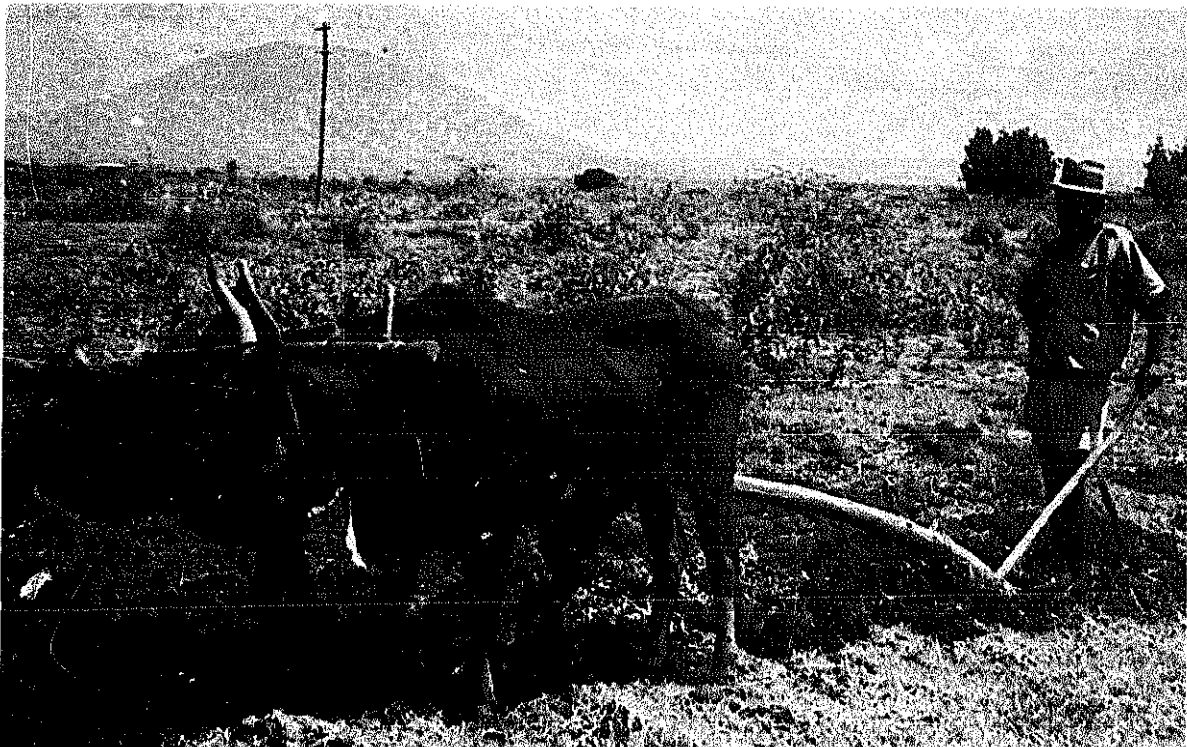


Fig. A/3: Ethiopia: ploughing with local zebu using the "maresha"; harness is a simple withers yoke. (Photo: Reh)

TABLE A/2: SITUATION AND DEVELOPMENT AS REGARDS THE USE OF DRAUGHT ANIMALS IN EAST AFRICA 1)

COUNTRY	START/MOST COMMONLY USED ANIMALS	REGIONS WITH RELATIVELY LARGE-SCALE USE	PROMOTIONAL ORGANIZATIONS	PRODUCTION OF DRAWN IMPLEMENTS	DETAILED INFORMATION
ETHIOPIA	TRADITIONAL, VERY IMPORTANT FOR CENTURIES; HORSES, MULES, CAMELS, OXEN, DONKEYS	THROUGHOUT HIGHLANDS (APPROX. 80% OF FARMS ARE SAID TO USE DRAUGHT ANIMALS)	FAO, ILCA; SUBSTANTIAL STATE SUPPORT UNTIL 1978	(SEE 3.7) LOCAL CRAFT INDUSTRY PRODUCES SIMPLE IMPLEMENTS	HUFFNAGEL, H.P. (1961) KNUTSSON, K.E. (1969) KLINE, C.K. ET AL. (1969) BORGET, M. (1976) WIGGINGS, L.L. ET AL.
KENYA	EARLY COLONIAL DAYS; TODAY ONLY OXEN AND IN SOME CASES DONKEYS FOR TRANSPORT	IN SOME HIGHLAND AREAS, IMPORTANCE GROWING AGAIN ON SMALLHOLDINGS	FED, FAO/UNDP, GTZ; STATE SUPPORT SINCE 1978 BY MINISTRY OF AGRICULTURE AND KENYAN INDUSTRIAL ESTATES	VARIOUS MANUFACTURERS (SEE 3.7); LOCAL CRAFT INDUSTRY PRODUCES CARTS FROM SCRAP PARTS IN SOME PLACES	ADELHELM, R. ET AL. (1975) HEYER, J. (1975) KLINE, C.K. ET AL. (1969) SCHMIDT, H. (1979) JOHNSTON, B.F. (1979)
MADAGASCAR	FIRST ATTEMPTS DURING COLONIAL DAYS, BROAD-BASED EFFECT FROM 1900; OXEN (ZEBU BREEDS); (SEE CASE STUDY IN PART C)	EAST COAST, NORTHERN AND SOUTHERN PARTS OF ISLAND, "MID-WEST"; 1975: 165 000 PLOUGHS 140 000 HARROWS 127 000 CARTS	MISEREOR, FED, FAC, FAO/UNDP; STATE SUPPORT, PARTICULARLY DURING 60s	SIDEMA WITH 7 FIELD WORKSHOPS; LOCAL CRAFT INDUSTRY PROMOTED IN SOME PLACES	GIDELE, W. (1967) HAUT DE SIGY, G. (1968) LE MOIGNE, M. (1979) SCHERRER, J. (1966)
MALAWI	SINCE COLONIAL DAYS; LOCAL BREEDS OF OXEN, DONKEYS IN DEDZA AND LI-LONGWE DISTRICTS	MARGINAL AREAS AROUND LAKE MALAWI, HIGHLANDS; SPREADING	N.I.A.E., GTZ; MINISTRY OF OVERSEAS DEVELOPMENT, LONDON; STRONG GOVERNMENT SUPPORT	VARIOUS MANUFACTURERS (SEE 3.7)	MILLS, J.C. (1973) MORRIS, J.
MOZAMBIQUE	DURING COLONIAL DAYS IN SOME PLACES	TSETSE-FREE AREAS, HIGHLANDS	FAO/UNDP; NO STATE SUPPORT TO DATE	IMPLEMENTS ARE IMPORTED	CARSON, S.P. (1979)
TANZANIA	USED MAINLY ON PLANTATIONS IN COLONIAL DAYS; TODAY OXEN, DONKEYS, A FEW MULES	SUKUMA LAND (SHINYANGA REGION), ARUSHA REGION; NUMBER OF PLOUGHS SOLD: 1967 8 000 1974 15 000 TSETSE PROBLEMS!	IBRD, FAO/UNDP, GTZ; INTENSIVE STATE PROMOTION DURING 70s BUT WITHOUT MAJOR SUCCESS	UBUNGO FARM IMPLEMENTS; TANZANIA MACHINERY TESTING UNIT (TAMTU), ARUSHA (SINCE 1957)	JOHNSTON, B.F. (1979) KLINE, C.K. (1969) SINGH, J. (1977) FFLDMANN, D. (1969) DAUG, H. (1978) LINK, H./KALB, D. (1980)
UGANDA	AROUND 1910 BUT WITHOUT BROAD-BASED EFFECT, MORE RECENT PROMOTION SINCE 1960; OXEN (ANKOLE, ZEBUS)	TSETSE-FREE AREAS IN HIGHLANDS	UNIDO, FAO/UNDP, GTZ	UNIDO WORKSHOP IN S'RUUTI BUT MOST IMPLEMENTS IMPORTED	DIMA, S.A./AMMANN, U.F. (1974) OKAI, M. (1977)
ZAMBIA	PRACTISED IN PART DURING BRITISH COLONIAL DAYS; OXEN (FORMERLY ALSO HORSES AND MULES)	DRAUGHT OXEN HAVE ACQUIRED CERTAIN IMPORTANCE IN SOUTH-EAST; PROMOTION ALSO IN NORTH-WEST	FAO, GTZ; START OF STATE SUPPORT FROM MINISTRY OF AGRICULTURE AND WATER DEVELOPMENT	LOCAL PRODUCTION NEAR LUSAKA, OTHERWISE IMPORTS FROM MALAWI, ZIMBABWE, SOUTH AFRICA	FERNSEBNER (1979)

1) IN SOMALIA AND THE SUDAN OXEN AND CAMELS ARE USED IN PART FOR TRANSPORT WORK AND TO OPERATE WATER SCOOPS FOR IRRIGATION, BUT THESE ARE (STILL) OF MINOR IMPORTANCE.

IN BURUNDI AND RWANDA ANIMAL TRACTION IS OF ALMOST NO IMPORTANCE. IN ADDITION TO THE UNSUITABLE TOPOGRAPHY THE RELATIVELY HIGH POPULATION DENSITY (COMPETITION BETWEEN MAN AND ANIMAL) ALSO PREVENTS ITS SPREAD.

If it is possible to further limit the spread of the tsetse-fly, animal traction (particularly draught oxen) can become considerably more important in future in East Africa, for most East African nations also lack sufficient natural resources of their own, available on a long-term basis, to be able to introduce other forms of agricultural mechanization on a large scale. Moreover, the fact that the agriculture is for the most part based on smallholdings also speaks in favour of the use of draught animals on account of cost advantages for the individual holdings (see also Part B/IV).

3.4 Central Africa

In most Central African countries the development of the use of draught animals is once again totally different from that in West, East or North Africa. This is principally a result of:

- different climatic conditions,
- the dense natural vegetation found over wide areas (tropical rain forest),
- the unfavourable living conditions for cattle, horses and donkeys,
- the traditional social structures.

Although heavy livestock are kept here too by nomadic tribes, this is only the case in the northern grasslands (and in the tree-covered savannahs). Most of the arable farmers in the rain forest zone (see map in Part B/III) still use the shifting cultivation system, which from the technical point of view is at the manual-labour level.

Here again, the first changes took place during colonial days. Attempts were made in some areas to mechanize the plantation-based agriculture of the European settlers - this form of cultivation already having been introduced in part by them - using animal-drawn implements. The majority of these measures failed and did not spread to the local rural population, which largely retained its traditional system.

It was not until after independence that various former colonial administration companies succeeded in inducing the local arable



Fig. A/4: In poorly cleared fields it is particularly difficult to use draught oxen for ploughing, as is shown here in the Central African Republic. (Photo: GTZ Archives)

farmers in some regions to make increased use of draught animals. The particular aim of this was to win over these farmers for market production in order thereby to guarantee and promote the continued production of export crops (mostly cotton and groundnuts) after independence. The first attempts in this direction achieved somewhat varying degrees of success and in many cases it was a long time before any positive effects became evident. Some of these promotional approaches were later taken up by international development organizations and continued in a modified form.

Seen as a whole, it was possible to spread the use of draught animals only to a very small extent on account of the comparatively unfavourable framework conditions (see also Section 4). Moreover, other forms of mechanization started to receive promotion during the early sixties (cf. e.g. Killip et al., 1967), particularly on large farms and those run by the state. Here too, only modest success was achieved, but the beginnings of the development of animal traction nevertheless received a severe setback.

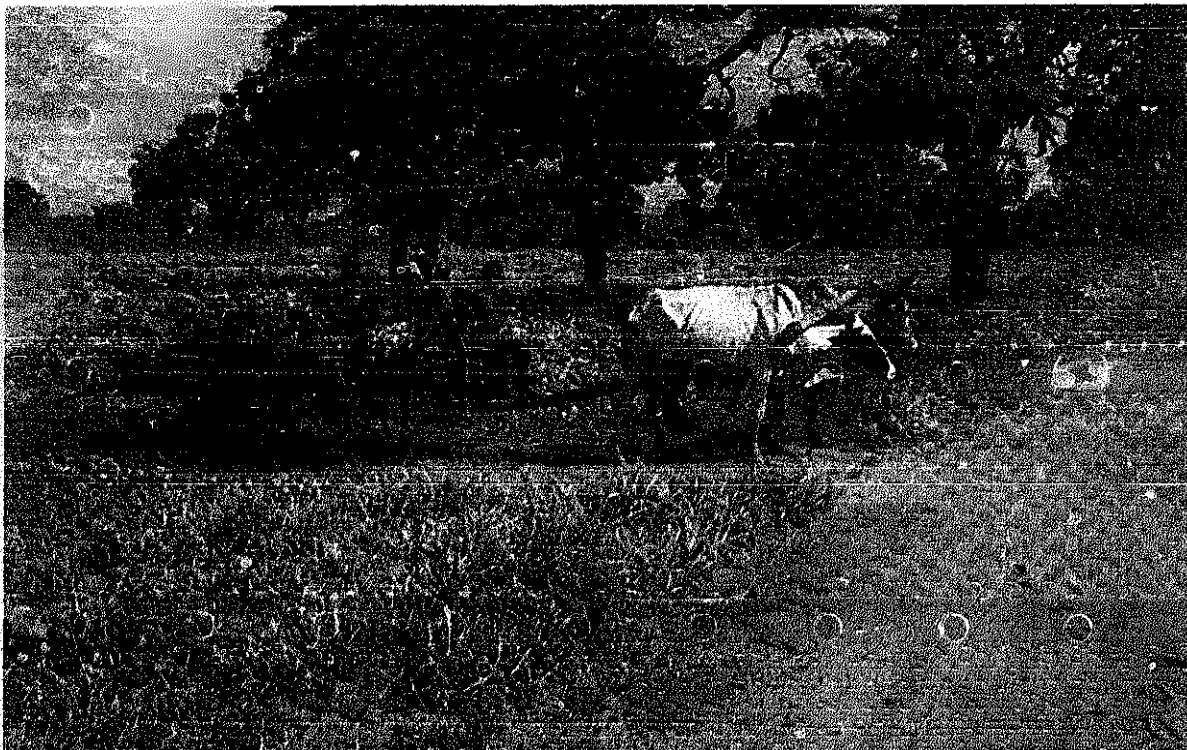


Fig. A/5: A sufficient number of field tracks must be created and maintained for effective use of draught animals for transport work both on and off the farms.
(Photo: GTZ Archives, north-west Cameroon)

TABLE A/3: SITUATION AND DEVELOPMENT AS REGARDS USE OF DRAUGHT ANIMALS IN CENTRAL AFRICA¹⁾

COUNTRY	START/MOST COMMONLY USED ANIMALS	REGIONS WITH RELATIVELY LARGE-SCALE USE	PROMOTIONAL ORGANIZATIONS	PRODUCTION OF DRAWN IMPLEMENTS	DETAILED INFORMATION
CAMEROON	AROUND 1908, DURING GERMAN COLONIAL DAYS, OXEN (WIDE VARIETY OF LOCAL BREEDS); IN SOME CASES DONKEYS FOR TRANSPORT	NORTH AND NORTH-WEST (TRADITION FOR AROUND 40 YEARS)	FAC, IBRD, FED, GTZ, C.F.D.T.; SODECOTON (SOCIÉTÉ POUR LE DÉVELOPPEMENT DU COTON), FONADER (FOND NATIONAL DE DÉVELOPPEMENT RURAL); FURTHER STATE PROMOTION PLANNED	TROPIC IN DOUALA	FOURNIER, A. (1979) CASSE, ET AL. (1965) KLINE, C.K. (1969) NEUNHAUSER, P. ET AL. (1977)
CENTRAL AFRICAN REPUBLIC	1953, FAILURE BECAUSE OF TSE-TSE-FLY, ONLY OXEN TODAY (LOCAL BREEDS)	NORTH-WEST AND NORTH, OTHERWISE TSE-TSE PROBLEMS	FAC, FED, GTZ, C.F.D.T.; FURTHER STATE PROMOTION ALREADY BEING INITIATED	MOST IMPLEMENTS IMPORTED FROM CAMEROON (TROPIC COMPANY)	GROSSER, E./PFEIFFER, J. ET AL. (1977/78) MOREL, J. (1966)

1) IN ZAIRE, GABON, EQUATORIAL GUINEA AND THE CONGO THE USE OF DRAUGHT ANIMALS HAS TO DATE BEEN OF NO SIGNIFICANCE. NO PROMOTION IS KNOWN TO HAVE TAKEN PLACE, APART FROM A FEW MISSION STATIONS.

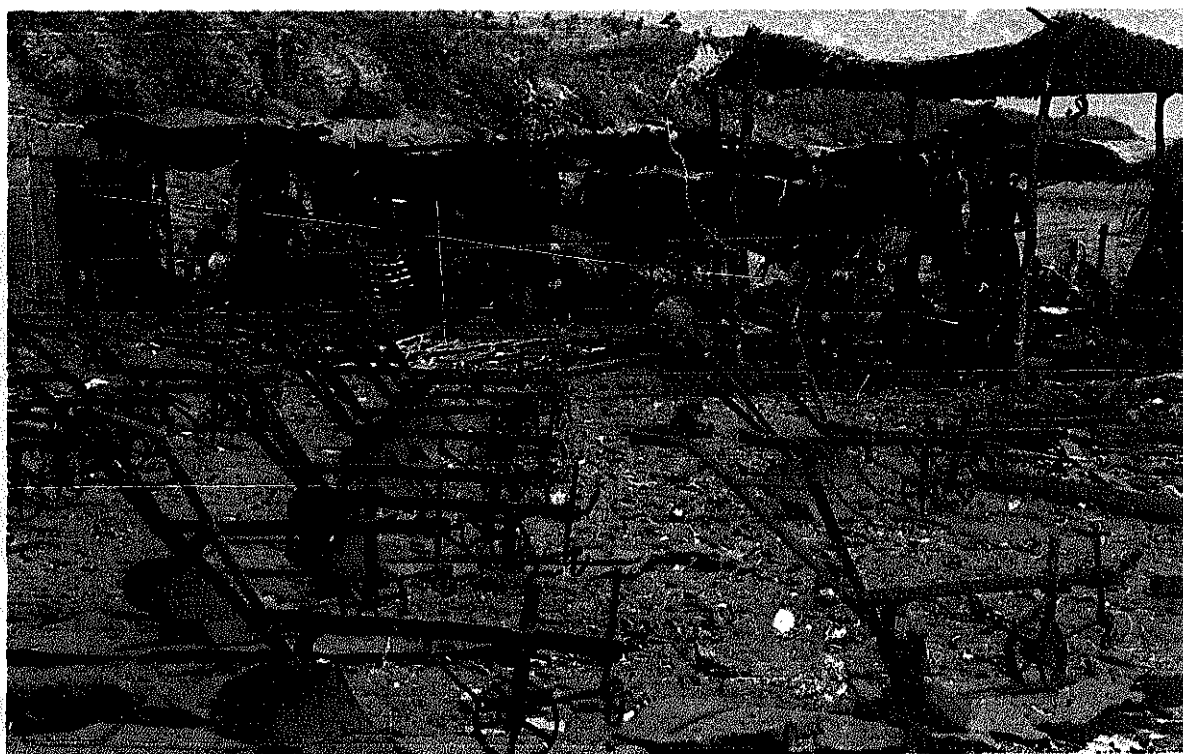


Fig. A/6: Production of simple drawn ploughs from scrap parts near Bamako, Mali. All the plough parts are forged by means of communal work using relatively simple aids. (Photo: Munzinger)

3.5 Southern Africa¹⁾

Although the use of animal traction was already highly widespread among white settlers over much of Southern Africa during the long colonial period, it now plays only a secondary role in the same regions, mostly only on farms owned by the African population. This is the case, for example, in Zimbabwe or in the Republic of South Africa, where the average holding covers around 900 hectares and the large farms are in general fully mechanized with tractors and related implements (BRUWER/CROSBY, 1977).

In some southern African countries, however, animal traction has never been of major importance (e.g. Lesotho, Namibia) and has only recently been promoted there on an experimental basis, here again aimed specially at the African smallholders. Reports and detailed accounts of experiences are unfortunately not yet available.

Wherever draught animals (mainly oxen) are already being used intensively (e.g. in Botswana and Zimbabwe) efforts are being made, among other things, to use animal traction in a more efficient and varied manner by improving the implements (e.g. introduction of multi-purpose implements).

National and international organizations have not yet implemented direct promotional measures in Southern Africa to the same extent, for example, as in West Africa. This situation may change relatively quickly, particularly if the price development of tractors and the required implements, machines and operating supplies is increasing as strongly as at present.

Local production facilities for animal-drawn implements, machines and transport carts are relatively well developed, particularly in Zimbabwe and in the Republic of South Africa; ploughs, harrows and other drawn implements, for example, have for decades been exported to neighbouring countries.

1) The lack of detailed information means that only very general statements can be made on draught animal use for this part of Africa and this is reflected in Table A/4. Given appropriate ideas and a better information flow once this handbook has been published this shortcoming could be remedied in a subsequent revised edition.

In some parts of Southern Africa the generally more favourable natural conditions for keeping draught animals, i.e. the low incidence of serious infectious diseases, the better climatic conditions and the available breeds of cattle well suited to draught work, form a good basis for spreading the use of draught animals.

TABLE A/4: SITUATION AND DEVELOPMENT AS REGARDS USE OF DRAUGHT ANIMALS IN SOUTHERN AFRICA

COUNTRY	START/MOST COMMONLY USED ANIMALS	REGIONS WITH RELATIVELY LARGE-SCALE USE	PROMOTIONAL ORGANIZATION	PRODUCTION OF DRAWN IMPLEMENTS	DETAILED INFORMATION
ANGOLA	ON "WHITE" FARMS DURING PORTUGUESE COLONIAL DAYS; LOCAL AND IMPORTED ZEBU BREEDS USED FORMERLY	OF LITTLE IMPORTANCE TODAY; BECAUSE AFRICAN FARMERS DID NOT ADOPT USE OF DRAUGHT ANIMALS	NO PROMOTIONAL MEASURES KNOWN; LITTLE STATE SUPPORT	DRAWN IMPLEMENTS MOSTLY IMPORTED; A FEW LOCAL REPAIR WORKSHOPS EXIST	NO LITERATURE KNOWN; INFORMATION PROVIDED ORALLY
BOTSWANA	AROUND 1900; SOIL TILLED ALMOST EXCLUSIVELY WITH DRAUGHT OXEN, (AFRIKANDERS). A FEW DONKEYS	EAST OF COUNTRY, ALONG FRANCISTOWN - GABARONE RAILWAY LINE; 60% OF HOLDINGS ARE SAID TO OWN DRAUGHT OXEN	UNIDO, NIAE, MINISTRY OF OVERSEAS DEVELOPMENT, LONDON	MOST IMPLEMENTS IMPORTED FROM SOUTH AFRICA, SMALL PRODUCTION CENTRES IN GABARONE AND FRANCISTOWN	MANNING, W. (1977/ OTTO, J. AND LITERATURE LISTED BY SAME WILLCOCKS, (1960)
LESOTHO	USE OF DRAUGHT ANIMALS STARTED AROUND 1955 AND SPREAD VERY SLOWLY; LOCAL CATTLE, A FEW HORSES	40% OF ALL HOLDINGS ARE SAID TO HAVE DRAWN IMPLEMENTS	GTZ SINCE 1978; FAO	NONE; IMPORTED, MOSTLY FROM SOUTH AFRICA	NO LITERATURE KNOWN
REPUBLIC OF SOUTH AFRICA AND NAMIBIA	MUCH USE OF OXEN, HORSES AND MULES AS DRAUGHT ANIMALS IN ALL SECTORS OF ECONOMY DURING COLONIAL DAYS; DRAUGHT ANIMALS NOW ONLY OF MINOR IMPORTANCE		NO PROMOTION KNOWN	NUMEROUS PRODUCTION CENTRES, GOODS HAVE LONG BEEN EXPORTED TO NEIGHBOURING COUNTRIES	BRUWER, J.J. (1977) CROSBY, C.T.
SWAZILAND	BEGAN DURING COLONIAL DAYS, TODAY OXEN (AFRIKANDERS AND LOCAL ZEBU BREEDS) AND DONKEYS ARE USED	THROUGHOUT COUNTRY, PARTICULARLY ON AFRICAN HOLDINGS	NO PROMOTION KNOWN	IMPORTS, MOSTLY FROM SOUTH AFRICA	NO LITERATURE KNOWN
ZIMBABWE	DURING BRITISH COLONIAL DAYS (OXEN, HORSES, MULES, DONKEYS); STILL VERY IMPORTANT (MAINLY OXEN OF LOCAL BREED, ALSO TULI, AFRIKANDERS AND ZEBUS)	MOSTLY IN THE FORMER TRIBAL TRUST LANDS, I.E. LAND CULTIVATED BY AFRICAN FARMERS	AFTER INDEPENDENCE ANIMAL TRACTION IS NOW PROMOTED BY THE GOVERNMENT. INTERNATIONAL SUPPORT IS DEMANDED	VARIOUS MANUFACTURERS (CF. SECTION 3.7), ALSO SMALL REPAIR WORKSHOPS	TRACEY, H. (1947/48) INFORMATION ORALLY PROVIDED TO THE AUTHOR IN 1981

3.6 National and international organizations with experience in promoting the use of draught animals

The list below gives in alphabetical order the addresses of the most important organizations and institutions which have genuinely useable experience reports and further information on the subject or which themselves support or plan projects concerning draught animal use or implement production in Africa. All these bodies are repeatedly mentioned in the country-by-country tables in Section 3.2 - 3.5.

- B.D.P.A. = Bureau pour le Développement de la Production Agricole,
202, rue de la Croix Nivert, 75738-Paris, France.
- C.E.E.M.A.T. = Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropical,
B.P. 92160, Antony, France.
- C.F.D.T. = Compagnie Française pour le Développement des Fibres Textiles,
13, rue Monceau, 75008-Paris, France.
- C.I.D.T. = Compagnie Ivoirienne pour le Développement des Fibres Textiles,
Abidjan, Ivory Coast.
- C.N.R.A. = Centre National de Recherche Agronomique,
Bambey, Senegal.
- FAC = Fonds d'Aide et de Cooperation, 20, rue Monsieur, Paris, France.
- FAO = Food and Agriculture Organization of the United Nations,
Via delle Terme di Caracalla, 00100-Rome, Italy.
- FED = Fonds Européen de Développement,
200, rue de la Loi, Brussels, Belgium.
- GTZ = Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency
for Technical Cooperation),
Postfach 5180, 6236 Eschborn 1, Federal Republic of Germany.
- IBRD = International Bank for Reconstruction and Development ("World Bank"),
1818 H Street, N.W., Washington, D.C. 20433, USA.
- ILCA = International Livestock Centre for Africa,
P.O.B. 5689, Addis Ababa, Ethiopia.
- N.I.A.E. = National Institute of Agricultural Engineering,
Wrest Park, Silsoe, Bedford, MK45 4HS, United Kingdom.
- SODEPRA = Société pour le Développement de la Production Agricole,
Abidjan, Ivory Coast.
- UNDP = United Nations Development Programme,
1, United Nations Plaza, New York, 10017, USA.
- UNIDO = United Nations Industrial Development Organization,
Felderhaus, Rathausplatz 2, 1010 Vienna, Austria.
- USAID = United States Agency for International Development,
Washington D.C., 20523, USA.

3.7 Manufacturers of animal-drawn implements in Africa¹⁾

The majority of the manufacturers of animal-drawn implements and carts listed here have been or are still being promoted by the various development cooperation organizations. These small companies are on the whole far too few in number to ensure that the increasing requirements can be met on a permanent basis.

However, the manufacturers in many cases have immense problems in procuring raw materials and producing goods of an adequate quality. There are therefore still numerous opportunities for development and promotion, for in some African countries these small enterprises can undoubtedly initiate a certain process of industrialization.

1. West Africa

- BENIN : a) COBEMAG, Parkoua
b) MECANELEC, Cotonou
- GHANA : a) AGRICO Agricultural Engineering Ltd., Accra
b) Northern Engineering Company, Tamale
- IVORY COAST : a) APIDJAN INDUSTRIES, Abidjan
b) IVOIRE-OUTILS, Abidjan
- MALI : SMECMA (= Société Malienne d'Etudes et de Constructions des Matériels Agricoles), Bamako
- NIGER : SONIFAM/SEFAMAG (= Société Nigérienne de Fabrication des Matériels Agricoles), Niamey
- SENEGAL : SISCOMA (= Société Industrielle Sénégalaise de Constructions Mécaniques et des Matériels Agricoles), B.P. 3214, Dakar
- UPPER VOLTA : ARCOMA (= Agence Rurale de Construction de Matériels Agricoles), Ouagadougou and Bobo-Dialasso

2. East Africa

- ETHIOPIA : a) Ethiopian Metal Tool Co. Ltd., Addis Ababa
b) CADU Working Industries, Asella
- KENYA : a) NDUME Ltd., Gilgil, P.O.Box 62
b) "Ploughs and Allied Instruments", Kisumu, P.O.B. 467
c) "Agricultural Implements"/Nakuru Industrial Estates, Nakuru
d) IDEAL CASEMENTS Ltd., P.O.B. 45319, Nairobi
- MADAGASCAR : SIDEMA (= Société Industrielle pour le Développement du Machinisme Agricole), B.P. 14, Tananarive
- MALAWI : a) AGRIMAL Ltd., P.O.B. 143, Blantyre
b) Brown and Chapperton Group, P.O.B. 1528, Blantyre
c) Petroleum Services (Malawi) Ltd., Ginnery Corner, P.O.B. 1900, Blantyre

1) This section does not claim to be exhaustive.

- TANZANIA : a) UBUNGO-Farm Implements, P.O.B. 20126,
Dar es Salaam
b) TAMTU (= Tanzania Machinery Testing Unit),
P.O.B. 14, Arusha

3. Central Africa

- CAMEROON : TROPIC, B.P. 706, Douala

4. Southern Africa

- ZIMBABWE : a) Albert Amato & Sons, P.O.B. 2277, Salisbury
b) Arian & Co. F.D. (Pvt) Ltd., P.O.B.1802, Salisbury
c) Bulawayo Steel Products, P.O.B. 1603, Bulawayo
d) Mealie Brand Products, P.O.B. 1059, Bulawayo
e) Pennel (Pvt) Ltd., R., P.O.B. 3375, Bulawayo
f) Purcell Engineering (Pvt) Ltd.,
P.O.B. Waterfalls, Salisbury
g) Rhoplw Ltd., P.O.B. 1059, Bulawayo

5. Addresses of manufacturers of wheeled tool carriers

Ets. Mouzon, Construction de Machines Agricoles,
B.P. 26, 60250 Mouy (Oise), France

SISCOMA, B.P. 3214, Dakar, Senegal

National Institute of Agricultural Engineering
Overseas Division, Wrest Park, Silsoe,
Bedford MK45 4HS, United Kingdom

Mekins Agro-Industrial Enterprises,
S-16, EEI Estate Phase II, Balanagar,
Hyderabad - 500 037, India

Vicon Ltd., 35/5 Langford Road,
Bangalore - 560 025, India

Medak Agricultural Centre (Equipment)
Cathedral Compound, Medak,
Andhra Pradesh - 502 110, India

The use of draught animals as a form of agricultural mechanization is already comparatively widespread in places where local craftsmen already manufacture drawn implements and carts using available materials (Figs. A/6 and A/7), for small production facilities of this type are only worthwhile in the long term if there is a sufficiently heavy demand by the rural population.

In a few African countries animal drawn tool carriers are of importance. In future, there is a good chance for their further promotion and utilization. Some addresses of well-known manufacturers are given above.¹⁾

1) Based on ICRISAT Information Bulletin No. 8. Additional information can be obtained at the International Crops Research Institute for the Semi-Arid Tropics P.O.B. 502 324, Andhra Pradesh, India.



Fig. A/7: Old passenger-car axles - which are, however, relatively scarce in African countries - are particularly suitable for manufacturing animal-drawn transport carts. Local carpenters can usually make the necessary cart bodies themselves using available wood as shown here in Kenya. (Photo: Munzinger)

4. Conditions restricting the use of draught animals and the factors influencing them

Before a specific type of agricultural mechanization can be introduced as an innovation into the agricultural production process it is essential to be familiar with the most important influencing factors and framework conditions which could cause the project to fail. In the case of mechanization based on animal traction the conditions restricting or even preventing the introduction or spread of the use of draught animals will be presented and briefly discussed in this section.¹⁾ Table A/5 summarizes them and shows the varying but complex interrelationships.

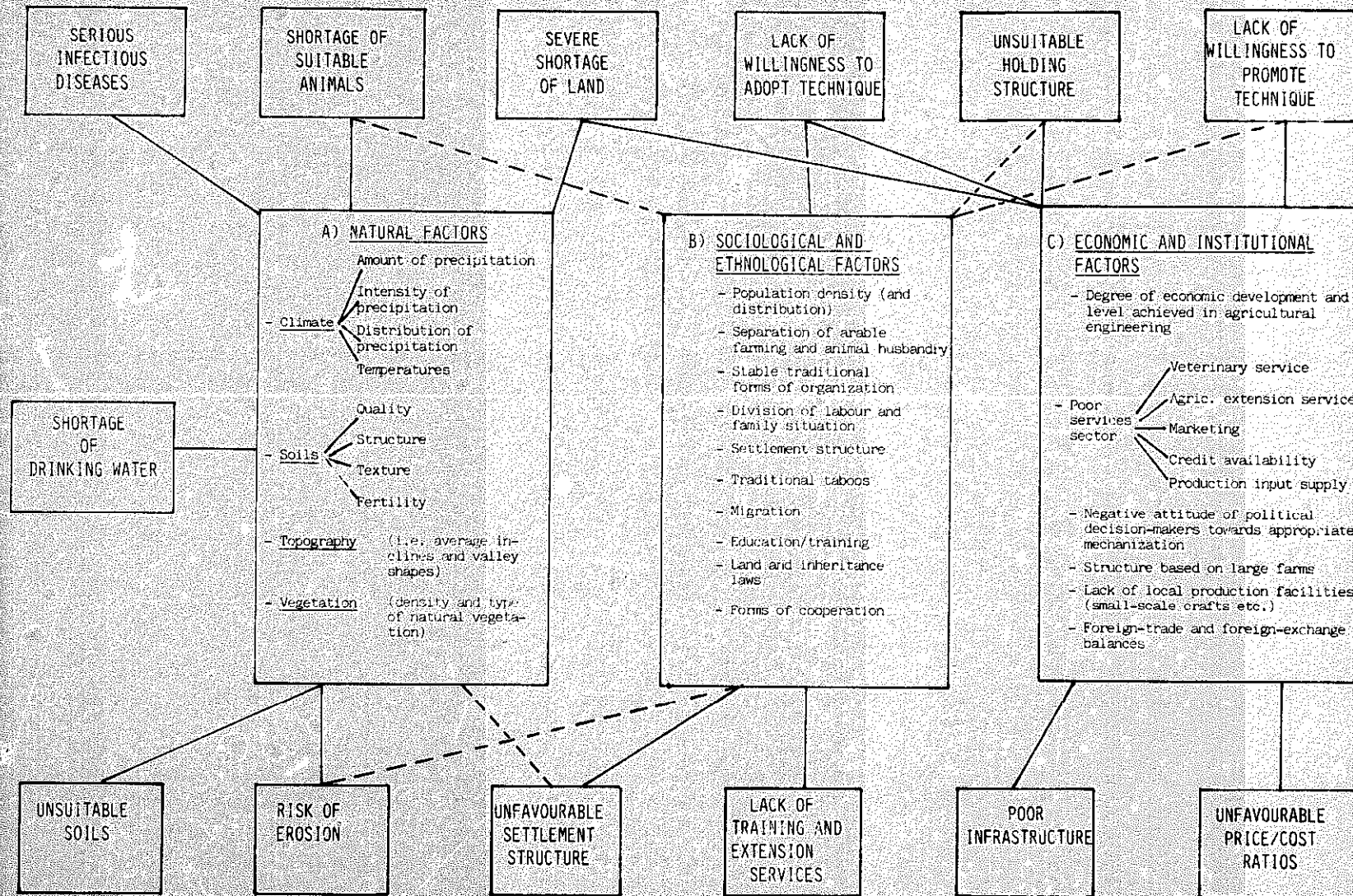
The statements made here apply mainly to African conditions, since only the factors relevant to this continent have been included. The information is essentially based on experience gained in the course of various development projects aimed at promoting animal traction.

It must be pointed out that not all the "limiting factors" given restrict the use of draught animals in general. Some of them, mostly those resulting from natural conditions, often, for example, prohibit the use of draught animals altogether. However, there are numerous examples of places where draught animals are used successfully despite relatively unfavourable framework conditions of the type described below. The aspects listed, therefore, must not be regarded as completely limiting factors, since either suitable promotional measures can be used to change the local framework conditions accordingly or the project measures to be planned can - as far as possible - be largely geared to the unchangeable factors.

The fact that local conditions vary greatly from region to region means that corresponding variations must usually be included when a project is actually being planned and a detailed and comprehensive situation analysis is therefore essential before promotional measures are started. The "checklist" given in Section 4.4 can act as a valuable guide in this area.

1) It cannot be claimed that all potential influencing factors are listed here, since other factors may well be of greater importance under specific conditions. The various aspects are discussed in more detail in the individual sections of Part B.

TABLE A/5 : CONDITIONS RESTRICTING THE USE OF DRAUGHT ANIMALS AND THE FACTORS INFLUENCING THEM¹⁾



¹⁾THE RESTRICTING CONDITIONS ARE ARRANGED SO AS TO SHOW THE COMPLEX INTERRELATIONSHIPS (— = DIRECT INFLUENCE; - - - = LIMITED INFLUENCE)

4.1 Conditions resulting from natural influencing factors

The natural conditions in a specific region are substantially more important than other framework conditions, since in most cases they are at the same time general indicators of whether agricultural production is possible at all in the region in question. The factors restricting draught animal use in Africa which arise as the result of natural conditions will therefore be set out first here and regarded as the primary limiting factors.

1. Severe shortage of land

The use of draught animals has no long-term development potential if there is a severe shortage of agricultural land and in particular of arable land. The question of extending agricultural areas as is usually done under African conditions using animal traction thereby plays a lesser role for the time being than the shortage of fodder or the possible competition between man and draught animal (given a high population density).

If there is a relative shortage of land there are possibilities for limited keeping of draught animals through the utilization of fallow areas and of wayside vegetation, harvest residues (straw, shells, etc.) or industrial waste (e.g. oil cake).

2. Shortage of suitable animals

If there are no suitable animals for draught work this form of agricultural mechanization of course cannot be introduced and the possibility of importing draught animals from other more remote regions must generally be considered only very cautiously. In such circumstances the causes of the shortage (e.g. infectious diseases) must firstly be analyzed and eliminated, which usually involves immense problems or is in many cases totally impossible.

Special breeding programmes for draught animals take a long time and may involve setbacks.

3. Serious infectious diseases

The existence of serious infectious diseases (e.g. trypanosomiasis, East Coast fever) is a major obstacle - particularly as regards the heavy livestock making suitable draught animals - preventing the spread of animal traction in areas where arable farming is

generally possible and profitable on account of the climatic conditions.

Appropriate control measures on the part of a veterinary service to be set up or promoted (see Part B/1), in conjunction with specifically directed extension services for the animal owners, may be successful in that the keeping of heavy livestock, and thus the use of draught animals, becomes possible. Such schemes, however, entail heavy expenditure, which can jeopardize all measures in the area of animal traction from the economic point of view. When a project is being planned in this field, corresponding cost-benefit considerations must therefore be taken into account beforehand. The comparatively complex problems involved in providing a good veterinary service, together with the possible introduction and/or rearing of disease-resistant breeds, should be analyzed in as much detail as possible.

4. Shortage of drinking water

A shortage of drinking water available throughout the year occurs in all arid and many semi-arid regions of Africa and is therefore a serious limiting factor. Insofar as arable farming is possible at all in oases or as a result of short rainy seasons, it must be determined on a case-to-case basis whether it is nevertheless practical in economic terms to spread the use of draught animals by sinking wells, possibly in conjunction with irrigated fodder-growing

5. Unsuitable soils

The existence of particularly heavy, shallow, stoney or root-filled soils can severely restrict the use of draught animals, since either the animals cannot provide the necessary traction power or tilling of the soil is not possible in general.

A number of measures can help to reduce this problem, such as:

- tilling of the soil at the optimum time,
- use of several teams, particularly on heavy soils (the economic aspects of keeping several teams must be borne in mind),
- use of tractors for clearance and initial tilling after clearance (possibly in conjunction with loosening of the subsoil in particularly shallow soils),
- selective removal of pebbles, stones, roots etc.

6. Risk of erosion

Regions where there is a serious risk of erosion as a result of extreme topography, insufficient vegetation, poor soil quality, heavy and sudden precipitation or strong winds are less suitable for the use of draught animals. Existing erosion tendencies may be increased still further by inappropriate use of ploughs, treading down of the ground by the draught animals, overgrazing etc.

Particularly if there is a severe average gradient (more than 15-20%) and the road network is consequently poor, use of draught animals is only possible for the most part in the flat valleys.

If the use of draught animals is nevertheless to be promoted in such regions on account of other factors, the following measures would be possible ways of improving the framework conditions (cf. also Part B/III):

- tillage and planting along the contour lines (contour ploughing) with simultaneous creation of erosion-prevention strips,
- creation of terraces with appropriate planting of their edges,
- introduction or promotion of the cultivation of ridge-grown crops,
- improvement of the soil through the use of (farmyard) manure,
- control of surplus water in conjunction with road construction.

4.2 Conditions of sociological and ethnological origin

Experience in development policy to date has shown that with any type of development promotion sociological and ethnological influencing factors in particular play a major role alongside the natural, institutional and economic conditions. Project planning has often failed to take sufficient account of socio-ethnological questions, which in part explains the failure of many development endeavours. This also applies in particular to the promotion of agricultural mechanization.

It is essential to be as familiar as possible with the conditions discussed below, for they are closely related to one another and to the natural and economic influencing factors.

These "limiting factors" will be treated in more detail in Part B/V.

1. Lack of willingness to adopt technique

The willingness of the target group to adopt innovations forms the basis for successful change in the case of any innovation forming part of a development process. If there is no such willingness, a state of affairs which may itself in turn stem from numerous widely varying sociological, economic and ethnological causes, and if this willingness cannot be created even by exerting a certain amount of influence, any attempt to actually introduce the innovation in question is usually doomed to failure.

When applied to the use of draught animals as an innovation this may mean, for example, that

- traditional behaviour or specific taboos (e.g. women are not allowed to touch ploughs);
- tried and experienced forms of division of labour and employment structure;
- stable, restrictive and/or traditional forms of organization;
- other objectives, e.g. not connected with agriculture

together with various other influencing factors prevent adoption of the innovation. This can happen even if the use of draught animals as an innovation is offered only to a specific target group as part of a specific development programme.

Before corresponding development projects are started, therefore, it is essential to carry out detailed sociological studies in order to determine beforehand to a very large extent the aims, and willingness to adopt innovations, of the envisaged target groups.

2. Unfavourable settlement structure

An unfavourable settlement structure, e.g. widely scattered settlements with no corresponding links, possibly resulting from

- low population density,
- marginal availability of arable land,
- specific land use systems (e.g. shifting cultivation over wide areas),
- ethnic conflicts

has in some cases proved to be a major factor limiting the introduction of animal traction (e.g. in certain parts of Zambia and Angola).¹⁾

A generally poor infrastructure, a lack of marketing opportunities and limited operation of extension and veterinary services usually serve to reinforce this negative effect.

In some places attempts have therefore been made, parallel to the promotion of animal traction, to implement resettlement campaigns or to move the farmers trained as draught-animal owners as part of a corresponding project to other regions or village communities (e.g. in north-west Cameroon, see case study I in Part C). Reports on such action are seldom positive and the experience gained has not yet been sufficiently evaluated.

3. Lack of training and extension services

No development process can be successfully started without a minimum amount of training or extension services. The word "training" is to be taken in its broadest sense, i.e. ranging from basic reading and writing skills to simple but permanent agricultural extension services.

As far as long-term adoption of draught animals is concerned, it has become apparent in many cases in the course of promotional measures that smallholders receiving relatively intense training and continuous advice on the keeping and use of draught animals have not only adopted this innovation earlier but also continue to use it in the long term.²⁾ Farmers without any training at all frequently refuse to participate in corresponding programmes or, having initially adopted the innovation, return to their traditional land use systems at the first sight of setback or failure (e.g. loss of a draught animal through sickness or death, breaking of implements supplied).

The inadequate level of training and lack of permanent extension services for the target group must therefore also be included among the factors hindering the spread of animal traction.

1) Author's findings on the basis of various discussions with development experts from these countries.

2) cf. for example case study II in Part C of the handbook.

4.3 Conditions resulting from economic and institutional influencing factors

In addition to the limiting factors already mentioned various economic and institutional aspects in African countries have a restrictive effect on the spread of the use of animal traction. Depending on the situation and level of development of the country, region or district involved, these elements have complex and highly interdependent causes and it is therefore inappropriate to consider and analyze these points in isolation from the relevant interrelationships. In order primarily to increase awareness of the complex relationships only the most important aspects which must be considered during the planning process will be listed and briefly discussed here. A more detailed examination is always necessary in actual practice.

Some of the "potential limiting factors" referred to below are also subject to changing influences, e.g. if political changes occur in the country in question, usually bringing with them a new economic orientation and different development policy objectives.

1. Lack of willingness to promote techniques

The insufficient or non-existent willingness of political (and economic) decision-makers to make increased use of "intermediate" or "appropriate" technologies - which, on the basis of our definition, include the use of animal traction in the agricultural production process - must be regarded as the most important limiting condition alongside the aspects based on natural influencing factors.

The negative effect of this factor is often reinforced by:

- the clear preference of local political decision-makers for so-called "modern" agricultural mechanization and
- the partial inability of those responsible to coordinate various efforts in agricultural mechanization which are frequently determined or at least heavily influenced by external forces and interests (e.g. attempts by agricultural engineering companies to open up a market).

Possible ways of changing such situations involve the specific advising and informing of the governments and administrations concerned on the advantages of draught animals for both individual

farms and the economy as a whole. A positive influence could be exercised here, for example, by correspondingly motivated government advisors who could formulate mechanization strategies geared specifically to the agriculture in the country in question.

2. Unsuitable holding structure

An agrarian structure based markedly on large enterprises, e.g.

- state-run farms,
- operational large-scale farms, either run privately or on a cooperative basis, and
- large plantations

is a less favourable precondition for the promotion or introduction of animal traction. Under African conditions the use of draught animals is at present mainly economically practical for small and medium-sized holdings (up to around 25 hectares). However, local conditions may limit this statement accordingly.

Draught animals can certainly also be used on large farms, as is indicated, for instance, by positive results in Tanzania and Brazil. Under present conditions, however, tractor technology is usually still more profitable for well-organized large holdings. This may accordingly have negative repercussions for smallholdings as far as the rejection of animal traction is concerned if smallholdings using animal-drawn implements are forced to operate in the same region as efficient large farms using tractors.

Experience gained to date has shown that such project measures can be successful only if the economic improvements for the smallholders resulting from the use of draught animals are substantially more attractive than those which could possibly be achieved through cooperative tractor usage above single-farm level.

3. Poor infrastructure 1)

When defining the poor infrastructure of a country or project region as a condition restricting the introduction or promotion of animal traction, it must be borne in mind that, as experience has shown, tractor-based agricultural mechanization places far heavier demands on the existing (or still to be created) infra-

1) A number of individual factors limiting the use of draught animals have been combined under the heading "Poor infrastructure" in order to simplify matters (see Diagram A/6). The points concerning the agricultural "services sector" could of course also be given as individual limiting factors if they did not exist or did not operate efficiently.

structure. However, the demands imposed by the two forms of mechanization differ greatly in part, i.e. they are characterized by varying individual aspects.

Whereas the primary requirements of tractor technology, for example, are a good road and track network, the availability of efficient repair workshops with well-trained personnel and a guaranteed spare-part supply, draught animals can only be successfully introduced on a long-term basis if

- there is an efficient veterinary service;
- there is an agricultural extension service dealing with the appropriate topics;
- credit and/or subsidy programmes for the target group among the farmers are in existence and are implemented;
- the (additional) produce obtained through the use of draught animals can be marketed profitably and at the right time (preferably without transport and storage problems);
- the supply of agricultural production inputs (e.g. seed, mineral fertilizer and - especially for the draught-animal owners - the necessary implements and spare parts) is guaranteed to some extent.

Some of these requirements apply to all types of agricultural or agricultural-technology development measures, but they have a relatively restrictive effect if not fulfilled, particularly when the introduction of animal traction is involved. As long as the individual farms cannot be appropriately supported, supplied and assisted and as long as they have no adequate marketing opportunities, animal traction, too, as a form of "appropriate" agricultural mechanization can be introduced only very slowly, if at all.

Even if the majority of farmers in a region have a positive attitude towards the use of draught animals - mostly in areas where animal traction has already been used for some time to a certain extent - a continued shortage of suitable (or improved) drawn implements, for example, may considerably restrict the further spread of the technique.

The reason for the lack of a sufficient quantity of implements is often the fact that most countries have no local production possibilities (cf. also Tables A/1 - A 4) and cannot finance imports themselves due to a lack of foreign exchange.

Such situations can be partially improved by a number of important development-policy measures, such as:

- Promotion of local craft industry and local production facilities (small workshops and factories etc.);
- Facilitation of the import of appropriate implements or the raw materials necessary for local production (if the country in question lacks resources of its own);
- Provision of credits and/or subsidies for implement procurement by individual farmers.

4. Unfavourable price/cost ratios

One factor imposing particular restrictions on the economic development of most African holdings, particularly the smallholdings with a relatively high proportion of subsistence farming, is constituted by unfavourable ratios between the price of the produce and the cost of the production inputs required. This is particularly true as regards the introduction or spread of innovations requiring substantial capital.

Use of animal traction calls for relatively heavy investment on the part of the individual farmer (or his family) in order to provide draught animals and implements. In most cases this investment is - in the long term - profitable only if a sufficiently high price level can be guaranteed for the produce and if the production inputs also required can be made available at economically appropriate prices. Agricultural credits and/or subsidy programmes are often the only effective ways of providing these guarantees.

When a development project of this type is being planned, therefore, such programmes must be provided for as early as possible; the target in the long term should be to stabilize agricultural producer prices at a suitable level.

In many cases it is possible to initiate actual project measures aimed at meeting the above-mentioned conditions or overcoming almost

all limiting factors. These activities must then often be regarded as supplementing the actual project measure "Introduction (or promotion) of the use of draught animals". Additional funds must be earmarked accordingly and the necessary local personnel trained for implementation of the measures.

4.4 "Checklist" for planning animal-traction projects

The checklist given here is intended essentially for use in an "ex-ante" situation analysis during the planning of development projects involving the introduction or promotion of the use of draught animals. It thus provides a series of guidelines briefly listing all the major criteria which must be examined or borne in mind under African conditions in conjunction with the use of draught animals.

The list is divided up in accordance with Part B of the handbook, since in some cases reference must be made to sections within Part B in order to aid understanding and clarify various points. The subject matter of the individual sections of the checklist was largely compiled by the relevant authors of Part B.¹⁾

In view of the fact that data collection is of fundamental importance in the analysis and particularly in the planning of development projects the following basic principles should be borne in mind:

1. The aims of the investigation have a decisive influence on the information level required for decision-making during planning. In many cases a qualitative answer is sufficient, whereas in others detailed data are necessary.
2. The available resources (funds, non-cash resources and personnel resources) should if possible be known before planning starts.
3. The level of development of the country or region must be taken into account.
4. The type of project or programme determines the complexity of the investigation. If there is a low degree of complexity simplified investigation methods may be chosen.

1) When using the checklist it is not essential to take the individual items in the order given here. In individual cases it may be more practical to combine sections in a manner other than that shown here.

5. It must be determined before project planning starts what information will be required in the course of time and to what extent information will become available during project implementation (and whether it can be further used).
6. The credibility gap, which the information can have in order to remain useable, should be determined.
7. It should be established what degree of latitude the data can have to ensure that the planning result still falls within a reasonable divergence range.
8. The principles of comparability, classifiability and completeness of data must also be observed.

These fundamental considerations are intended to lead to optimum assessment of the expenditure required for data collection.

The most important forms of data collection are by means of questionnaires and observation; the former may be either written or oral.

Some of the aspects mentioned in the "checklist" can be investigated only through observation.

"CHECKLIST FOR PLANNING DEVELOPMENT PROJECTS INVOLVING USE OF DRAUGHT ANIMALS

Basic information to ascertain the current situation	Necessary considerations for further planning (and text references)
<p>A) <u>GENERAL BASIC DATA ON COUNTRY (OR PROJECT REGION)</u></p> <p>1. <u>National economy:</u></p> <ul style="list-style-type: none"> - Size of country (or project region) - Gross National Product (total and per capita) and development of the same in recent years. - Natural resources (extent of development and exploitation) - Individual sector's share of the overall economy (e.g. agriculture) - Economic links (e.g. trading partners and development of exports and imports) - Development of balance of payments and balance of trade - Infrastructure (roads and railways, part etc.) <p>2. <u>Demographic structure:</u></p> <ul style="list-style-type: none"> - Total population (and distribution of same) - Population growth - Proportion of employed persons in individual sectors of economy - Migration trends - Level of education of over-all population - Number of holdings (and breakdown of same into size categories) <p>3. <u>Climatic data and basic ecological information:</u></p> <ul style="list-style-type: none"> - Amount and distribution of precipitation (rainy and dry seasons) 	<p>Influence on agricultural meachnization! Attitude of political decision-makers to appropriate mechanization?</p> <p>Number and use of imported agricultural machines! Dependence relationships as regards spare-parts supply!</p> <p>Influence on potential labour force in rural areas!</p> <p>See Section B/IV</p> <p>Compare figures obtained over as many years as possible and include non-occurence risks in planning.</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<ul style="list-style-type: none"> - Special climatic features - Natural vegetation (possibly broken down by region) - Erosion tendencies 	
<p>B) <u>SPECIFIC BASIC DATA ON USE OF DRAUGHT ANIMALS</u></p>	
<p>I. ANIMAL HUSBANDRY AND VETERINARY ASPECTS</p>	
<p>1. <u>Total livestock population (in country/project region):</u></p>	
<p>1.1 Cattle (number, herd structure, herd development)</p>	<p>Availability of draught cattle (Section B/I/1)</p>
<p>1.2 Horses, donkeys, mules (numbers, annual herd development)</p>	<p>Availability of other draught animals (Section B/I/8)</p>
<p>1.3 Small ruminants and other domestic animals kept for economic purposes</p>	<p>Competition for fodder</p>
<p>2. <u>Situation of animal traction (at start of planning):</u></p>	
<p>2.1 Draught cattle</p>	<p>Preference among target groups for specific draught animals?</p>
<p>2.2 Horses, donkeys, mules</p>	
<p>2.3 Conditions for training draught animals.</p>	<p>Organization and planning of draught-animal training by the project (Section B/I/2.1)</p>
<p>3. <u>Potential and availability of draught animals:</u></p>	<p>Is there a need for project measures to increase reproduction?</p>
<p>3.1 Potential</p>	
<ul style="list-style-type: none"> - Available types/breeds and their suitability (liveweights) 	<p>Effort required for the draught work to be done.</p>
<ul style="list-style-type: none"> - Estimated numbers per breed/type, herd structure and development 	
<ul style="list-style-type: none"> - Current use of young male and female animals (reproduction, fattening, draught work) . 	<p>Potential rivalry due to measures promoting industrial or peasant fattening operations.</p>
<p>3.2 Availability</p>	
<ul style="list-style-type: none"> - Management systems 	<p>Production of draught animals by the farms themselves?</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<ul style="list-style-type: none"> - Willingness of traditional livestock owners to sell young animals. - Traditional marketing of young animals - Prices, pricing, price fluctuations, price trends in recent years. 	<p>Measures to increase willingness to sell and develop marketing structure?</p> <p>Determination of optimum time for purchase (see Section B/IV/2)</p>
<p>If the availability analysis for the <u>project region</u> reveals that not enough draught animals are available in the area the analysis must be extended to cover <u>neighbouring regions</u> or if necessary more distant parts of the country. In addition to the data listed in Item 3 the following information must then be obtained:</p>	
<p>3.3 Transportation of young animals</p> <ul style="list-style-type: none"> - Means of transport and veterinary care during transportation - Organization of transportation, responsibility, transport costs. 	<p>Observe veterinary legislation!</p>
<p>4. <u>Fodder supply and types of fodder for draught animals:</u></p>	<p>(See Section B/III/8)</p>
<p>4.1 Availability of fodder (amount, seasonal availability, current use, if necessary cost of providing fodder)</p>	<p>Measures to improve pasture capacity. Possibility of increasing amount; possibility of better utilization; possibility of selective fodder shrub cultivation.</p>
<p>4.2 Fodder nutritive values</p> <ul style="list-style-type: none"> - Availability of nutritive values at regional or national level - Nutritive-value analyses necessary. 	<p>(See Section B/I/3)</p>
<p>4.3 Drinking-water supply availability, seasonal variations, quality, if necessary cost).</p>	<p>(See Section B/I/3.1)</p> <p>Consideration of the water requirements resulting from the project, apart from water for draught cattle (e.g. irrigation).</p>
<p>4.4 Traditional feeding practices</p>	
<p>5. <u>Draught animal management</u></p> <ul style="list-style-type: none"> - Housing - Care - Minding and pasturing conditions - Reproduction techniques 	<p>(See Section B/I/4)</p> <p>Situation on individual farms based on local price/cost ratios.</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<p>6. <u>Veterinary situation</u> (at national, regional and local level):</p> <p>6.1 Endemic and sporadic diseases affecting draught animals.</p> <p>6.2 Structure of (existing?) veterinary service</p> <ul style="list-style-type: none"> - Administration and organization - Personnel and finances <p>6.3 National veterinary programmes and legislation</p> <p>6.4 Veterinary pharmaceutical products</p> <p>7. <u>General structure of draught-animal market:</u></p> <ul style="list-style-type: none"> - Livestock markets, livestock dealers, marketing organizations - Livestock trails - Price situation and demand for animals (for slaughtering) 	<p>(See Section B/I/5)</p> <p>Consideration of potential diseases which are not widespread but which may occur among draught animals under stress!</p> <p>Possibility of calling upon farmers to pay for veterinary services?</p> <p>(See Section B/I/7 and Section B/IV/2)</p>
<p>II. AGRICULTURAL ENGINEERING</p>	
<p>1. <u>Situation and development of agricultural mechanization</u></p> <ul style="list-style-type: none"> - Holdings using manual labour - Holdings using draught animals - Holdings using tractors (at single-farm and multi-farm level) <p style="margin-left: 150px;">} Nation-wide and/or regional</p> <ul style="list-style-type: none"> - Number of agricultural machines (tractors and implements) imported annually (customs regulations!!!) - Number and regional distribution of repair workshops and spare-part suppliers 	<p>Possibilities for extending the individual forms of mechanization?</p> <p>Promotion measures for mechanization generally practical or already introduced?</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<ul style="list-style-type: none"> - Preference for tractors - draught animals <p style="margin-left: 150px;">} Among target group and political decision-makers</p> <ul style="list-style-type: none"> - Number of contractors, cooperatives etc. using or hiring out tractors <p>2. <u>Manufacture of agricultural machines and implements:</u></p> <ul style="list-style-type: none"> - Industry or local craftsmen - Types of machines and implements produced (specially for use with draught animals?) - Supply of raw materials (national resources, import regulations) 	<p>Possible and practical to exert influence?</p> <p>Support already available or necessary?</p> <p>Possible and advisable to provide know-how? (Other types of implements); (see Section B/II/3)</p>
<p>III. CROP FARMING</p>	
<p>1. <u>Cultivation by holdings</u> (nationwide and region specific):</p> <ul style="list-style-type: none"> - Subsistence crops - Cash crops - Permanent crops (on plantations) - Export crops - Fallow and pastureland <p style="margin-left: 150px;">} Proportions on each holding and in total agricultural production</p> <p>2. <u>Natural vegetation and clearance:</u></p> <ul style="list-style-type: none"> - Type of natural vegetation (savannah, rainforest etc.) - Degree of difficulty in clearing unused areas (availability of heavy clearance equipment, labour requirements). 	<p>Can cultivation be mechanized using draught animals or are alternatives required?</p> <p>Change in cultivation techniques necessary if draught animals introduced?</p> <p>(See Section B/III/2 and 3)</p> <p>Utilization of timber!</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<p>3. <u>Soils and soil tillage:</u></p> <ul style="list-style-type: none"> - Quality of existing soils nutrient content, texture, structure, suitability for mechanical tillage etc.) - Traction power required for tillage - Possibility and necessity of irrigation (and possible function of draught animals) <p>4. <u>Topography and erosion</u></p> <ul style="list-style-type: none"> - Suitability of topography for arable farming (or mechanical tillage) - Nature and extent of existing erosion damage - Measures initiated to maintain and improve soil - Gradients, valleys and erosion hazards 	<p>Need for cultivation-related measures to improve soil? (See Section B/III/4)</p> <p>(See Section B/II/2)</p> <p>Traditional water rights!</p> <p>(See Section B/III/5)</p>
<p>IV. ECONOMIC ANALYSIS AND EVALUATION</p> <p>1. <u>Individual farms</u> (to supplement I-III)</p> <p>1.1 Types of existing farms</p> <ul style="list-style-type: none"> - Family farms - Hired-labour farms - State-run farms - Cooperatives and farms with joint management <p>1.2 Type of production by farms</p> <ul style="list-style-type: none"> - Exclusively arable farming - Exclusively livestock husbandry (nomads, ranches, etc.) - Mixed farms - Farms with irrigated areas 	<p>Fundamental data on individual farms are the basis for comparative profitability calculations (see Section B/IV/2)</p> <p>Rights of ownership of draught animals and implements!</p> <p>Possibility of using machines and implements on a multi-farm basis</p> <p>Possibility for use of draught animals at all?</p> <p>Integration of arable farming and livestock husbandry practical and possible in the long term?</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<p>1.3 Capacity of farms</p> <ul style="list-style-type: none"> - Labour force (family labour, hired labour, seasonal labour) - Land reserves (fallow, pastureland, irrigable areas) for use of draught animals - Intensification potential (perhaps by means of non-agricultural possibilities) - Other capacities 	<p>Labour released by mechanization?</p> <p>Possible to expand agricultural area!</p>
<p>1.4 Yield level of farms (estimates may be necessary)</p> <ul style="list-style-type: none"> - Yield from subsistence crops - Yield from market crops - Yield from other agricultural produce - Non-agricultural yields and additional farm income 	<p>Determination of competitiveness of various production methods using draught animals!</p>
<p>1.5 General farm management data</p> <ul style="list-style-type: none"> - Working periods (available working days per period) - Produce prices (subsistence and market produce) 	<p>(See Section B/IV and the basic data for the farm economics calculation given there)</p>
<p>1.6 Farm infrastructure</p> <ul style="list-style-type: none"> - Suitability of tracks (paths) for use of draught animals - Average distances between fields and farmyards (village) - Special infrastructure features (of the region) 	<p>Need for improvement!</p>
<p>2. <u>National economy</u> (to supplement A/1):</p> <p>2.1 General information</p> <ul style="list-style-type: none"> - Development policy targets of the country and attitude of government/local authorities to draught animals - Previous measures to promote agricultural mechanization 	<p>The analysis of the overall economic effect of the use of draught animals must always be considered in conjunction with other possible forms of agricultural mechanization (see Section B/IV/3)</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<ul style="list-style-type: none"> - Other important information for assessing the advisability (for the national economy) of promoting animal traction <p>2.2 Overall economic cost-benefit analysis of draught animal use</p> <p>a) <u>Possible benefits:</u></p> <ul style="list-style-type: none"> - Additional revenue from individual crops - Increased net value added through increase in income - Improved income distribution - Positive employment effects - Positive effects on balance of payments through foreign-exchange revenue from exports <p>b) <u>Possible costs and expenditures:</u></p> <ul style="list-style-type: none"> - Credit and subsidy programmes - Improvement of extension service - Support of veterinary service - Promotion of local production of implements and spare parts - Land improvement and infrastructure measures - Other costs relating to the national economy 	<p>Bear in mind effect on other countries (regions)!</p> <p>Often only an estimate possible</p> <p>When deciding for or against use of draught animals the benefits must be set against the costs!</p> <p>When calculating the cost of "services" (extension and veterinary services) the countries' budgetary limitations must be taken into account, together with the frequent shortage of trained personnel.</p>
<p>V. SOCIOLOGICAL AND ETHNOLOGICAL ASPECTS</p>	
<p>1.1 Socio-economic and demographic conditions</p> <ul style="list-style-type: none"> - Population density, distribution and growth (assessment of general trends: population development (land shortage?); commercialization; governmental or private economic and development programmes) - Types of village and settlement of existing ethnic groups 	<p>(See Section B/IV/2)</p> <p>The aspects mentioned must be investigated and their effects on the spread of draught-animal use examined.</p>

Checklist (continued)

Basic information for recording the situation	Necessary considerations for further planning (and text references)
<ul style="list-style-type: none"> - Education, health services, communication centres (e.g. markets) - Land use systems and land ownership distribution (is traditional common ownership or private land ownership predominant? Transitional and intermediate forms?) <p>1.2 Keeping of draught animals</p> <ul style="list-style-type: none"> - Attitude to keeping and use of heavy livestock (traditionally practised or unknown) - Are elements of livestock keeping the subject of taboos? - Are elements of livestock keeping identity features of a neighbouring ethnic group not identical with the target group? (Approximate clarification) <p>1.3 Social stratification</p> <p>Definition of high, average and low status groups on the basis of the following features:</p> <ul style="list-style-type: none"> - Distribution of livestock ownership, particularly cattle - Labour force per household (hired labour taken on?) - Area cultivated per household - Access to non-agricultural sources of income - Division of labour within family (determination of roles of men and women in production) <p>1.4 Assessment of production decisions on smallholdings:</p> <p>Subsistence-oriented (reduced risk:) or market-oriented?</p>	<p>(Section B/V/2.4)</p> <p>Do not include just the actual target group in the analysis!</p> <p>(Section B/V/2.1-2.6)</p> <p>(Section B/V/2.5)</p>

PART B

Basic aspects of the use of draught animals

B/I

**Animal husbandry and
animal health**

B/I ANIMAL HUSBANDRY AND VETERINARY ASPECTS

(I. Reh)

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1. Selection and availability of draught cattle

1.1 General selection criteria

- (1) Well developed muscles, particularly in back and hindquarters
- (2) Broad, deep chest, well-developed barrel
- (3) Short, powerful, straight limbs
- (4) Strong, hard, healthy hooves
- (5) Docility

If a withers yoke is to be used:

- (7) Powerful shoulders which do not slope too much
- (8) Presence of a hump makes it easier to fit the withers or shoulder yoke

If a head yoke is to be used:

- (9) Strong horns, neither too short nor too long (if the horns are too long the animals may get in each other's way)
- (10) Powerful neck and throat

1.2 Selection of breeds

1.2.1 Suitability of breeds

In principle all African breeds, with the exception of the dwarf breeds (lagoon cattle; Dwarf Shorthorn), are suitable for draught work. However, dwarf breeds with average live weights of less than 200 kg can be used for light transport work on relatively level and well-surfaced roads. The setting-up of a draught-cattle project based on these dwarf breeds is therefore of little relevance on account of their limited use.

1.2.2 Availability

In view of the fact that almost all African breeds of cattle, with few exceptions, are suitable for agricultural draught work, the choice of breed must be based on other considerations, the most important economic aspect being the extent of the availability of young cattle and its long-term prospects.

The price of draught cattle is influenced by the following factors:

- 1) Existence of cattle keeping on farms

- 2) Existence of nomadic herds of cattle
- 3) Readiness of cattle owners to sell their young animals
- 4) Regular cattle markets
- 5) Possible alternative uses for young cattle (e.g. farm-based or industrial-scale fattening, commercial milk production)

The local breed or cattle population available most readily and on a long-term basis enjoys the greatest advantage when the selection is made. Non-local breeds and those which may have to be imported make it more expensive to keep draught cattle as a result of high transport costs and the higher mortality rate resulting from lengthy transportation and the animals' susceptibility to sickness.

1.2.3 Required tractive effort

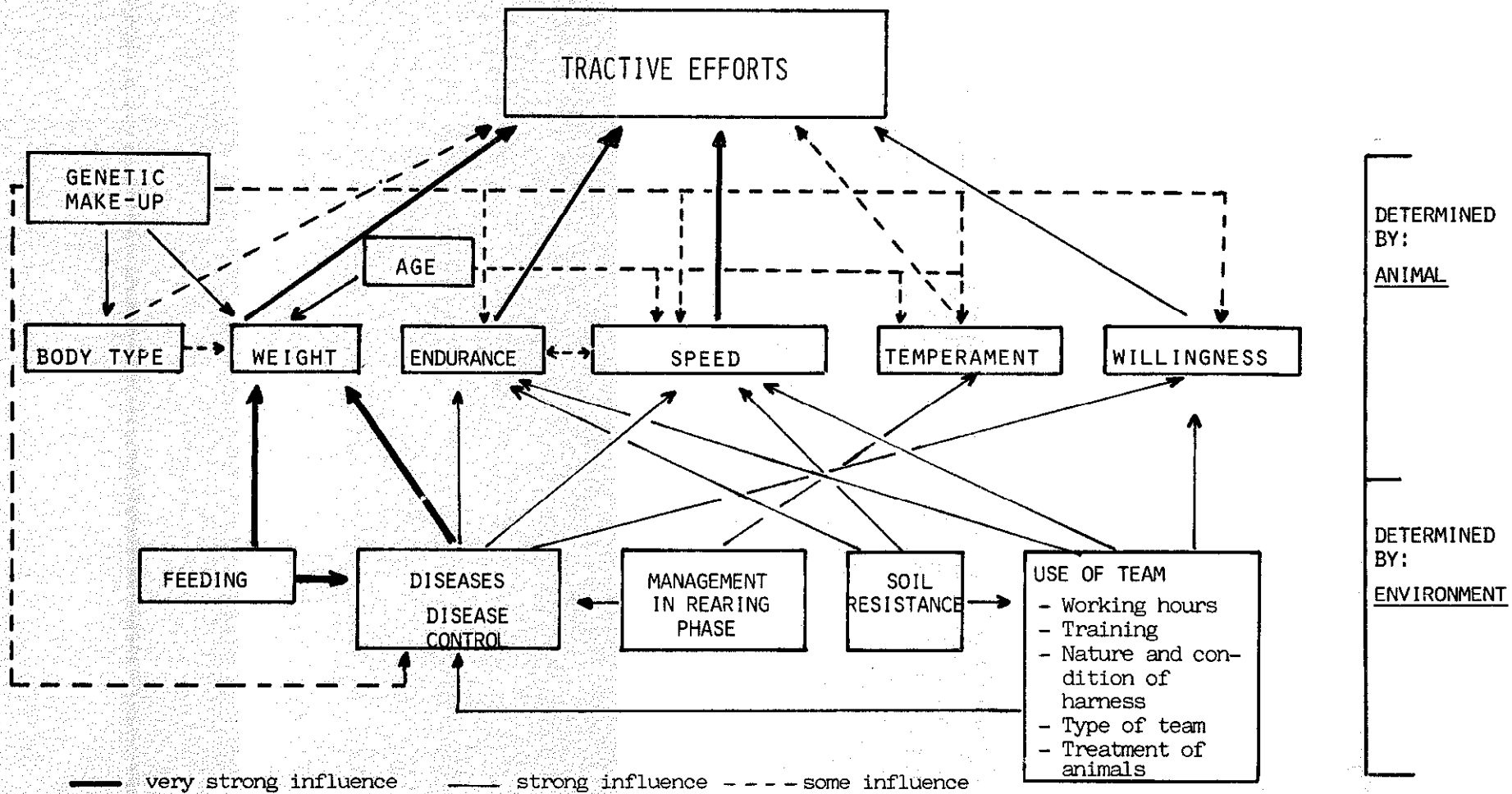
The draught work which must be performed is determined on the basis of conditions relating to arable farming and economics. The available tractive effort of the cattle is a function of various influencing factors (see Fig. B/I/1). The most important criterion is the body weight of the animals. The values for the average sustained tractive effort calculated by CEEMAT (1968) are roughly as follows:

1/10 of the body weight on uncleared land with soil containing roots and stones

1/7 of body weight on cleared land containing no shrub roots.

Maximum efforts over short periods may be four times as great as the average sustained tractive effort. Table B/I/1 gives the average live weights of a number of African breeds of cattle; if the required tractive effort is taken as a selection criterion and applied to the various breeds, it becomes clear that heavier breeds are more suitable for draught work requiring a large sustained effort.

FIG.BI/1 : DIAGRAM SHOWING THE MOST IMPORTANT FACTORS AND THEIR INTERDEPENDENCIES AFFECTING THE TRACTIVE EFFORT



The varying intensity of the influences is based on empirical data which was provided verbally and has not yet been quantified.

Table B/I/1: Average live weights of some African breeds of cattle and likely tractive effort (1/10 to 1/7 of body weight)

Breed	Type	Main areas	Average weight (kg)		Average tractive effort		Suitability for work	Actual use
			m	f	m	f		
1. WEST AFRICA								
Gobra (Senegalese Peul)	Zebu	Senegal, southern Mauretania	350	300	35-50	30-43	Good	Little
Maure Zebu (Sahel zebu)	Zebu	Mauretania, Mali, Upper Volta	350	280	35-50	28-40	Good	Yes (little)
Sudanese Peul	Zebu	Mali, Upper Volta, Niger	320	250	32-46	25-36	Good	Yes
Azouak	Zebu	Niger, northern Nigeria	350	300	35-50	30-43	Good, very quiet	Little also as beast of burden
Sokoto Gudali	Zebu	Nigeria, northern Ghana, southern Niger	450	330	45-64	33-47	Very good, endurance	Yes
White Fulani (Sud. Peul)	Zebu	Nigeria, southern Niger	350	280	35-50	28-40	Very good, quiet	Yes
Bororo: see Central Africa								
N'Dama	Taurine	Guinea, Gambia southern Senegal, Sierra Leone	280	230	28-40	23-33	Very good, endurance	Yes
Baoulé (West African Shorthorn)	Taurine	Ivory Coast, Liberia	230	190	23-33	19-27	Light draught work only	Very little
Djakoré (at station)	Zebu x taurine	Senegal, CNRA Bambey	450	350	45-64	35-50	Very good, endurance	Bred for draught work
Borgou (Keteku)	Zebu x taurine	Benin, Togo, Nigeria	260	220	26-37	22-31	Good for light work	Yes
Méré (Bambara)	Zebu x taurine	Mali	300	250	30-43	25-36	Very good, endurance	Yes, intensive
Ghana Shorthorn (Sanga), also called West African Shorthorn	Zebu x taurine	Ghana	280	220	28-40	22-31	Good	Yes

Table B/I/4 (continued)

Breed	Type	Main areas	Average weight (kg)		Average tractive effort		Suitability for work	Actual use
			m	f	m	f		
2. CENTRAL AFRICA								
Bororo (Rahaji)	Zebu	Chad, Niger	400	320	40-57	32-46	Poor, violent temperam.	No
Shuwa arab (Arab. zebu)	Zebu	Chad, Niger, Nigeria	380	300	38-54	30-43	Good, quiet	Yes, intensive
Fulbe (Adamaoua zebu)	Zebu	Cameroon, Central Afr. Republic	400	330	40-57	33-47	Good, quiet	Little
Kenana	Zebu	Sudan	450	350	45-64	35-50	Good	Yes
Western Baggara	Zebu	Sudan	350	290	35-50	29-41	Good	As beast of burden
Toposa	Zebu	Sudan	400	300	40-57	30-43	Good	Occasional
N'Dama: see West Africa								
Baoulé: see West Africa								
3. EAST AFRICA								
Barca		Ethiopia	300	240	30-54	24-34	Moderate	Yes
Arado	Zebu x sanga	Ethiopia	310	250	31-44	25-36	Good, quiet	Yes endurance
Tuni (Jiddu)	Zebu x sanga	Ethiopia	400	300	40-57	30-43	Good	Yes
Boran (unimproved)	Zebu	Kenya, Somalia Ethiopia	350	300	30-43	30-43	Good	Occasional as beast of burden
Tanzania zebu (Small East Afric. Short-horn Zebu)	Zebu	Tanzania	300	220	30-43	22-31		Little
Bukedi (S.E.A.Z)	Zebu	Uganda	380	300	38-54	30-43	Good	Yes
Nganda	Zebu x sanga	Uganda	400	330	40-57	33-47	Good	Yes
Ankole	Sanga	Tanzania, Uganda, Zaire	500	350	50-71	35-50	Good	Little
Watussi (Ankole)	Sanga	Burundi, Rwanda	420	310	42-60	31-44		No

Table B/I/1 (continued)

Breed	Type	Main areas	Average weight (kg)		Average tractive effort		Suitability for work	Actual use
			m	f	m	f		
4. SOUTHERN AFRICA AND MADAGASCAR								
Malawi zebu/ Angoni (S.E.A.Z)	Zebu	Malawi, Zambia	400	300	40-57	30-43	Good	Yes
Barotse	Sanga	Zambia, Angola Botswana	580	400	58-63	40-57	Very good	Yes, intensive
Tonga	Sanga	Zambia	500	330	50-71	33-47	Good	Yes
Landim (Nguni)	Sanga	Angola	550	380	55-79	38-54		Unknown
Nkone (Manguni)	Sanga	Zimbabwe	700	450	70-100	45-64		Unknown
Mashona	Sanga	Zimbabwe	400	300	40-57	30-50	Good	Yes
Tuli		Zimbabwe, Botswana	500	380	50-71	38-54		Unknown
Tswana	Sanga	Botswana	500	390	50-71	39-56		Occasional
Afrikander	Sanga	South Africa, neighbouring countries	700	450	70-100	45-64	Very good	Originally bred for draught work
Bonsmara	Sanga x taurine	South Africa	800	550	80-114	55-79	Good	No
Nguni (Bavenda)	Sanga	South Africa, Swaziland	500	380	50-71	38-54	Good	Yes
Madagascar zebu	Zebu	Madagascar	400	320	40-57	32-46	Good	Yes, intensive
Renitelo (station)	Zebu x taurine	Madagascar	700	450	70-100	45-64	Very good	Yes, but few animals available

1.2.4 Selection in areas infested with tsetse-flies

Trypanotolerance refers to the ability of some breeds of cattle - acquired by way of pre-immunization - to live and produce in areas with tsetse-flies. This tolerance is not the same thing as resistance, since it may break down under the effect of extremely unfavourable environmental factors, such as malnutrition, onset of other diseases, overwork or exhaustion as a result of draught work or having to walk long distances. If the tolerance collapses, animals of trypanotolerant breeds can develop trypanosomiasis in the same way as non-tolerant breeds, frequently also with fatal consequences.

Trypanotolerant breeds of cattle are to be found in the humid and semi-humid regions of Western and Central Africa infested with tsetse-flies; in contrast to the zebus they have no hump.

Findings to date indicate that the tolerance is first created on the basis of an initial infection and subsequent immunization during the calf stage and necessitates repeated reinfection if it is to remain intact. Animals of trypanotolerant breeds which were born and raised in tsetse-free areas exhibit no tolerance when they first fall victim of the disease but, if they survive, they develop a tolerance against further infections, which is not the case for non-tolerant breeds. So-called non-tolerant breeds may, however, survive mild infection without major losses if the feeding conditions are good and the animals are protected against other diseases (e.g. during fattening).

It is interesting to note that all trypanotolerant breeds are smaller than those which are semi-tolerant or non-tolerant. However, no studies are yet available on the correlation between body size/weight and the degree of tolerance within a homogeneous breed.

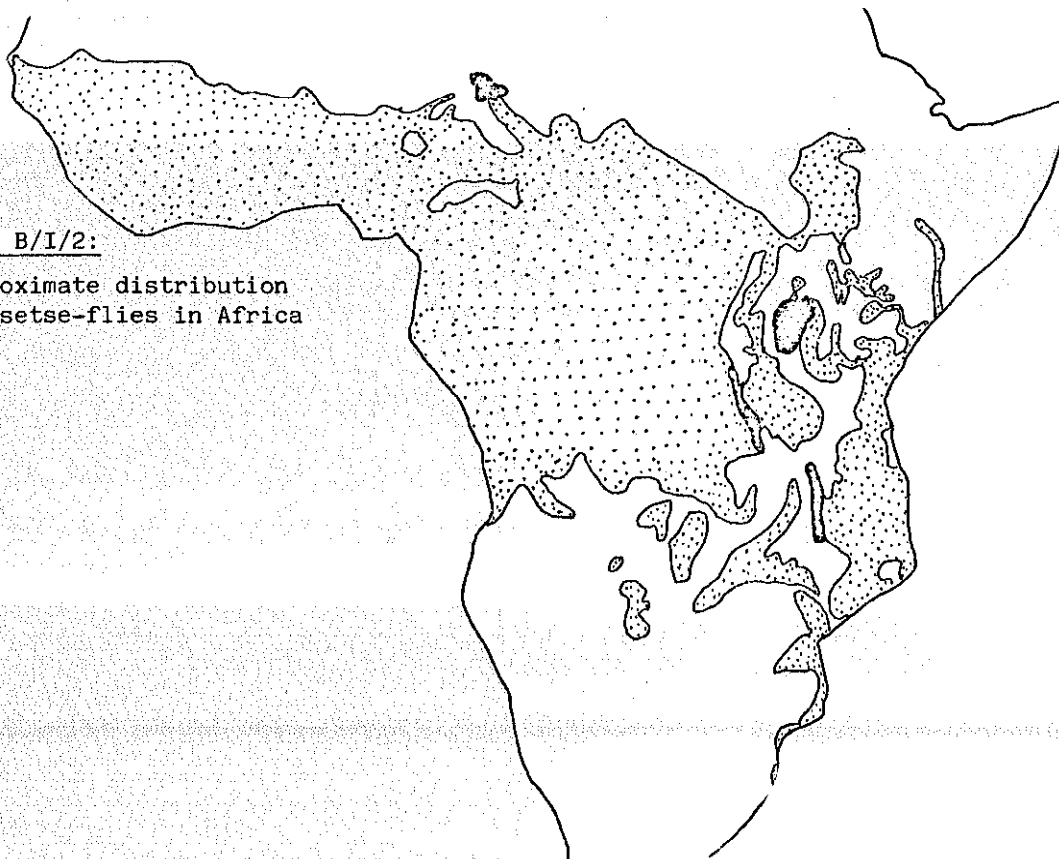
The term "semi-tolerant" is applied to crosses between trypanotolerant breeds and the non-tolerant zebus or exotic breeds of cattle. The degree of tolerance clearly decreases as the proportion of zebu genes increases and this point must be borne in mind during cross-breeding experiments.

Table B/I/2: Trypanotolerance of African breeds of cattle

Trypanotolerant breeds (main areas)	Semi-trypanotolerant breeds	Non-trypanotolerant breeds
N'Dama (Guinea, all of West Africa)	Djakoré (Senegal) Méré (Mali)	All zebus, East and Southern African
Baoulé (Ivory Coast)	Borgou (Benin) Keteku (Nigeria)	Sanga and imported performance breeds
Lagoon cattle (Togo, Ivory Coast)	Sanga (Ghana)	
Somba (Benin)	Bambara (Mali)	
Méré (Upper Volta)		
Ghana Shorthorn/West African Shorthorn		
Muturu (Nigeria)		

It has already been pointed out that non-tolerant breeds can live in areas with slight tsetse-fly infestation if they are kept under excellent conditions. Breeds coming into more frequent contact with tsetse-flies appear to have a better survival capacity (e.g. White Peul/Fulani, Small East African Zebu, Nuba) than breeds which have little or no contact with tsetse-flies (e.g. Bororo, Boran). It should, however, be pointed out that favourable conditions of this type are rare and cannot generally be expected in practice, particularly as far as working animals are concerned.

Fig. B/I/2:
Approximate distribution
of tsetse-flies in Africa



1.2.5 Endurance and temperament

Experience in practical agriculture indicates that there are differences in endurance between humpless cattle and zebus, but there is no scientific proof for this assertion. It is impossible to measure endurance and thus compare it, since this factor is heavily dependent on the following elements:

- 1) Constitution and condition of the animals
- 2) Guidance and treatment of the animals by the person driving the team
- 3) Nature of the draught work (e.g. evenness)
- 4) Speed

Endurance therefore appears to be governed by the environment rather than by the breed.

In the same way, temperament also seems to be determined more by the environment (personal contact when young) than by the breed and animals from smallholdings or small herds are therefore more suitable for harnessing than animals from ranches.

Temperament thus plays a secondary role in breed selection but must be considered when selecting an individual animal. The less the farmers know about cattle and the less they are accustomed to them, the greater the importance of temperament. "Fear of cattle" can become a major reason for the failure of a project aimed at promoting use of draught cattle.

1.2.6 Selection on the basis of tractive effort/breeding of new types of draught cattle

In the areas of Africa south of the Sahara - with the exception of Ethiopia - draught cattle have only been kept for 40 - 50 years at the most and in many areas are not to be found at all; use of draught cattle is on the whole still relatively uncommon (e.g. in comparison with India). Neither natural evolution nor selection and crossbreeding have as yet produced particularly efficient draught breeds.

In addition to selection on the basis of body weight, the breeding of a draught breed also necessitates selection based on other factors which determine the tractive effort (e.g. endurance, willingness,

temperament); these factors are determined genetically only to a limited extent and possible heritabilities are not yet known. Under African conditions, therefore, it does not appear practical to take "breeding of high-performance draught cattle" as a direct target.

If, however, breeding activities aimed at producing suitable beef cattle are being carried out in a particular region, the resulting fairly heavy cattle are generally more suitable for draught work than the lighter local animals, assuming trypanotolerance or the necessary prophylactic measures in the areas concerned.

1.3 Sex

1.3.1 Oxen

Oxen are more suitable than bulls for draught work on account of their quieter temperament. Preference is given to oxen castrated later on (2 1/2 - 3 years), since their weight and muscles are better developed than those of animals castrated too early. Where oxen (or bulls are to be used, however, it must be borne in mind that alternative use of these animals for fattening is increasing to an ever greater extent.

1.3.2 Bulls

Although they would be more suitable for heavy draught work on account of their greater live weight, bulls are seldom harnessed since they are more difficult to handle and train than oxen.

1.3.3 Cows

Draught cows are still of minimal importance, although - in Senegal, for example, - their significance is increasing. In 1974 only 3% of the newly trained draught cattle in the SODEVA extension area in Sine Saloum were cows, while in 1976/77 the figure had increased to 27%.¹⁾ The use of female animals in Senegal is nothing new; around 20% of the draught horses and donkeys are females.

The following disadvantages of using cows for draught work have been given to date:

1) Insufficient weight and thus insufficient tractive effort

1) Source: SODEVA and author's own investigations.

- 2) Fodder requirements too great in comparison with oxen
- 3) Reduction of milk yield
- 4) Deterioration of reproduction rate
- 5) Unavailable for draught work for around 2 months (1 month before and 1 month after calving if calving occurs in the rainy season and thus in the main working period of draught cattle).

Disadvantages 1) and 5) undoubtedly exist. However, there is sufficient work on a farm that does not require a large tractive effort. If a large tractive effort is required (e.g. for ploughing) it may be possible to harness several pairs of animals, so that even this work can theoretically be performed by cows, provided that it does not occur during the calving period.

Disadvantage 5) can be overcome by planned breeding but necessitates the availability of sufficient fodder during the dry season.



Fig. B/1/3: Cows harnessed for threshing work with a threshing sledge in Egypt. (Photo: Schmieg/GTZ)

Lactating draught cows or those which are heavily in calf undoubtedly do require more fodder than oxen. However, this high fodder requirement of draught cows kept on an intensive basis is not simply a burden

on draught work and meat production (as in the case of oxen); it also takes into account the production of calves and milk and may therefore even be more economical than the smaller fodder requirements of draught oxen which provide only meat and draught work.

The situation of dairy cows in Africa differs so fundamentally from that of dairy cows in Europe that values determined in Europe can only be applied to Africa with extreme caution. The milk yield of the African cows is considerably lower, with an average of between 2 and 5 litres per day. If an intensive livestock-keeping system were to be used for these animals in which nutrient requirements and nutrient supply were equal, milk production would undoubtedly be greater than that achieved with the traditional method of extensive livestock keeping. With an additional supply of nutrients for the animals' working requirements there is no reason to assume that there may be a milk loss, given the relatively low yields. Investigations in Senegal revealed that the weight development of Djakoré calves whose mothers were used for draught work and received a working ration was significantly better than that of calves whose mothers did not work.

As far as both milk production and reproduction are concerned it can be assumed that, provided there is sufficient fodder, an increase in output in comparison with traditional methods of keeping dairy cows is more likely.

Use of cows for draught work has a number of advantages which must not be underestimated:

- 1) No competition with cattle fattening and therefore better and more continuous availability of draught cattle in the long term in many areas.
- 2) With high prices for young male cattle (fattening schemes) additional income from the sale of animals otherwise required for draught work or - provided that they have sufficient fodder available - fattening of young cattle by the individual farmers.
- 3) Cows are easier to train and can move faster than oxen.
- 4) Cows can be used for draught work over a lengthy period, thereby reducing the need to train animals so frequently (7-9 years in comparison with 2-5 years, particularly if the draught oxen are still to achieve a good meat value).
- 6) Guaranteeing of a supply of new draught animals for the farm.

When the possibility of using draught cows is being assessed, it is their profitability in comparison with oxen which is the major point. It goes without saying that milk and reproduction capacity must be included in this calculation to the same extent as the working and meat values. The prerequisite for keeping draught cows - even if profitability is guaranteed - is the availability of sufficient fodder, including during the dry season, in order to meet the cows'

nutrient requirements, which are greater than those of oxen and which additionally cover milk and calf production.

The provision of draught cows is often difficult if draught cattle are to be introduced into a region where there is no tradition of sedentary cattle keeping, since traditional cattle owners seldom sell female animals. The use of draught cows is thus possible mainly in areas where the farmers already have their own herds of cattle.

1.4 Age/weight

As the keeping of draught cattle has spread and discarded draught cattle have become increasingly important as meat producers, the age of the animals at the start of training has dropped from 4-5 years to around 2-3 years. More important than age, however, is weight; an initial weight at the start of training of at least 200 kg for humpless breeds and 250 kg for zebus is regarded as optimum.

If draught cows are to be used, it is advisable to start training as early as the heifer stage.

1.5 Castration

Young animals should be castrated around 4 weeks before the start of training so that they are no longer suffering from the resultant stress when the new stress caused by the training starts. If necessary, castration may also take place after the first working period but not while the animals are actually required for work.

The following castration methods are possible:

- 1) The method involving bleeding with the advantage of complete castration and the disadvantage of possible infection.
- 2) Bloodless method using the Burdizzo tongs, with the advantage of a greatly reduced infection risk and the disadvantage of possibly incomplete castration if the work is done badly.

Castration of the animal while still a calf is undoubtedly the safest method; however, this slows down the animal's development in terms of weight and is therefore unsuitable for draught cattle.

The bloodless method 2) is recommended for draught cattle on account of the reduced infection risk. However, this method may be used only by people trained in veterinary medicine, i.e. not by the cattle owner or an extension worker.

2. Time, duration and procedure for training draught cattle

2.1 Location

In countries where the use of draught cattle has long been traditional, training by the farmers on their own farms is a matter of course. However, this requires substantial experience in handling the animal, something which does not exist in areas where the use of draught cattle is still relatively new or is to be introduced for the first time. In this case it is essential to find transitional forms of training which in the long run, however, must enable the farmers to train their own draught cattle.

The forms of training described below must therefore be regarded simply as a transitional stage on the way to training by the farmers. The animals can be trained in three different locations:

- 1) At centralized or regional level (training station)
- 2) At village level (extension centre, demonstration farmers or mobile training units)
- 3) On the farmer's holding (through instructors, mobile training unit, assistance from neighbours)

The three methods differ in terms of cost and in many cases - albeit not inevitably - in terms of efficiency.

2.1.1 Training station

In numerous programmes aimed at promoting use of draught animals the training station is of major importance, particularly in places where there is no tradition of animal husbandry and the farmers have little or no experience of handling cattle (see also case study C/I).

Advantages of a training station:

- 1) Administrative concentration of training and extension work; easy to monitor the work of the instructors.
- 2) Centralized procurement of cattle by the station facilitates and simplifies purchase for the farmers, who have little access to cattle markets or dealers and have no tradition of owning cattle.
- 3) Possibility and administrative simplification of necessary veterinary measures (e.g. inoculation), particularly important if the veterinary service lacks mobility and personnel.
- 4) Opportunity to advise and instruct the farmers - beyond the actual animal-training work - as regards:
 - animal husbandry
 - animal feeding
 - necessary veterinary measures

- selection and appropriate use of implements
- handling of implements
- types of soil tillage and their advantages
- necessity and practicality of crop rotation etc.

Disadvantages:

- 1) High cost, particularly as a result of having to provide accommodation for farmers and animals.
- 2) Possible increase in cost of draught cattle if bought and sold through the station.
- 3) Farmers absent from their holdings for at least 4 weeks (particularly important if animal training and instruction take place during the rainy season).
- 4) Children, who in actual fact are mostly responsible for driving and looking after the draught cattle, are usually excluded from the instruction for reasons of cost.
- 5) Need for the station to be used to its full capacity throughout the year, resulting in training at unsuitable times (see also 2.2).

A training station can only be efficient if the accompanying extension and training services for the farmers are actually provided. If use is not made of this opportunity the station cannot be expected to make a meaningful contribution towards developing the use of draught cattle and the resultant necessary changes in the structure of the holdings.

It must be borne in mind that the station may no longer be required after a few years, i.e. when the farmers become able to train their own cattle, while an attached training centre will still be needed within the scope of extension work.

2.1.2 Village extension centre, mobile training units and demonstration farmers

Advantages:

- 1) Less expensive than a training station since there is no need to provide accommodation.
- 2) Greater interest on the part of the farmers since they do not have to leave their holdings.
- 3) Opportunities for extending the training to include children and adolescents who are later responsible for driving and frequently also for looking after the draught cattle.
- 4) If training is carried out by a demonstration farmer he usually acts as a good example, being an accepted and highly regarded member of the village population.
- 5) Apart from the costs of the instructor the farmers incur no other expenses (e.g. transport/accommodation in the case of training stations).

Disadvantages:

- 1) Transport costs for extension workers and instructors.
- 2) Risk of inadequate training as a result of insufficient checks on instructors.
- 3) Risk of inadequate initial veterinary services, particularly if there is a shortage of veterinary personnel or if these lack mobility.

2.1.3 Training on the farmers' own holdings by an instructor or by means of help from neighbours

Advantages:

- 1) Farmers, children and draught animals are instructed and trained in familiar surroundings.
- 2) Opportunity for on-the-spot adaptation of accompanying extension services to the conditions on the farms (e.g. availability of fodder).

Disadvantages:

- 1) Large number of extension workers and instructors required, therefore high personnel costs.
- 2) High degree of instructor mobility necessary, resulting in high transport cost.
- 3) Risk of inadequate monitoring of instructors.
- 4) Instructors not used to their full capacity if only a few farmers are to be trained in a particular village.

Training by a neighbour who already keeps draught animals is likely to have a substantial broad-based effect. However, there is a risk that the accompanying training and provision of advice may be neglected unless they can be supplied by an existing extension service.

2.2 Time and procedure for training

2.2.1 Time of training

Training can theoretically take place throughout the year, provided that the young animals subsequently have the opportunity to make regular use of what they have learned. If they are not given the chance to work immediately after training they forget what they have learned and must be retrained before the start of field work.

2.2.2 Duration of training

Experience has shown that training takes on average 2 to 4 weeks. The period varies according to:

- 1) the farmers' familiarity with cattle,
- 2) the temperament of the animals,
- 3) the ability of the extension workers and instructors,
- 4) the degree to which the optimum number of working hours per day is observed,
- 5) the learning capacity and learning intensity of the farmers.

2.2.3 Training programme

The various elements of training are covered in the following order:

- 1) Getting the animals used to the reins, which can pass either through the nose ring or round the ears.
- 2) Getting the animals used to the yoke.
- 3) Walking forwards while wearing the reins and yoke.
- 4) Obeying verbal commands and guidance by means of the reins.
- 5) Pulling a light object (e.g. tree trunk).
- 6) Pulling various agricultural implements.
- 7) Getting the animals used to walking in a straight line.

When draught animals are being introduced the instruction of the farmers is just as important as training of the animals. This should therefore also form a part of the training work and should cover at least the following areas:

- 1) Knowledge and practice of handling cattle.
- 2) Method of accommodating the cattle.
- 3) Care of draught animals, including keeping them in good health.
- 4) Feed requirements and feeding.
- 5) Feed planning, collection and storage of fodder.
- 6) Production, collection and storage of dung.
- 7) Hours of work, symptoms of fatigue.
- 8) Function, importance and use of the various agricultural implements
- 9) Correct times for using the various implements.
- 10) Simple repairs.
- 11) Use of specific cattle for specific implements and jobs (distinction between young and old cattle).
- 12) Aspects of arable farming (e.g. importance of crop rotation, soil conservation measures, fertilizing, seed selection).

13) Profitability aspects.

When draught animals are introduced, training of the animals and of the farmers must take place simultaneously, a point which must be borne in mind when selecting the location and time for training. All topics covered in training must be the subject of subsequent extension work on the farms for at least one and preferably two years, during which time they will be dealt with in more detail, progress monitored and the farmers given follow-up supervision.

2.2.4 Amount of training per day

2-3 hours, with a maximum of 4 hours once training has reached the advanced stage. The midday heat should be avoided.

2.2.5 Composition of the team

Two different methods of forming a team are used in training:

- 1) Simultaneous training of two or more young animals of the same size, weight and condition so that they form a team together.
- 2) Training of a young animal alongside an older, experienced one. The young animals who will subsequently form the new team must then be brought together during the last phase of training.

Whichever method is used, attention must be paid to ensuring that the animals are always on the same side of the team during training. If there is a slight difference in strength between the animals in a team, it is advisable to harness the stronger animal such that it walks on the loose, already ploughed soil (usually on the right-hand side) during ploughing.

A well-trained team will require only one person to control it when it is working.

3. Feeding of draught cattle

3.1 Nutrient and drinking-water requirements

A number of different systems are used in the African countries to evaluate nutrient requirements and the nutrient content of the various types of fodder. The French-speaking countries use the fodder unit (Unité fourragère, UF), while the English-speaking countries prefer the concept of Total Digestible Nutrients (TDN). In France, Great Britain and the USA, however, new feed-value units have recently been introduced or are being planned; these have not yet been adopted in the African countries but could lead to a changed evaluation in the future.

These new units are set out in the following two tables for information purposes; all nutrient requirements and nutrient contents specified in this handbook are given in the old units, UF and TDN since these are still being used in Africa.

The Starch Unit (Stärkeeinheit, StE), which is used in the Federal Republic of Germany, has not been adopted anywhere in Africa.

The conversion of StE (Starch Units) into old UF (Fodder Units) and vice versa presents no problems, since both feed value units are based on the same evaluation of digestible nutrients including the biological value. The conversion of StE/UF into TDN and vice versa is, on the contrary, problematic since the evaluation of digestible nutrients is done on a different basis. The respective correlations depend not only on the digestible crude protein content of the feed-stuffs but also on the value factor which is in turn influenced by the digestible crude fibre content.

The factors given below therefore permit only rough conversion into and out of TDN.

Table B/I/3: Conversion factors for Starch Unit (StE), Fodder Unit (UF), Total Digestible Nutrients (TDN), Net Energy (NE) and Metabolizable Energy (ME) for ruminants*

Feed unit	e q u i v a l e n t t o				
	kg StE	UF	kg TDN	NE (Mcal)	ME (Mcal)
1 kg StE	1.00	1.43	1.01	3.03	4.25
UF	0.70	1.00	0.71	2.12	2.98
1 kg TDN	0.99	1.41	1.00	3.00	4.20

* With constant digestible crude protein content (157 g per kg StE, 110 g per UF, 155 g per 1 kg TDN).

Source: KIELANOWSKI, 1972: Equations and Tables for Reciprocal Conversions of Different Feed Units, FAO, Rome.

Table B/I/4: Calculation of the various feed units for ruminants

Feed unit (evaluation unit)	Evaluation unit for digestible nutrients	Multiplication factor for digestible				Calculation method
		Crude protein	Crude fat	Crude fibre	N-free extract	
StE - Starch Unit (Unit of weight or %)	Unit of weight or %	0.94	2.41 (1) 2.12 (2) 1.91 (3)	1.00	1.00	Addition, then multiply by value factor
UF - Fodder Unit (UF per 1 kg)	g/kg	0.94 (new calcul- ation: (1.43)	2.41 (1) 2.12 (2) 1.91 (3)	1.00	1.00	As for StE, then divide by 700; new calculation: divide by 750
TDN - Total Digestible Nutrients (unit of weight or %)	Unit of weight or %	1.00	2.25	1.00	1.00	Addition
ME - Metabol- izable Energy (kcal/kg)	g/kg	4.32	7.73	3.59	3.63	Addition
NE - Net Energy (kcal/kg)	g/kg	1.71	7.52	2.01	2.01	Addition

- (1) For oilseeds and their derivatives, feedstuffs of animal origin
- (2) For cereal grains, legume seed and their derivatives
- (3) For roughage and green fodder, root crops and tubers

3.1.1 Energy and protein requirements

Table B/I/5: Standard energy and protein requirements for draught cattle

	UF	TDN (kg)	Digestible protein (g)
1. Maintenance requirement (adult cattle)			
200 kg weight (LW)	2.0 (1)	1.7 (2)	120 (1)
250 kg "	2.3	2.0	150
300 kg "	2.6	2.3	180
350 kg "	2.9	2.5	210
400 kg "	3.2	2.8	240
450 kg "	3.5	3.1	270
500 kg "	3.8	3.3	300
550 kg "	4.1	3.6	330
600 kg "	4.4	3.8	360
2. Growth (in addition to maintenance requirement for the relevant weight)			
Increase: 100 g/day	0.3 (3)	0.26 (4)	17 (3)
" 200 g/day	0.6	0.52	35
" 300 g/day	1.0	0.87	52
3. Pregnancy			
7th month	0.1/100 kg LW (1) in addition to 1.	0.1/100 kg LW (4) in addition to 1.	100/UF; 115 kg TDN (1;4) total requirement
8th month	0.2/100 kg LW	0.17/100 kg LW	100/UF; 115 kg TDN
9th month	0.3/100 kg LW	0.26/100 kg LW	100/UF; 115 kg TDN
4. Milk production			
per litre of 4% milk	0.38 (1)	0.32 (2)	60 (1)
5. On the move (looking for food and water)			
per 100 kg LW and per km	0.022 (1)	0.019 (4)	1.4 (3)
6. Work (rough guideline for total requirement)			
- Light work (sowing, light transport work)	(1) $\frac{3 \times \text{maintenance requirement}}{2}$		60/100 kg LW (1)
- Medium-heavy work (harrowing, cultivating)	2 x maintenance requirement		80/100 kg LW
- Heavy work (ploughing, chisel ploughing, training)	$\frac{5 \times \text{maintenance requirement}}{2}$		80/100 kg LW

Sources: (1) MINISTERE DE LA COOPERATION, 1974

(2) MORRISON, 1954

(3) TACHER, 1969

(4) Calculated from (1) and (2) with maintenance requirement:

1 UF = 0.87 kg TDN

TABLE B/1/6: EXAMPLES OF ENERGY AND DIGESTIBLE PROTEIN REQUIREMENT FOR WORKING CATTLE
OF VARIOUS WEIGHTS AND DOING VARIOUS TYPES OF WORK

TYPE OF CATTLE/ TYPE OF WORK	L I V E W E I G H T (K G)								
	200	250	300	350	400	450	500	550	600
1. ADULT OX/COM									
LIGHT WORK:									
UF (KG)	3.000	3.500	3.900	4.400	4.800	5.300	5.700	6.200	6.600
TDN (KG)	2.600	3.000	3.400	3.800	4.200	4.700	5.000	5.400	5.700
DIGESTIBLE PROTEIN (KG)	0.120	0.150	0.180	0.210	0.240	0.270	0.300	0.330	0.360
MEDIUM-HEAVY WORK:									
UF (KG)	4.000	4.600	5.200	5.800	6.400	7.000	7.600	8.200	8.800
TDN (KG)	3.400	4.000	4.600	5.000	5.600	6.200	6.600	7.200	7.600
DIGESTIBLE PROTEIN (KG)	0.160	0.200	0.240	0.280	0.320	0.360	0.400	0.440	0.480
HEAVY WORK:									
UF (KG)	5.000	5.750	6.500	7.250	8.000	8.750	9.500	10.250	11.000
TDN (KG)	4.250	5.000	5.750	6.250	7.000	7.750	8.250	9.000	9.500
DIGESTIBLE PROTEIN (KG)	0.160	0.200	0.240	0.280	0.320	0.360	0.400	0.440	0.480
2. COM									
2 LITRES OF MILK, LESS THAN 7 MONTHS PREGNANT									
LIGHT WORK:									
UF (KG)	3.800	4.300	4.650	5.150	5.550	6.050	-	-	-
TDN (KG)	3.250	3.650	4.000	4.450	4.850	5.350	-	-	-
DIGESTIBLE PROTEIN (KG)	0.240	0.270	0.300	0.330	0.360	0.390	-	-	-
MEDIUM-HEAVY WORK:									
UF (KG)	4.750	5.350	6.000	6.550	7.150	7.750	-	-	-
TDN (KG)	4.050	4.650	5.250	5.650	6.260	6.850	-	-	-
DIGESTIBLE PROTEIN (KG)	0.280	0.320	0.360	0.400	0.440	0.480	-	-	-
HEAVY WORK:									
UF (KG)	5.750	6.500	7.250	8.000	8.750	9.500	-	-	-
TDN (KG)	4.950	5.650	6.400	6.900	7.650	8.400	-	-	-
DIGESTIBLE PROTEIN (KG)	0.280	0.320	0.360	0.400	0.440	0.480	-	-	-
3. COM									
8TH MONTH OF PREGNANCY, NO LACTATION									
LIGHT WORK:									
UF (KG)	3.400	4.000	4.500	5.100	5.600	6.200	-	-	-
TDN (KG)	2.900	3.450	3.900	4.400	4.900	5.450	-	-	-
DIGESTIBLE PROTEIN (KG)	0.340	0.400	0.450	0.510	0.560	0.620	-	-	-
MEDIUM-HEAVY WORK:									
UF (KG)	4.400	5.100	5.800	6.500	7.200	7.900	-	-	-
TDN (KG)	3.750	4.450	5.100	5.600	6.300	7.000	-	-	-
DIGESTIBLE PROTEIN (KG)	0.440	0.510	0.580	0.650	0.720	0.790	-	-	-
HEAVY WORK:									
UF (KG)	5.400	6.250	7.100	7.950	8.800	9.650	-	-	-
TDN (KG)	4.700	5.450	6.250	6.850	7.700	8.500	-	-	-
DIGESTIBLE PROTEIN (KG)	0.540	0.625	0.710	0.795	0.880	0.960	-	-	-
4. OX/COM									
NOT WORKING, COVERING DISTANCE OF 10 KM DAILY (GRAZING/SEARCH FOR FOOD)									
UF (KG)	2.450	2.850	3.250	3.700	4.100	4.500	4.900	5.300	5.700
TDN (KG)	2.000	2.500	2.900	3.200	3.550	3.950	4.250	4.650	4.950
DIGESTIBLE PROTEIN (KG)	0.150	0.185	0.225	0.260	0.300	0.335	0.370	0.410	0.445
5. YOUNG OX/HEIFER									
TRAINING (HEAVY WORK), 200 G DAILY WEIGHT INCREASE									
UF (KG)	5.600	6.350	7.100	7.850	8.600	9.350	-	-	-
TDN (KG)	4.500	5.500	6.300	6.750	7.500	8.250	-	-	-
DIGESTIBLE PROTEIN (KG)	0.195	0.235	0.275	0.315	0.355	0.395	-	-	-

3.1.2 Mineral requirement

Table B/I/7: Calcium and phosphorus requirements of draught cattle

	Calcium	Phosphorus	NaCl
Maintenance	5 g/100 kg LW	3 g/100 kg LW	5 g/100 kg LW
Growth	15 g/kg growth	6 g/kg growth	2 g/kg growth
Pregnancy (last 3 months)	6 g/100 kg LW	5.5 g/100 kg LW	-
Lactation	2.5-3 g/kg milk	2.0-2.5 g/kg milk	2 g/kg milk

Source: Ministère de la Coopération, 1974.

3.1.3 Dry matter

2.5 - 3 kg dry matter/100 kg of live weight for cattle of tropical origin.

Actual dry-matter consumption depends on the following:

- Condition of fodder
(e.g. chopped fodder is more easily consumed)
- Palatability
- Protein content
(the higher the crude protein content, the greater the dry matter consumption)

In French-speaking areas the ratio of dry matter to Fodder Unit (UF) is still given and should be between 1.5 and 2.

3.1.4 Water requirement

Daily requirement during rainy season:

10-23 litres (16 litres on average) for zebus

7-19 litres (13 litres on average) for African taurines

Daily requirement during dry season:

12-29 litres (21 litres on average) for zebus

12-25 litres (20 litres on average) for African taurines

Draught cattle doing medium-heavy to heavy work require around 10 litres per day more, as do dairy cows.

A dry matter : water ration of 1 : 4 can serve as a guideline.

3.2 Nutrient content of selected feedstuffs

Table B/I/8 gives reference values for the energy and digestible crude-protein contents of the most important feedstuffs used in Africa. In view of the fact that dry matter, energy and protein content can change very quickly during the vegetation period, the figures given can serve only as approximate values, which can aid in initial planning of fodder rations, particularly with regard to adequate availability of feedstuffs. Some countries have already carried out their own investigations of the nutrient contents of numerous feedstuffs to be found in the country concerned, or have studied simply a few fodder crops cultivated on a trial basis. For every project promoting the use of draught animals the nutrient contents given in the table must be supplemented or revised using the figures available in the country in question.

If no feedstuff analyses have yet been performed for a particular region, these must be carried out during the first year of the project, in cooperation with a research institution in the country itself or, if necessary, elsewhere.



Fig. B/I/4: If feedstuffs are not stored properly - as is the case here with groundnut cake at a Centre d'Animation Rurale in Mali - the result is not only nutrient losses but also the risk that the feedstuffs will become unusable as a result of contamination, rotting or acetic acid fermentation.

Table B/I/8: Nutrient contents of selected feedstuffs

(based on a compilation by the Documentation Office
at the University of Hohenheim in Stuttgart)

Feedstuffs	DM	per kg DM			per kg of feedstuff		
		DP	UF	TDN	DP	UF	TDN
1. Grasses (excl. cereals)							
Andropogon gayanus, fresh	20,0	2,5	0,63	60.3	0,5	0,14	12.1
" " hay	86,0	0,7	0,34	45.6	0,6	0,34	39.3
" " silage	20,0	1,2	0,47	47.3	0,2	0,11	9.5
Brachiaria mutica, fresh	20,0	6,7	0,59	58.1	1,3	0,13	11.6
" " hay	86,0	3,4	0,34	45.1	2,9	0,33	38.8
Brachiaria ruzizienses, fr.	20,0	6,9	0,72	66.1	1,4	0,16	13.2
Cenchrus ciliaris, fresh	20,0	8,4	0,70	67.8	1,7	0,16	13.6
" " hay	86,0	2,2	0,41	51.3	1,9	0,41	44.1
Chloris gayana, fresh	20,0	5,0	0,63	60.1	1,0	0,14	12.0
" " hay	86,0	2,9	0,51	59.1	2,5	0,50	50.8
Cynodon dactylon, fresh	20,0	7,7	0,54	54.4	1,5	0,12	10.9
" " hay	86,0	3,6	0,34	46.2	3,1	0,34	39.7
Cynodon plectostachyus, fr.	20,0	9,9	0,60	57.6	2,0	0,14	11.5
" " hay	86,0	3,4	0,37	47.1	2,9	0,36	40.5
Melinis minutiflora, fresh	20,0	3,2	0,52	52.7	0,6	0,12	10.5
Panicum maximum, fresh	20,0	5,7	0,54	53.7	1,1	0,12	10.7
" " hay, start, flowerg.	86,0	4,1	0,35	46.3	3,5	0,34	39.8
" " hay, middle flowering	86,0	2,4	0,38	48.2	2,1	0,37	41.4
" " hay, after sprouting	86,0	7,4	0,43	53.5	6,4	0,42	46.0
" " silage	20,0	2,0	0,51	49.3	0,4	0,12	9.9
Pennisetum clandestinum, hay	86,0	6,4	0,41	50.7	5,5	0,40	43.6
Pennisetum purpureum, fresh	20,0	6,4	0,57	57.6	1,3	0,13	11.5
" " hay	86,0	6,4	0,44	52.4	5,5	0,43	45.0
" " silage	20,0	3,7	0,58	55.7	0,7	0,13	11.1
Setaria sphacelata, fresh	20,0	9,2	0,67	63.8	1,8	0,15	12.8
Trypsacum laxum, fresh	20,0	3,3	0,64	61.0	0,7	0,14	12.2
" " hay	86,0	5,0	0,47	54.6	4,3	0,46	46.9
2. Legumes							
Medicago sativa, fresh	20,0	17,7	0,81	71.9	3,5	0,18	14.4
Dolichos lablab, hay	86,0	9,0	0,48	55.9	7,8	0,47	48.1
Puereria phaseoloides, fresh	20,0	13,9	0,62	60.6	2,8	0,14	12.1
Stylosanthes gracilis, fresh	20,0	11,9	0,65	60.9	2,4	0,15	12.2
Vigna sinensis, hay	86,0	11,2	0,60	61.9	9,7	0,59	53.3
" " seeds	88,0	21,0	1,03	84.0	18,5	1,03	73.9
3. Cereals and cereal residues							
Barley, green fodder, fresh	20,0	8,1	0,83	74.8	1,6	0,19	15.0
" hay	86,0	4,9	0,53	60.9	4,2	0,52	52.4
" straw	86,0	1,2	0,40	46.8	1,0	0,40	40.2
" .. grains	88,0	8,5	1,00	81.9	7,5	1,00	72.1
" bran	88,0	10,8	0,87	75.1	9,5	0,87	66.1
Oats, green fodder, fresh	20,00	8,4	0,58	57.4	1,7	0,13	11.5
" hay	86,0	5,7	0,50	58.4	4,9	0,49	50.2
" silage	20,0	4,6	0,56	54.8	0,9	0,13	11.0

/continued

Table B/I/8 (continued)

Feedstuffs	DM	per kg DM			per kg of feedstuff		
		DP	UF	TDN	DP	UF	TDN
Cereals and cereal residues, contnd.							
Maize, green fodder, fresh	14,0	5,8	0,75	67.8	0,8	0,12	9.0
" green fodder, fresh, milk ripeness	20,0	5,8	0,70	64.8	1,2	0,16	13.0
" silage	14,0	4,1	0,58	56.6	0,6	0,09	7.9
" grains	88,0	6,8	1,11	89.1	6,0	1,11	78.4
Rice, silage, milk ripeness	20,0	5,7	0,71	66.2	1,1	0,16	13.2
" " dough ripeness	25,0	5,1	0,72	66.8	1,3	0,21	16.7
" straw	86,0	1,9	0,31	44.2	1,6	0,31	38.0
" bran	88,0	6,1	0,91	80.4	5,4	0,91	70.8
" stalk meal, nat. dried	88,0	0,3	0,41	50.4	0,2	0,41	44.3
" straw	86,0	1,2	0,35	46.5	1,0	0,34	40.0
" bran	88,0	8,5	0,70	66.7	7,5	0,70	58.7
" fodder meal, yellow, 6-10% crude fibre	88,0	9,0	0,91	79.9	8,0	0,92	70.3
" fodder meal, white, up to 6% crude fibre	88,0	10,0	1,11	92.2	8,8	1,11	81.2
Millet, grains	88,0	8,1	0,95	79.5	7,1	0,95	69.9
" straw	86,0	1,5	0,47	55.2	1,3	0,46	47.5
Sorghum, green fodder, fresh	20,0	4,5	0,59	57.8	0,9	0,13	11.6
" hay	86,0	0,9	0,45	54.2	0,8	0,44	46.6
" straw	86,0	1,2	0,47	54.0	1,1	0,46	46.4
" silage	20,0	4,6	0,59	57.9	0,9	0,13	11.6
" grains	88,0	5,5	1,00	80.2	4,9	0,88	70.6
" bran	88,0	9,4	0,92	84.8	8,3	0,92	74.7
Wheat, straw	86,0	0,5	0,35	42.7	0,4	0,34	36.7
" grains	88,0	10,2	1,10	89.5	8,9	0,97	78.8
" bran	88,0	12,1	0,64	66.8	10,6	0,56	58.8
" semolina bran	88,0	13,6	0,78	75.7	12,0	0,69	66.6
4. Root crops and tubers							
Cassava, manioc, leaves, fresh	15,0	17,1	0,68	59.4	2,6	0,12	8.9
" " roots, fresh	22,0	0,4	1,04	83.5	0,1	0,26	18.4
Sweet potatoes, leaves, fresh	15,0	17,9	0,85	72.5	2,7	0,14	10.9
" " tuber, fresh	22,0	1,6	1,12	90.2	0,4	0,28	19.8
5. Oil plants, fibre plants and processing residues							
Groundnuts, leaves/hay	86,0	6,9	0,60	61.4	5,9	0,58	52.8
" hulls, dried	86,0	6,5	0,20	23.4	5,6	0,20	20.1
" extracted meal, dehulled	90,0	52,2	1,03	85.8	47,0	0,93	77.3
" " " not dehulled	90,0	34,6	0,62	62.8	31,2	0,56	56.6
" " " part dehulled	90,0	47,5	0,95	81.9	42,7	0,86	73.7
" cake, dehulled, 4-8% fat	90,0	48,7	1,07	88.3	43,9	0,96	79.4
" " " 8-12% "	90,0	46,7	1,17	95.4	42,1	1,05	85.9
" " not dehul., 4-8% fat	90,0	35,5	0,70	70.0	31,9	0,63	63.0
" " " 8-12% "	90,0	27,1	0,68	66.8	24,4	0,61	60.1
" " part " 4-8% fat	90,0	44,6	0,94	79.7	40,2	0,85	71.8
" " " 8-12% "	90,0	43,9	1,06	89.5	39,5	0,95	80.6
Oil palm, kernel extraction meal	90,0	15,6	0,92	75.4	14,0	0,83	67.8
Oil palm, kernel cake 4-8%fat	90,0	14,2	0,99	80.0	12,8	0,91	72.0
Oil palm, kernel cake 8-12%fat	90,0	15,3	1,05	84.7	13,8	0,95	76.2

/continued

Table B/I/8 (continued)

Feedstuffs	DM	per kg DM			per kg of feedstuff		
		DP	UF	TDN	DP	UF	TDN
5. Oil plants, contnd.							
Cotton, seeds	80,0	17,1	1,09	89,0	15,1	0,98	78,3
" extracted meal, depodded	90,0	34,1	0,78	65,4	30,7	0,72	58,9
" extracted meal not depodded	90,0	17,1	0,55	55,5	15,4	0,50	50,0
" seed cake, depodded, 4-8% fat	90,0	36,7	0,90	74,1	33,1	0,82	66,7
" seed cake depodded, 8-12%fat	90,0	39,3	1,03	84,0	35,4	0,93	75,6
" seed cake not depodded, 4-8%fat	90,0	19,4	0,64	63,5	17,4	0,85	57,2
" seed cake, not depodded, 8-12%fat	90,0	23,9	0,70	61,4	21,5	0,63	55,2
Kapok, cake 4-8% fat	90,0	23,9	0,70	61,4	21,5	0,63	55,2
Kapok, cake 8-12% fat	90,0	33,4	0,80	70,3	30,1	0,72	63,2
6. Sugar cane and processing residues							
Sugar cane, tips, fresh	20,0	3,3	0,57	55,4	0,7	0,13	11,1
" " molasses	78,0	0,0	0,64	69,1	0,0	0,57	53,9
" " bagasse, dried	88,0	0,0	0,39	45,8	0,0	0,34	40,3
7. Brewing residues							
Brewer's grains, fresh	25,0	18,9	0,76	70,0	4,7	0,22	17,5
" dried	88,0	18,2	0,67	63,8	16,0	0,59	56,2
8. Fruit and processing residues							
Pineapple, canning waste, fresh	25,0	2,0	0,85	70,2	0,5	0,21	17,5
" " dried	88,0	0,4	0,87	71,5	0,4	0,77	62,9
" leaves, fresh	15,0	3,8	0,81	71,8	0,6	0,14	10,8
Bananas, leaves, fresh	15,0	6,1	0,66	60,3	0,9	0,11	9,0
" skins, fresh	20,0	2,0	0,72	60,5	0,4	0,16	12,1
Citrus, fruit, fresh	8,0	4,6	1,15	92,7	0,4	0,10	7,4
" peel, fresh	20,0	3,8	1,03	85,2	0,8	0,24	17,0
" residues, fresh	25,0	4,5	0,94	88,2	1,1	0,27	22,0
" residues, silaged	25,0	4,1	0,90	84,6	1,0	0,26	21,1
" residues, dried	88,0	3,5	0,82	76,8	3,1	0,72	67,6
9. Products of animal origin							
Blood meal	90,0	69,7	0,85	71,1	62,7	0,77	64,0
Fish meal, generally 50-55% protein, over 8%fat	90,0	48,9	0,88	70,4	44,0	0,79	63,3

Explanations:

DM = Dry matter in %
DP = Digestible protein in %
UF = Unité fourragère (fodder unit)
TDN = Total Digestible Nutrients

3.3 Practical aspects of feeding

3.3.1 Current situation as regards feeding of draught cattle

Although there are substantial variations in feeding practices in Africa as a whole, the general situation can be described as follows:

- 1) In most cases the basis for feeding is the natural pasture, both in the rainy season and in the dry season, when - as in the case of traditional cattle keeping - the pasture forms the sole basic fodder for the majority of holdings with draught cattle.
- 2) Only in a few cases are draught cattle better fed than cattle kept under the traditional system. The animals do not usually receive sufficient quantities of minerals and arable-farming residues, at least during their main working period.
- 3) During the main working period the cattle are frequently kept in the farmer's living area or are tethered or housed in the immediate vicinity. During the dry season, however, they are either left to their own devices as far as feeding is concerned or integrated into the traditional herd so that they can be fed with the latter during transhumance.
- 4) Draught cattle kept in this manner have lost a considerable amount of weight and are in poor condition when they return to the farmer at the end of the dry season; when the rainy season starts, the farmer often calls upon the thin and frequently sick cattle to perform extremely heavy work.
- 5) There is almost no systematic collection and storage of fodder. Residues from arable crops are left in the fields, resulting in nutritive value losses of up to 50%. The residues are then gathered up as required or the cattle allowed to graze the stubble pasture.
- 6) In many cases the residues are divided up among all the animals kept near the farmer's living area, i.e. there is competition between draught cattle, sheep and goats, and in some cases also dairy cows, horses and donkeys.
- 7) Feedstuffs (e.g. cotton seed, groundnut cake, sunflower cake, rice bran, meal etc.) are seldom purchased.

The incorrect feeding of draught animals stems from a variety of causes, the most important of which are:

- 1) Traditional attitudes on the part of the animal owners; it is considered that cattle should look for their own food and the farmers are not easily prepared to use their own labour to collect and conserve feedstuffs.
- 2) Lack of knowledge as regards nutrient requirements and the value of various feedstuffs.
- 3) Lack of knowledge as regards the available quantities of fodder and the quantity actually given to the animals.

- 4) Shortage of cash
- 5) Underestimation of the need for appropriate feeding during both planning and implementation of projects aimed at promoting the use of draught animals.
- 6) Shortage of animal breeders/veterinary surgeons and extension workers with appropriate knowledge of animal feeding.

3.3.2 Grazing

If draught animals are to work efficiently they cannot be expected to make their way to pasture several kilometres distant once their working day is over. If pastureland is to be an inexpensive basis for the keeping of draught animals, the following conditions must be fulfilled:

- 1) Proximity to the village
- 2) Availability of high-grade fodder plants
- 3) Opportunity to divide area grazed by draught animals from that grazed by other herds and by sheep and goats if the fodder basis for various types of animal is not sufficient
- 4) Possibility of rotation and setting-aside of specific areas for the dry season

The natural pastures to be found in most areas come nowhere near meeting these requirements. The situation is characterized by:

- 1) Expansion of the arable area near the villages, shifting of pastureland to regions well away from the villages which are too distant for draught animals to be able to use them as their main grazing area during the working period.
- 2) Reduction of fallow areas which previously served as natural pastureland and shortening of fallow periods, resulting in a reduction in green-material production.
- 3) Existence of traditional general grazing rights, whereby fallow areas are regarded as common pastureland, whereas the same area is accepted as being the property of the farmer concerned if it is planted with a food crop or industrial crop. The fallow land therefore cannot be allocated to draught cattle alone, nor is it possible to observe pasture rest periods or use the area for fodder conservation.
- 4) Increasing overstocking of pastureland which in the Sudan zone as well is a result of increased use of the land by herds of cattle from the Sahel zone during transhumance (increasingly serious droughts in the Sahel, better opportunities for prophylactic measures against trypanosomiasis) on the one hand and the expansion of sedentary cattle keeping (increased numbers of draught cattle, herdsmen and their families settling in one place) on the other.

It is possible, however, to improve the pasture basis by establishing artificial fallow areas, since a reduction of the fallow period frequently results in a decrease in soil fertility. The selection of plants which have a positive effect of the soil structure and soil purification can also have a favourable influence on fertility (e.g. *Andropogon gayanus*). It must be remembered, however, that systematic fallowing also deprives the soil of nutrients and application of small quantities of fertilizer to these areas is essential in order to preserve fertility.

3.3.3 Fodder storage

Inadequate use is frequently made of the arable residues produced in agriculture. In most cases they are left lying in the fields, exposed to the rays of the sun, and thus lose a substantial proportion of their nutrients. In the case of groundnut hay, for example, the energy content is reduced by 20% and the protein content by 27% if the hay is left lying in the fields instead of being collected and stored in an appropriate manner immediately after harvesting. As regards actual feeding of the animals this means that an average harvest of 1500 kg of groundnut hay per hectare could supply one



Fig. B/I/5: Simple storage of teff straw for fodder. (Photo: Reh)

bullock or similar with 4UF (3.48 TDN) per day for a period of 206 days. assuming that the hay was properly stored, in comparison with only 166 days if the hay were left lying in the fields.

It becomes apparent from this that the storage of fodder - particularly of high-grade arable residues such as groundnut hay, niébé hay and dolichos hay - can make a major contribution towards full utilization of the available feedstuff potential for draught animals, since these residues are in scarce rather than abundant supply.

Fodder storage fulfils the following purposes:

- 1) Maintaining of the nutritive value of the feedstuffs by protecting them against leaching by rain and sun.
- 2) Avoidance of "trampling losses" which result if the animals "graze down" the hay or straw themselves on the stubble pasture.
- 3) Setting-aside of feedstuffs for the dry season when little fodder is available and for the main working period when the draught cattle are fed in the compound.
- 4) Rapid, labour-saving availability of feedstuffs at times when there is a great deal of work to be performed, particularly if there is no pasture near the village available.

The following conditions for suitable fodder storage must be observed:

- 1) Collection of fodder as soon as possible after harvesting.
- 2) Availability of means of transport, on a communal, private or commercial basis.
- 3) Availability of storage facilities in the compound or in the near vicinity.
- 4) Feedstuffs with a high energy and protein content must be stored under cover in order to minimize nutrient losses.
- 5) Feedstuffs with a low energy and protein content need not be stored under cover.
- 6) Protection of storage facilities (both in the compound and outside) against roaming livestock (particularly small ruminants).
- 7) Quantity to be kept in storage (groundnut or bean hay): 40 - 50 kg/m³ if stored loose.

3.3.4 Fodder conservation

Apart from fodder storage and the setting-aside of pastureland for the dry season, fodder conservation, in the form of silage and hay production, is still of little significance in Africa; only in con-

junction with the growing of arable forage crops or the creation of artificial fallow does it become more relevant. Hay harvesting problems occur in humid regions, since the best time for cutting the hay (immediately before flowering) occurs during a period when the humidity is still very high and the rainy season has not yet come to an end, thereby making drying of the fodder problematic. In such areas it is better to produce silage, which involves fewer problems; however, before this practice is introduced, it is essential to draw up a profitability calculation which must take particular account of the substantial work involved and the readiness of the farmers to perform it.

Two main types of silo can be used to permit the removal of the relatively small quantities of fodder required for draught cattle:

- the pit silo
- the trench-earth silo (if the terrain is hilly).

From the point of view of rapid filling and fodder removal, it is better to have several small silos rather than one large one.

Approximate dimensions: Depth 1.80-2.50 m; width 3-4 m;

Length according to desired capacity.

If silage making is to be introduced, the following points must be borne in mind:

- 1) Availability of large quantities of feedstuffs with a high energy and/or protein content (cultivation of arable forage crops).
- 2) Optimum cutting time with regard to:
 - nutrient content
 - rainfall
 - availability of labour
- 3) Small silos can be filled and emptied more quickly than large ones and losses are smaller.
- 4) Chopped fodder ferments better and more quickly than that which has been left whole.
- 5) The addition of fodder salt (4 kg per tonne of green material) improves the feed value of the silage.
- 6) The addition of molasses improves the fermentation process and the feed value of the silage.
- 7) Considerable compaction of the cut fodder improves the fermentation process and reduces nutrient losses (possible use of the draught animals for this purpose).

8) Around 1-1.5 tonnes of wilted green fodder can be ensilaged in an eight-hour day (transport by ox cart, chopping of fodder using the machete knife).

9) 1 m³ of silage = 600-700 kg.

Fodder crops suitable for silage making:

- Green sorghum
- Fodder millet
- Fodder barley
- Pennisetum purpureum (napier grass)
- Tripsacum laxum (Guatemala grass)
- Andropogon gayanus

Fodder crops particularly suitable for hay making:

- Andropogon gayanus
- Brachiaria ruziziensis
- Chloris gayana
- Cynodon plectostachyus
- Panicum maximum
- Dolichos lablab

The introduction of silage making and/or hay harvesting requires a great deal of extension and monitoring work.

3.3.5 Fodder rations (examples)

Fodder rations for draught animals should be geared to the following factors:

- nutrient requirement for maintenance and performance (work, milk and reproduction, if applicable),
- availability and quality of the feedstuffs.

The following points should be observed in order to guarantee optimum ration composition:

- 1) Low costs
- 2) The basis of the fodder should be formed by residues and waste accumulating on the farm and in the household, which must be considered and collected as far as possible.
- 3) When the availability of feedstuffs on the farm is being considered, the competition from dairy cattle, sheep, goats, pigs and possibly also horses and donkeys must be borne in mind (this is particularly important if promotion measures aimed at increased establishment of other types of animal or production facilities are envisaged or are already being implemented).
- 4) Feedstuffs obtainable from trees and shrubs (leaves and young branches) should be considered as sources of fodder from outside the farm.

- 5) Reasons of cost demand that the purchase of feedstuffs be kept to a minimum and restricted to products available within the country.
- 6) The use of cereals usually involves high utilization costs.¹⁾ They should therefore be used as little as possible or only in cases where a serious energy shortage cannot be countered in any other way.
- 7) Feedstuffs with a high protein content can only be used to overcome an energy shortage if they are available in sufficient quantities on the farm (e.g. bran) and do not have to be purchased. This problem can sometimes occur in the Sudan/Sahel region, where the abundance of groundnut hay, niébé hay and various types of bran means that there are more protein-containing feedstuffs than energy feedstuffs available.
- 8) Ration planning is not a job which has to be done just once. If grazing or green fodder is used to provide the basis of the ration the rapid changes in the nutrient content and digestibility of the nutrients necessitate frequent recalculation.
- 9) If a draught-animal project finds that there are no country or region-specific feed surveys at its disposal, investigations of the available feedstuffs should be planned, since general values may exhibit substantial differences from region-specific values (influence of climate or soils). Feed surveys must cover in particular the numerous vegetation stages of green crops as well as the stages involved in the storage of waste products, hay and silage.
- 10) The rations should contain as few different components as possible in order not to confuse the farmers.
- 11) It is advisable to specify quantities in comprehensible units, since most farmers do not have any weighing equipment.
- 12) The limitations on dry matter consumption have to be taken into account.

1) See part B/IV/Section 2 for explanation.

Table B/I/9: Examples of fodder rations for draught cattle¹⁾

Ox / 300 kg Medium-heavy work	Cow / 250 kg 2 litres of milk Medium-heavy work	Ox / 400 kg Medium-heavy work	Cow / 350 kg 2 litres of milk Medium-heavy work
Requirement: 5.20 UF 4.60 TDN 240 g DP 7.5-9 kg DM	5.35 UF 4.65 TDN 320 g DP 6.25-7.5 kg DM	6.40 UF 5.60 TDN 320 g DP 10-12 kg DM	6.55 UF 5.65 TDN 400 g DP 7.5-10 kg DM
7 kg groundnut hay 3 kg millet straw 1 kg millet bran	4 kg groundnut hay 3 kg niébé hay 1 kg millet straw 0.5kg millet bran	10 kg groundnut hay 1 kg millet bran 1 kg millet straw	8 kg groundnut hay 2 kg millet bran 1 kg millet straw
or	or	or	or
5 kg sorghum straw 3 kg sorghum bran 1 kg cotton seed	3 kg niébé hay 3 kg sorghum straw 2 kg sorghum	7 kg sorghum straw 3 kg sorghum bran 2 kg sorghum	5 kg sorghum straw 3 kg niébé hay 2 kg sorghum 1 kg sorghum bran
or	or	or	or
5 kg rice straw 2 kg manioc 1 kg niébé hay 1 kg rice meal	3 kg rice straw 2 kg niébé hay 2 kg rice meal 2 kg manioc	6 kg rice straw 3 kg rice meal 2 kg rice bran 1 kg manioc chips	5 kg millet straw 3 kg rice meal 3 kg rice bran 1 kg millet
or	or	or	or
4 kg sorghum straw 2 kg manioc leaves 2 kg maize bran 1 kg maize 0.5 kg manioc	4 kg maize straw 3 kg maize bran 1 kg manioc 1 kg palm kernel cake	30 kg Andropogon gayanus	20 kg Andropogon gayanus 3 kg millet bran
or	or		or
25 kg Andropogon gayanus	15 kg Andropogon gayanus 2 kg millet		20 kg Andropogon gayanus 3 kg rice bran 1 kg rice straw
or	or		
15 kg Andropogon gayanus 10 kg Stylosanthes gracilis 2 kg millet straw	15 kg Andropogon gayanus 10 kg Stylosanthes gracilis		

1) See Part B/I/Section 3.1 for explanation of abbreviations.

3.3.6 Mineral supply

The most reliable way of guaranteeing the animals' mineral supply is to provide them with a mineral lick containing calcium, phosphorus and sodium chloride in, for example, the following proportions:

- 82 % sodium chloride
- 4 % calcium biphosphate
- 2 % calcium bicarbonate

Mineral licks are already being manufactured commercially in many African countries. They should be fixed in the cattle shed or in a covered place such that every animal has access to them.

3.3.7 Feeding and watering

Feeding

The animals should be fed twice a day, preferably in the morning and evening. During the main working period there may not be sufficient time for feeding in the morning and the animals should then be fed at midday when the work is over. If they are also required to work in the afternoon, they should be given only part of the total amount of fodder at midday, since they do not have the necessary time and peace to consume larger quantities. If the animals are sent out to pasture, they must be allowed a grazing time of at least 6 hours, if the pasture is to be used as the main source of fodder. They should be given additional roughage, bran, meal, cereals or oil cakes in the evening in the sheds or in the compound.

Watering

During the main working period the animals should be watered three times a day, in the morning, at midday and in the evening. Watering in the morning is particularly important if the animals are given little or no fodder at the start of the day. If the animals work in the morning and afternoon, they must at all events be watered at midday, although water supply problems may arise, if the fields are located some distance from the village, farm or nearest watering point.

4. Draught cattle husbandry

4.1 Housing

Draught cattle need continuous contact with the farmer and his family, as regards both daily feeding and watering and the necessary veterinary checks. The cattle must be kept within easy reach since the work usually starts very early in the morning and the traditional methods of keeping the animals in "kraals" near the village or within the village herd are therefore unsuitable for draught cattle. The animals should be accommodated individually within the farmer's living complex so that a permanent eye can be kept on them.

Draught animals do not require particularly sophisticated housing but 5 basic requirements must be met:

- 1) Protection against sun and rain
- 2) Firm, level and dry floor
- 3) Provision for tying up the animals
- 4) Feeding trough
- 5) Protection at the sides against wind and rain in areas with strong winds and rain squalls.



Fig. B/I/6: Shade-providing roofs made of local materials usually fulfil the requirements for draught-cattle housing and are also cheap to erect. (Photo: Reh)

The following materials can be used for the construction of sheds:

Roof: Straw, palm leaves, reeds, corrugated metal sheeting

Framework: Wood (protection against termites), borassus palm trunks, iron bars

Walls: Clay, palm leaves, branches and brushwood

Boundary marking for loose housing sheds: Wood, iron bars, round wire, wire mesh

Floor: Trodden-down earth, clay, stones, concrete

Dimensions:

Covered area: Minimum of 3.25 m² per animal for tying stalls, 5 m² per animal for zebu loose housing sheds, 4 m² for small taurine breeds (minimum). If the feeding trough is not protected by a wall against entry of rain from the side, an additional protective roof must be added on this side.

Feeding trough: Width 40 cm; length 60-70 cm; height above ground approx. 40 cm. If several animals are to share one trough, the width of the horns must be taken into account in the case of some breeds (e.g. Ankole) to ensure that the cattle do not get in each other's way while eating.

Floor: 2% gradient so that urine and rainwater can run off.

Height of shed: Approx. 2 m. If the roof is made of straw, it must be sufficiently far above the cattle to ensure that they cannot pull it down.

4.2 Dung collection area

The keeping of draught cattle in sheds leads to concentrated accumulation of dung, a highly desirable by-product which can and must be put to practical use in crop growing. Daily application of manure, however, often fails to have any effect at all, which means that the dung must be collected and stored. It must first of all be established, however, whether the dung can be used as fuel; this is the case particularly in semi-arid regions where no other fuel is available. If the farmers are already aware of the value of the cattle-shed dung as a fertilizer, it is not too difficult to encourage them to collect and store it, whereas in areas where the farmers do not have this awareness, the introduction of dung utilization is frequently problematic since it involves additional labour and a certain amount of capital expenditure.

Storage of dung requires not just a storage area but also transport facilities and can therefore only be introduced easily in areas where carts are already available or sufficient credits for the purchase of carts are provided.

A dung collection area must be simple to construct and involve little expenditure, e.g.

- 1) firm flat area or pit,
- 2) roofing-over or covering with plastic sheeting or palm leaves to provide protection against rain, sun and drying-out.

The amount of dung produced varies according to:

- the amount of fodder (dry matter)
- the digestibility of the fodder
- the amount of litter
- the average length of time for which the animals are kept in the cattle sheds (per day and per year).

In Europe daily production of fresh manure, assuming that the animals are kept in the cattle shed all day, is calculated as follows:

Daily production = (0.5 fodder dry matter x litter dry matter) x 4

Decomposing manure amounts to around 50% of the figure for fresh dung. In most cases, however, less dung production should be anticipated since litter is seldom used.

Space requirement/weight: 1m^3 cattle-shed dung = 700-800 kg.

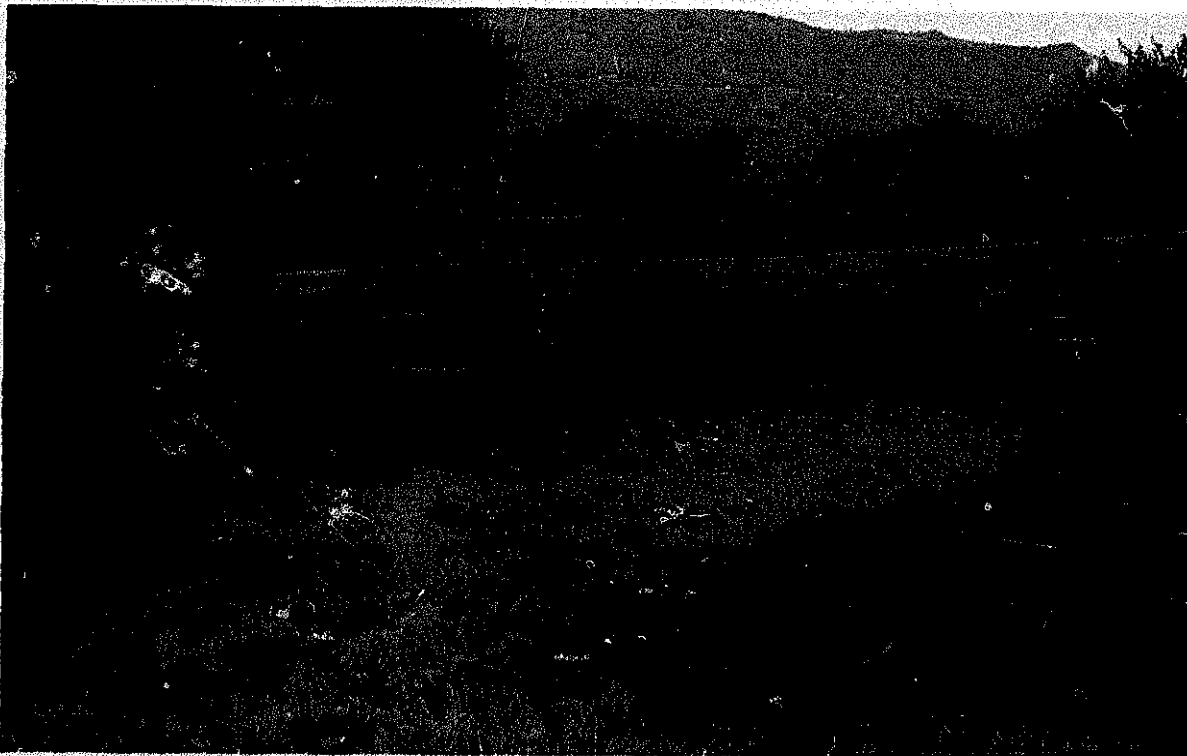


Fig. B/I/7: Draught animals kept in an open kraal to permit collection of dung.
(Photo: Munzinger)

4.3 Tending and herding

The problem of tending the cattle arises if they are to be allowed to graze. During the working period an eye must be kept on them in order to protect the crops, while in the dry season the animals must not be allowed to become too widely scattered when grazing throughout the day so that they cannot be driven back to the farm in the evening.

Night grazing, or even transhumance, is unsuitable for draught cattle even during the times when there is little or no work, since continuous contact with and daily handling by the farmer and his family are essential to ensure that the animals do not become wild and that they are subjected to regular checks as regards feeding and possible sickness.

There are a number of ways of tending the animals during the day: tethering, minding by members of the family (children or adolescents) or by hired labour (herdsmen).

5. Hygienic and veterinary aspects of draught cattle husbandry

Sickness of draught animal may lead to temporary or even permanent loss of an important production input and may severely affect the profitability of a smallholding, particularly if the loss of an animal or a substantial reduction in its working capacity means that only part of the potential crop area can be cultivated. Disease control is therefore of major importance in draught cattle husbandry from the point of view of both prophylactic measures and individual treatment.

Experience gained to date with measures promoting the use of draught cattle indicates that in very many cases veterinary aspects have not been given the necessary consideration during either the planning or implementation of such projects, and this has been a factor contributing to the failure of a number of schemes.

This situation can also be attributed to the fact that a number of draught-cattle projects were initiated by organizations promoting the export of industrial crops (cotton, groundnut-processing and

export organizations), which in general do not have staff who are familiar with animal husbandry. Another reason for the failure of these projects, however, is the lack or poor efficiency of local veterinary services. It should not be forgotten that the use of draught animals is in many cases being promoted in areas where there was previously little or no traditional cattle keeping.

5.1 Veterinary service

The structure of draught cattle husbandry differs fundamentally from traditional cattle-husbandry where the animals are concentrated in herds of varying size which are occasionally brought together to form larger units (at watering places during the dry season). The traditional veterinary service is geared to mass prophylaxis rather than individual treatment. In regions where draught cattle are kept, the animals are distributed more or less evenly over a wide area and in many cases a farmer will own only one pair. In view of the economic importance of the draught cattle for the smallholdings, the veterinary service must, in addition to prophylactic measures, provide individual treatment for the animals if they fall sick. The change of structure as regards cattle husbandry therefore also necessitates a change in the structure of the veterinary service if the latter wishes to meet its new responsibilities.

The keeping of draught cattle places the following demands on the veterinary service:

- 1) Higher personnel density than for traditional cattle keeping
- 2) Adequate degree of mobility permitting personnel to reach the villages quickly
- 3) Knowledge (on part of the veterinary personnel) of the treatment of diseases
- 4) Good, rapid communication between farmers and veterinary personnel
- 5) Availability of medicaments, instruments, equipment etc. other than that required for prophylaxis
- 6) Training and extension services for the owners of the draught cattle dealing with the necessary hygiene measures and diagnosis of the diseases

An efficient veterinary service is therefore more cost-intensive in areas where draught cattle are kept on an extensive basis. However,

in view of the fact that even now almost no African country provides its veterinary administration with a budget sufficient to cope with the existing structure, the planning of draught-cattle projects must include investigation of the extent to which new sources of budget financing can be utilized. In many countries veterinary services are still provided free of charge or at a minimal cost. Farmers earning a visible and measureable income through the use of draught animals should pay a share of the veterinary costs. However, calling upon the farmers to contribute in this way is only justified if they derive direct benefit from the sum which they pay in the form of immediately available medicaments. A revolving fund is necessary for this purpose; in some African countries, however, legislation prevents the establishment of such a fund since all incoming cash must be surrendered. This situation must be clarified and borne in mind during planning.

5.2 Hygiene and care of draught cattle

Expenditure for treatment of sick draught cattle can be reduced if the farmers provide the prerequisites for keeping the animals healthy and are taught how to treat injuries and cases of minor illness themselves.

The extension and training services for the farmers should initially concentrate on the most important areas only:

- 1) Washing-down of the sweating points with clean, fresh water, particularly in those places where the harness rests on the body (to be done regularly upon completion of work).
- 2) Checking the gaps in the hooves for foreign bodies and removal of same (lifting of the feet is a matter of habit and the animals must be taught to do this during training).
- 3) Cleaning of those points on the harness which come into contact with the animal's body. If sacking or other types of fabric padding are used: brushing-out of dried sweat and adhering hairs; washing-down using soap if there is a heavy encrustation of sweat. The padding must be completely dry, before the harness is used again.
- 4) Cleaning of feeding trough and watering bucket before every feeding time.
- 5) Keeping the animals' resting area clean.

It is particularly important to keep an eye on the animals for signs of fatigue:

- 1) More rapid breathing or even panting
- 2) Increased saliva flow
- 3) Acceleration of the cardiac rhythm
- 4) Slowing-down of pace
- 5) Difficulty in pulling an implement

5.3 General diseases and specific veterinary measures

Draught cattle are just as susceptible as other cattle to any disease occurring in a project region. The most important diseases and suitable prophylactic measures are given in Table B/I/10. In addition, Tables B/I/11 to B/I/13 list prophylactic measures for the two major types of disease, trypanosomiasis and tick-borne diseases.

5.4 Injuries and diseases specific to draught cattle

The stress involved in draught work, sometimes coupled with inadequate feeding for the performance required and insufficient resting periods, means that draught cattle are more susceptible to the generally occurring diseases and require special protection.

A distinction can be made between two types of ailments:

- 1) Those resulting directly from the draught work
- 2) Those resulting from the animals' increased susceptibility.

5.4.1 Mortality

In traditional cattle keeping the mean mortality rates vary between 15 and 35%, leaving aside acute or peracute epidemics.

In the case of cattle over the age of three, the figures are between 4 and 10%. It is theoretically possible to reduce mortality among draught cattle to around 2% per year (TACHER; LACHAUX and NICOLAS, 1969), since the keeping of draught cattle, in contrast to the traditional system, offers in principle excellent preconditions for optimizing keeping conditions. In practice, however, such figures are achieved only seldom; on the contrary, the mortality rates are higher than for traditional cattle keeping, since in many cases the traditional extensive methods are also used for draught cattle.

High mortality rates must be expected above all during the first few years following introduction of draught animals, particularly in areas where there was previously little or no cattle-keeping and where both the farmers and extension workers lack any experience in handling cattle. The mortality rate can rise to as much as 50% but will then drop to between 10 and 20%, once draught cattle have

become established. Under favourable circumstances and providing that there is an efficient extension and veterinary service, the figure can be as low as 5 to 8%.

5.4.2 Ailments resulting directly from draught work

Wounds

- Treatment: (1) Disinfection: 70% alcohol
Boracic acid (2%)
Potassium permanganate (1%)
Mercurochrome
- (2) Follow-up treatment: Sulphonamide powder
Antibiotic powder

Very deep wounds must be stitched, if necessary.

Cattle with deep, bleeding wounds in places where the harness rests on the body should not be required to wear the harness for a few days. New padding must be fitted to the harness at the points chafing against the animal's body.

Sprains

- Treatment: (1) Spray with cold water or immerse in water
- (2) Compresses: Mustard powder
Therebentine solution
Vinegar
- (3) Allow the animal to rest until the swelling has gone down and it can walk normally.

Tendinitis

Treatment: As for sprains

Inflamed hooves

- Treatment: (1) Removal of the foreign body
- (2) Disinfection and follow-up treatment as for wounds. The hoof affected must not be allowed to come into contact with manure.

5.4.3 General ailments resulting from increased susceptibility

This category includes in particular diseases for which the natural premunition or tolerance can quickly disappear under stress, e.g.: trypanosomiasis and piroplasmosis.

Abrasions and other wounds increase susceptibility to streptothrichosis, as does the increasing movement of zebus from the semi-arid regions to the more humid Sudan and Guinea zones.

Tired and overworked animals may be additionally weakened if infested by endoparasites, and draught cattle should therefore be regularly

dewormed and lungworm and liverfluke treatment carried out, if necessary. If cows are kept for draught work or for breeding draught oxen, brucellosis control is of importance for economic reasons.

5.4.4 Prophylaxis and treatment of trypanosomiasis

Non-trypanotolerant breeds can be kept in areas infested with tsetse-flies provided that appropriate prophylaxis and treatment are available.

Keeping such breeds in tsetse-infested areas for a short time (e.g. for fattening, short-term use of draught cattle, transhumance) presents no technical problems. If the animals are to remain in such areas for longer periods (e.g. for breeding, long-term use of draught cattle), however, the problem of resistance to trypanosomes arises and to date there has been no drug available on the market to which the trypanosomes do not build up resistance when it is used over a lengthy period. This problem can be avoided to a limited extent through alternative use of various drugs, at least in the medium term (keeping of draught cattle for 4-5 years). There is as yet no information on successful long-term breeding and rearing of non-trypanotolerant breeds in tsetse-infested areas with the aid of prophylactic measures.

Prophylactic measures will protect the animal for 3-6 months, depending on the drug used and the intensity of the infection.

There is a difference of opinion among veterinarians as to the need for prophylactic measures and the advantages of treatment on its own. Some consider that regular prophylaxis is uneconomical and unnecessary in areas where the tsetse-fly is found in smaller numbers or only at specific times, since it is sufficient to treat the sick animals. Prophylaxis is on the other hand considered essential in areas heavily infested with tsetse-flies. It must be expressly pointed out, however, that draught cattle which contract the disease will subsequently exhibit a temporary reduction in performance - and may even be unable to work at all - so that prophylaxis is imperative, at least during the main working period (rainy season), even if the area is only slightly infested.

Controversy surrounds the use of drugs to increase the trypanotolerance of tolerant and semi-tolerant breeds and in particular of animals subjected to stress.

Table B/1/10: THE MAJOR CATTLE DISEASES

DISEASES	OCCURRENCE	CAUSE	TRANSMISSION	SYMPTOMS	TREATMENT	PROPHYLAXIS	IMMUNITY
1. VIRUS DISEASES RINDERPEST (peste bovine)	Endemic in tropical Africa; kept largely under control thanks to vaccination.	Virus in blood, body fluids, intestinal mucous membrane; discharge by means of secretions and excretions.	Direct by means of mucous membrane contact and droplet infection.	Fever, inflamed mucous membranes, nasal discharge, diarrhoea, bent back, red spots on muscular mucous membrane, bleeding ulcers on mucous membrane in mouth, faeces containing black blood, loss of weight.	No effective treatment.	One-time vaccination for all cattle aged 9 months or over. 2nd vaccination for young animals after 1 year.	Permanent immunity following vaccination or recovery. Can be transmitted to calves via colostrum but only for 6-8 months.
RIFT VALLEY FEVER (Fisvre du Rift Valley)	East and Southern Africa, Chad, Cameroon	Virus in blood and tissue.	Mosquitoes (Mansonia and Medes species). Can be transmitted from animal to man through infected blood and tissue.	Reduced fodder consumption, increased salivation, rough hide, varying (abortion), sometimes with high temperature and death.	No effective treatment.	No effective prophylaxis.	Permanent after recovery.
2. BACTERIAL DISEASES ANTRAX (charbon bacterien)	Whole of Africa; frequent during the rainy season.	Bacillus anthracis in blood. Spore formation shortly before death. If animal's carcass remains unopened spores decompose as a result of putrefaction but penetrate the ground through the skin. If the carcass is opened the spores multiply.	Consumption of fodder containing spores. Infected pastures, animal carcasses, bone meal or drinking water infected by scavengers.	High temperature, haemorrhagic mucous membrane, muscular tremors, black blood, dark urine, death in 1-3 days.	Penicillin and oxytetracycline successful only if treatment applied during initial stage. Additional treatment with anti-anthrax serum is expensive and practical only for valuable high-performance animals. Complete treatment of carcasses and material coming into contact with them.	Vaccination once a year for all cattle.	Approx. 1 year following vaccination.
BLACKLEG (charbon symptomatique)	Whole of Africa, mainly affects young animals.	Poisoning by Clostridium chauvoei. Formation of spores in blood. Spores can survive for several years in the soil.	Consumption of material containing spores.	High temperature, lameness with hot, painful swelling on upper arm and shoulder, skin over swelling is hard, dry and dark. Death after 2-3 days.	Antibiotics effective only if treatment started early. Antitoxic serum economically practical only for valuable high-performance animals. Carcasses must be buried.	Vaccination once a year for all cattle.	Approx. 1 year following vaccination.
CONTAGIOUS BOVINE PLEURO-PNEUMONIA (pneumonie contagieuse des bovins)	Semi-arid and arid regions in West and East Africa, Sudan, Ethiopia.	Mycoplasma mycoides, mainly in lung, respiratory passages, lymph.	Direct transmission by droplet infection. Slow spread within a herd.	Rapid breathing, rough hide, coughing, mucorulant nasal discharge, mortality rate 10-50%.	Problematic because recovering animals remain carriers. Treatment practical only if it maintains the slaughter value and the animal is slaughtered soon afterwards. When the disease occurs for the first time in a previously unaffected area, all animals must be slaughtered to prevent the disease from gaining a hold.	Vaccination once a year for all cattle. Among animals where the disease has already taken a hold, at 3-month intervals until disease disappears.	For several years following recovery for approx. 1 year following vaccination.

Table B/1/10 (continued)

DISEASES	OCCURRENCE	CAUSE	TRANSMISSION	SYMPTOMS	TREATMENT	PROPHYLAXIS	IMMUNITY
HAEMORRHAGIC SEPTICÆMIA (pasteurellose)	Whole of Africa, mainly during the rainy season. Greater risk in humid tropics rather than arid tropics.	<i>Pasteurella multocida</i> .	Direct contact and through drinking water via saliva and nasal discharge. Animals subjected to stress more susceptible. Clinically healthy animals may be carriers.	Fever, fatigue, increased salivation, nasal discharge, hot doughy swellings on larynx, tongue and head; death after 6-24 hours.	Hopeless unless applied during earliest stage. Sulfamides and antibiotics (tetracycline, streptomycin, chloramphenicol) together with oil-adjuvant vaccine.	Vaccination once a year for all cattle.	Partial immunity after recovery. Immunity for approx. 2-12 months after vaccination.
BRUCELLA (brucellosis)	Whole of Africa, almost exclusively female animals affected.	<i>Brucella abortus</i> , mainly in uterine cotyledons.	Consumption of infected fodder; pasture infected by urine discharge. Calves and humans infected through milk; transmission by bulls rare but possible. Transmission by blood-sucking ticks is suspected.	Warping (abortion), frequently between 5th and 7th month, with subsequent pregnancies possible only at still-birth, after birth discharge with difficulty or not at all.	No effective treatment; antibiotics eliminate bacteria only sparingly.	Vaccination of female calves aged between 6 and 9 months; heifers not previously vaccinated should be immunized only when not pregnant.	Passive immunity following vaccination.
STREPTOTRICHOSIS (streptothricose)	Mainly in humid and semi-humid zones of West, Central and South-East Africa; increased occurrence during rainy season; African cattle without humps appear less susceptible	<i>Dermatophilus congolensis</i> .	Wounds; aided by bites and tick insects are suspected of being the vectors.	Skin wounds, pustules and skin ulcers, initially on the back, either local or extending to other parts of the body; formation of crusts and scabs; entire cutaneous tissue removed if rubbed. Severely affected animals refuse to eat and usually die of hunger.	Antibiotics (combination of penicillin and streptomycin), to date not fully effective.	No vaccine available; regular dipping or spraying to ward off ticks is regarded as protection.	Possibly a certain amount of tolerance among individuals.
3. PROTOZOAL DISEASES BABESIASIS/PLUROPALSMOSIS/RED WATER TICK FEVER (piroplasmose, babesiose)	Whole of Africa.	<i>Babesia bigemina</i> , <i>B. bovis</i> , <i>B. berbera</i> in erythrocytes.	Monoxenous, biexenous and triexenous ticks of genus <i>Bomphus</i> , <i>Rhipicephalus</i> and <i>Haemaphysalis</i> . With monoxenous ticks transmission by infected egg, with heteroxenous tick infection by eggs, larva and nymph.	Fever, reduced fodder consumption, increased salivation, diarrhoea, dark urine after 3 days, increased heart action, sometimes jaundice, death after 4-8 days in acute cases; recovery in less severe cases. <i>Babesiosis</i> frequently occurs together with anaplasmiasis.	<i>Babesin</i> , <i>Acaprin</i> , <i>Gonacrine</i> , <i>Lubodal</i> , <i>Beremini</i> . If animals are transported to areas unaffected by the disease total extermination of parasites necessary; if they remain in the enzootic region, immunization by means of a smaller dose.	Tick control through dipping, spraying or washing (Tigal, Gammatox, Neguvon, Tiphene, Asuntol, Cholerone, Dicox etc.)	Prevention for recovered animals if re-infected. Approx. 1 year following last re-infection. Cattle reared in enzootic areas are pre-immunized by early infection. Prevention may cease to be effective under stress.

Table B/1/10 (continued)

DISEASES	OCCURRENCE	CAUSE	TRANSMISSION	SYMPTOMS	TREATMENT	PROPHYLAXIS	IMMUNITY
EAST COAST FEVER (fièvre de la côte orientale)	East, North-east and South-east Africa, including Burundi, Rwanda and eastern Zaïre	<i>Theileria parva</i> , mainly in lymphoid tissue. Disease classified in the theileriosis group.	Ticks, mainly the tri-omous <i>Rhipicephalus appendiculatus</i> .	Swelling of lymphatic nodes, bristly hide, fever after 2-4 days, discharge from nose and eyes, diarrhoea, blood in faeces, death in 5-30 days.	No reliable treatment. Chlorotetracycline and oxytetracycline can reduce parasite infestation but only if applied during incubation period.	Tick control (see babesiosis)	Cattle passed in enzootic areas are immune due to primary infection; other calves, however, normally may contract this disease particularly as a result of malnutrition and other diseases.
TRYPANOSOMIASIS/ NAGANA (Trypanosomiasis)	In regions of West, Central, East and South-east Africa infested with tsetse-flies.	<i>Trypanosoma congolense</i> , <i>T. vivax</i> , <i>T. brucei</i> throughout; tsetse-fly dispersal areas; <i>T. anthracis</i> in Uganda and Zaïre; <i>T. dimorphum</i> in Guinea, Zaïre, Congo, Mozambique and Zimbabwe; <i>T. simiae</i> in East Africa, Zaïre and Congo. Major pathogens for cattle: <i>T. congolense</i> and <i>T. vivax</i> .	Tsetse flies (<i>Glossina</i> spp.) in which the trypanosomes multiplied mainly by <i>Glossina morsitans</i> , <i>G. pallidipes</i> and <i>G. brevipalpis</i> . <i>T. vivax</i> mostly transmitted by <i>G. palpalis</i> and <i>G. pallidipes</i> in East Africa and <i>G. tachinoides</i> in West Africa. Mechanical transmission by other biting flies (Tabanids, stomachs suspected).	Intermittent fever, reduced fodder consumption, dull bristly hide, rapid shallow breathing, anaemic exhaustion. In acute cases death after 1-2 weeks. In chronic cases increased anaemia, wasting (abortion), death after a long period. Diagnostic requires a blood test but in chronic cases the parasites can disappear from the blood for a time.	The most effective prevention at present is generally, since resistance occurs with other preparations, Berzolid should therefore preferably be used not just for prophylaxis. Large doses completely destroy the pathogens but this also destroys the natural protection of tolerant breeds. With restriction vitamin reactions result in death may occur.	See babesiosis schedule for draught cattle. Possibility of cross-resistance must be borne in mind so that an occasional change of product is necessary. Prophylaxis essential if non-tolerant breeds are kept in tsetse-infested areas. For colour breeds necessary only if animals are subjected to stress (shortage of fodder, disease, work).	Particular immunity not yet established. Prevention of disease by removal of tsetse flies, if necessary, is essential. In tolerant breeds see section on Nagana. Animals from tolerant breeds are immune and require no special measures to prevent infection.
4. RICKETTSIAL DISEASES ANAPLASMOSIS (Anaplasmose)	Whole of Africa	<i>Anaplasma marginale</i> , <i>A. centrale</i> in erythrocytes.	Ticks, mainly the monoxenous <i>Bombus</i> spp., game forms natural pathogen reservoir. Mechanical transmission by unsterilized hypodermic needles and castration knives.	More rapid breathing, reduced fodder consumption, anaemia, jaundice, stiff gait, warbling (abortion), constipation followed by bloody excreta, oedema around eyes, death after 3-4 days. Less serious cases: slow recovery with long-term anaemia.	Oxytetracycline or chlorotetracycline successful only in early stage and only for reducing parasitic infestation.	Tick control. Young animals less than 1 year old can be preimmunized by transfusion of blood from infected animals.	Recovered or pre-immunized animals remain pathogen carriers and thus potential transmitters of the disease.

Table B/I/11: Prophylaxis schedule for combatting trypanosomiasis in draught cattle

Type of breed	Low	Medium	High
Tolerant breeds (well fed)	-	1 x approx. 1 month before start of rainy season	1 x approx. 1 month before start of rainy season
Tolerant breeds (poorly fed)	1 x approx. 1 month before start of rainy season	1 x approx. 1 month before start of rainy season; 1 x after 3 months	1 x approx. 1 month before start of rainy season; 1 x after 3 months
Semi-tolerant breeds (well fed)	1 x approx. 1 month before start of rainy season	1 x approx. 1 month before start of rainy season; 1 x after 3-4 months	1 x approx. 1 month before start of rainy season; 2 x at 4-month intervals
Semi-tolerant breeds (poorly fed)	1 x approx. 1 month before start of rainy season; 1 x after 3-4 months	1 x approx. 1 month before start of rainy season; 2 x at 4-month intervals	1 x approx. 1 month before start of rainy season; 3 x at 3-month intervals
Non-tolerant breeds (well fed)	1 x approx. 1 month before start of rainy season; 3 x at 3-month intervals	1 x approx. 1 month before start of rainy season; 4 x at 2-month intervals during rainy season and 3-month intervals during dry season	1 x approx. 1 month before start of rainy season; 5 x at 2-month intervals
Non-tolerant breeds (poorly fed)	1 x approx. 1 month before start of rainy season; 4 x at 2-month intervals during rainy season and 3-month intervals during dry season	1 x approx. 1 month before start of rainy season; 5 x at 2-month intervals	1 x approx. 1 month before start of rainy season; 5 x at 2-month intervals

Table B/I/12: The most commonly used trypanocides

Preparation	Effective against	Used for	Dose mg/kg LW 1)	Duration of protection (months)	Cross-resistance with	Effective alternative preparation
Ethidium	T.congolense T.vivax	Treatment (Prophylaxis)	1 1	2-3	Samorin Prothidium Antrycide	Berenil
Novidium	T.congolense T.vivax	Treatment (Prophylaxis)	1 1	2-3	Samorin Prothidium Antrycide	Berenil
Prothidium	T.congolense T.vivax	Prophylaxis (Treatment)	2 0.2-0.4	2-4	Ethidium Antrycide Metamidium and occasionally Samorin	Berenil Samorin
Metamidium (M&B 4404)	T.congolense T.vivax	Treatment (Prophylaxis)	0.2-0.5 2-3	3-7	Prothidium	Berenil Samorin
Samorin (Trypamidium M&B 4180)	T.congolense T.vivax	Treatment Prophylaxis	0.2-0.5 1-2	5-6	Antrycide Ethidium and occ. Prothidium	Berenil
Anthrycide dimethyl- sulphate	T.congolense T.vivax T.brucei T.evansi	Treatment	4.4	3	Ethidium Prothidium Samorin Novidium	Berenil
Anthrycide chloride	T.congolense T.vivax T.brucei T.evansi	Prophylaxis	50	3	Ethidium Prothidium Novidium Samorin	Berenil
Anthrycide prosalt	T.congolense T.vivax T.brucei T.evansi	Prophylaxis	7.4	2-4	Ethidium Prothidium Novidium	Berenil
Berenil	T.congolense T.vivax T.brucei T.evansi	Treatment	3.5-7	0.5-1	Prothidium (occasionally)	-

1) LW = live weight

TABLE B/1/13: ADVANTAGES AND DISADVANTAGES OF THE VARIOUS TICK CONTROL METHODS

METHOD	ADVANTAGES	DISADVANTAGES	PREREQUISITES	POSSIBILITIES
1. TRADITIONAL DIP	<ul style="list-style-type: none"> - RELATIVELY GOOD GUARANTEE THAT CATTLE ARE COMPLETELY COVERED 	<ul style="list-style-type: none"> - HIGH WATER REQUIREMENT (10.000-12.000 LITRES) - RISK OF INJURY AS ANIMAL JUMP IN PARTICULARLY FOR HEAVILY PREGNANT COWS, CALVES AND CATTLE WITH PROJECTING HORNS - CONCENTRATION CAN BE DILUTED BY RAIN-WATER - HIGH INVESTMENT COSTS 	<ul style="list-style-type: none"> - LARGE NUMBER OF CATTLE - PROTECTIVE ROOF TO MAINTAIN SOLUTION CONCENTRATION PROVIDED BY VETERINARY PERSONNEL - DIP MUST BE EMPTIED 2-3 TIMES A YEAR 	<p>RECOMMENDED ONLY IF THERE ARE LARGE HERDS (TRADITIONAL HERDS IN ADDITION TO DRAUGHT CATTLE)</p>
2. MACHAKOS DIP	<ul style="list-style-type: none"> - REQUIRES LESS WATER THAN TRADITIONAL DIP (APPROX. 2250 L) - LOWER INVESTMENT COSTS THAN FOR TRADITIONAL DIP - NO INJURY RISK 	<ul style="list-style-type: none"> - RISK OF INCOMPLETE COVERING (PARTICULARLY INSIDE FARMS) IF AUXILIARY PERSONNEL ARE NOT CAREFUL - REQUIRES MORE AUXILIARY PERSONNEL THAN TRADITIONAL DIP 	<ul style="list-style-type: none"> - AVAILABILITY OF AUXILIARY PERSONNEL - CARE ON PART OF AUXILIARY PERSONNEL - PROTECTIVE ROOF TO MAINTAIN SOLUTION CONCENTRATION - DIP MUST BE EMPTIED 2-3 TIMES A YEAR - FACILITIES FOR KEEPING THE ANIMALS IN THE DIP (TETHERING, DIVIDING BARS) 	<p>GOOD FOR SMALLER HERDS OF CATTLE, E.G. FOR ONE OR MORE VILLAGES</p>
3. SPRAY INSTALLATION	<ul style="list-style-type: none"> - POSSIBLE TO KEEP CONCENTRATION OF INSECTICIDE SOLUTION CONSTANT - REQUIRES LESS WATER THAN DIPS - NO INJURY RISK - QUICKER THAN DIPPING - POSSIBLE TO ORGANIZE ON CONTRACTOR-RUN BASIS - MOBILITY 	<ul style="list-style-type: none"> - ENERGY REQUIRED TO POWER INSTALLATION - RISK OF INADEQUATE COVERING OF HARD-TO-REACH POINTS IF ANIMALS PASS THROUGH - IN MANY CASES INSTALLATION IS NOT YET MANUFACTURED IN THE COUNTRIES CONCERNED AND MUST BE IMPORTED IF NECESSARY - SUBSTANTIAL INVESTMENT REQUIRED 	<ul style="list-style-type: none"> - INSTALLATION MANUFACTURED IN COUNTRY CONCERNED - AVAILABILITY OF ENERGY 	<p>NOT RECOMMENDED BECAUSE PREREQUISITES OFTEN NOT FULFILLED</p>
4. SPRAYING BY HAND	<ul style="list-style-type: none"> - CAN BE PERFORMED ON FARM BY MEMBERS OF FAMILY - MINIMAL INVESTMENT COSTS 	<ul style="list-style-type: none"> - MAY BE INEFFECTIVE IF NOT DONE CAREFULLY (INCOMPLETE COVERING) - FARMERS OR EXTENSION WORKERS MUST PLAN INSECTICIDE REQUIREMENTS AND SUPPLY - RISK THAT CONTROL MAY BE DISCONTINUED BECAUSE OF SHORTAGE OF CASH FOR BUYING INSECTICIDES OR SHORTAGE OF TIME 	<ul style="list-style-type: none"> - SUPERVISION AND MONITORING BY VETERINARY PERSONNEL - INSECTICIDES READILY AVAILABLE TO FARMERS - FACILITIES FOR KEEPING THE ANIMALS STATIONARY 	<p>ALTHOUGH IT IS CHEAPEST, THIS METHOD IS UNSUITABLE DURING THE INITIAL PHASE OF DRAUGHT CATTLE KEEPING SINCE THE FARMERS CANNOT BE EXPECTED TO EXERCISE THE ESSENTIAL CARE AND THE VETERINARY SERVICE MAY STILL HAVE TO BE SET UP</p>
5. WASHING	<ul style="list-style-type: none"> - NO INVESTMENT COSTS APART FROM THOSE FOR BRUSHES AND BUCKETS - CAN BE CARRIED OUT ON THE FARM - POSSIBLE TO AVOID WASHING WOUNDS 	<p>SEE 4.</p>	<p>SEE 4.</p>	<p>SEE 4.</p>

5.4.5 Administrative prerequisites and costs for prophylaxis and treatment of trypanosomiasis

Prophylactic measures against and treatment of trypanosomiasis involve certain prerequisites, the existence, creating or non-existence of which are decisive factors when selecting a breed of cattle:

- 1) Availability of a regular veterinary service covering all farms.
- 2) Regular availability of medicaments on a long-term basis.
- 3) Regular availability on a long-term basis of financial resources required for purchasing medicaments.
- 4) If 1) and 3) are limited: readiness (coupled with appropriate training) on the part of the farmers to perform the prophylactic measures regularly themselves and to pay for the medicaments if necessary.
- 5) Economic advisability of the measures, which involve substantial costs.

These prerequisites must be created or already be in existence if

- 1) zebus are to be used as draught cattle in tsetse-infested areas or
- 2) zebus or exotic breeds are to be crossed with semi-tolerant breeds or
- 3) the stress-related loss of tolerance on the part of adapted breeds is to be prevented.

6. Period of use

In most parts of Africa draught cattle are used for a very long time (up to 10 years). Draught oxen are frequently kept until they die of natural causes; it is seldom the case that old draught cattle are sold at the right time for slaughtering or are slaughtered by the farmer himself. The average period of use appears to be between 4 and 6 years. In recent years - in Senegal for example - cases have occurred of animals being used for only one or two years to guarantee that full benefit can be derived from them as animals for slaughter and this practice is becoming increasingly significant.

BAJARD (1977) gives details of a survey in Sine-Saloum, Senegal, which revealed that out of 32 draught oxen sold for slaughter 52% had been used for only 1 year and that only one pair had been used for as long as 6 years.

However, reducing the period of use with a view to selling the animals at a good price for their meat value is apparently becoming more common in other West African countries as well (e.g. Mali).

This can be attributed to the sharp rise in beef prices; this has, however, also led to a rise in the cost of young animals so that the replacement of draught cattle has also become more expensive.

It is without a doubt right to regard draught cattle as potential sources of meat. However, reduction of their useful life to as little as one or two years has a number of negative effects which must also be calculated.

Consideration of the potential effects makes it clear that neither extreme represents the optimum situation. With a view to the quality of the arable work, draught cattle should be used at least until the young animals which will replace them have reached their final live weight and can satisfactorily handle the heavy work to be done on the farm. It cannot be expected that this will be the case until the third year of their working life and if they are kept under unfavourable conditions, it may be necessary to wait until the fourth year.

The following criteria must be borne in mind when assessing the optimum period of use:

- 1) Price of young cattle
- 2) Prices for slaughter cattle in various weight and age categories
- 3) Work to be performed on the farm and the tractive effort required
- 4) Long-term availability of young cattle on local and regional markets (including reproduction and mortality in existing traditional herds)
- 5) Availability of capital resources and credit (extent, term, interest)
- 6) Existence of alternative sources of demand for young cattle (industrial/small-scale fattening, export).

Table B/I/14: Advantages and disadvantages of short and long periods of use

	Desired period of use	
	Short (1-2 years)	Long (8-10 years)
Positive effects	<ul style="list-style-type: none"> - Increase in beef production - Meat value of animals provides additional income for farmers if paid on the basis of quality 	<ul style="list-style-type: none"> - Heavy work can be easily performed - Less capital investment needed for purchase of animals - Opportunity to keep draught cattle scattered over a wide area if limited number of animals available - Use of cattle not required for draught work for other purposes (e.g. industrial fattening, export)
Negative effects	<ul style="list-style-type: none"> - Heavy work (ploughing) can be performed only to a limited extent or not at all; risk of reduced yields - Rising prices for young cattle as a result of increasing demand - Risk of exhausting stock of young cattle available in the region, particularly if there are no back-up measures to improve reproduction within herds - Necessary to restrict keeping of draught cattle or import animals when available stock exhausted 	<ul style="list-style-type: none"> - Risk of increased mortality, particularly if animals kept under poor conditions - Non-utilization of natural meat potential in a country or region - Farmers lose additional income from sale for slaughter if animals die prematurely

7. Marketing of draught cattle

7.1 Marketing structure

The existence of efficient marketing structure is essential if culled draught cattle are to be exploited in economic terms, irrespective of whether they have previously undergone fattening or not. In practice, however, there is a frequent lack of marketing facilities; if they do exist they are often inefficient and it is difficult for the farmers to gain access to them. Livestock markets are in particularly short supply in areas where there is little traditional cattle keeping and draught cattle have been introduced only recently. The lack of incentive to sell also helps to explain why farmers use their draught cattle for so many years. The establishment or further development of a marketing structure is of major importance wherever the keeping of draught cattle is geared to profitability, and becomes even more significant as beef production becomes an additional aim of draught cattle husbandry.

7.1.1 Accessibility of livestock markets

In many parts of Africa the farmers do not have easy, rapid access to livestock markets, since such markets are either non-existent or controlled by dealers and middle-men. The cattle are usually bought directly from the farmers in the villages and then offered at the markets to butchers or other dealers. It is clear that the farmer thereby remains unaware of the market situation and the prices offered on the market and he has no incentive to sell - or refrains from selling - his cattle on account of price trends. Draught cattle are still often sold because the farmer needs cash and not always at a time when prices are at their best.

In areas where a traditional market structure of this type is already in existence, it is very difficult to replace it with a structure which directly involves the farmers, particularly if the dealer still acts as a procurer of credit and can thus place pressure on the farmers.

Promotional measures aiming to introduce draught cattle in areas where there has previously been little or no traditional cattle-keeping, should from the very beginning be oriented towards long-term development of an appropriate market structure so that undesirable middlemen can be excluded from the outset. The most important conditions to be kept in mind when setting up a marketing structure are free access to the market for the farmers and pricing on a basis of weight and condition (anticipated slaughter value) of the animals.

7.1.2 Pricing

In most parts of Africa where draught cattle are kept, pricing on the basis of actual weight is unknown. The middlemen's prices are traditionally established in the light of anticipated resale potential and those of the butchers on the basis of the estimated weight, taking into account the animal's condition and the anticipated slaughter value. The introduction of cattle weighing platforms and payment according to actual weight has, so far, proved unsuccessful, either as a result of the high investment costs or the resentment of the middlemen who consider that this robs them of their profit from their dealings with the farmers.

In place of quality-based payment, which requires dead marketing and which is still little used, a price scale based on weight or age can have a favourable effect on the market value of draught cattle. In some parts of West Africa, for example, 4-6 year old cattle are found to fetch higher prices than younger or older animals (per kilogramme of live weight).

7.1.3 Function of the extension service within the marketing system

The marketing situation must be such that it can be readily understood by the farmers. This understanding also involves being familiar with the situation on other large markets at regional and national level, something which, given the current system, is impossible for the farmers.

In view of the fact that suitable measures aimed at promoting the use of draught cattle must always entail the provision of an efficient extension service, it is this service which appears to be the best channel for clarifying the market situation for the farmers. It is therefore advisable that the extension service should incorporate a Marketing Section which should have, among others, the following tasks:

- 1) Imparting of knowledge on the situation concerning the market for young animals (purchase/sale for training purposes)
- 2) Imparting knowledge on the situation concerning the market for slaughter cattle
- 3) Advising the farmers on the optimum time for purchase/sale
- 4) Imparting of knowledge on prices and opportunities for purchasing production inputs e.g. feedstuffs and mineral licks

The function of this section is not to organize marketing but simply to advise the farmers on the basis of continuous monitoring of market trend.

7.2 Fattening of cull-cattle

For biological reasons draught cattle must be expected to be heavier than cattle in the same age group kept in a traditional herd. This is a result of:

- 1) Selection of more powerful and more healthy animals
- 2) Better feeding and health control

This is probably the case at any rate in special promotion projects where the animals are correctly fed and proper health control carried out. In general, however, this is seldom the case on farms, since most draught cattle are not fed adequately and the necessary disease control measures are not carried out.

It is well-known that weight gain and food conversion decrease as the animals become older, particularly when they are already fully grown. This is often used as a reason to regard finishing of fully developed animals as uneconomical. On the other hand, however, the substantial weight fluctuations (rainy-dry-rainy season) occurring amongst cattle kept under the traditional system show that even old animals can exhibit large daily increases in weight (compensatory growth).

During various fattening trials using 7-8-year old draught oxen, it was possible to achieve good daily increases in weight, e.g. 400 g and more in Matourkou, Upper Volta (ROCHEZ, 1977) and 450 g in Chad (LE HASIF, 1976). These two examples show that old cattle are certainly able to make fattening worthwhile by exhibiting satisfactory daily weight increases. It must be investigated on a case-to-case basis whether these increases can be achieved in a profitable manner, since the economic situation of the farm and the region plays a major role here.

The time, duration and intensity of fattening must be determined by the following factors:

- 1) Seasonal fluctuations in the prices for slaughter cattle and any weight-related price scales
- 2) Need for heavy cattle for work on the farm and times at which they are required

- 3) Availability of young draught cattle so that the farm's overall working schedule is not disrupted
- 4) Availability and cost of feedstuffs
- 5) Availability of labour
- 6) Biologically determined development of daily weight increase and food conversion during fattening

Table B/I/15: Advantages and disadvantages of terminating fattening at various times¹⁾ (taking Sine Saloum/Senegal as an example)

Middle of dry season	End of fattening period (total duration 3-4 months)		
	End of dry season	Middle of rainy season	End of rainy season
<p>Advantages:</p> <ul style="list-style-type: none"> - Adequate availability of feed stuffs produced on the farm - Main field work over when fattening starts (cattle) - Labour available - Income obtained before cash requirement increases 	<ul style="list-style-type: none"> -Excellent prices in the event of price variations for fleshy animals -Income obtained during time of increased cash requirement (seed, fertilizer, young animals) -Labour available -Relatively good weight increases since animals already in weakened condition when fattening starts 	<ul style="list-style-type: none"> -Excellent prices for slaughter cattle -Income obtained as cash becomes scarcer 	<ul style="list-style-type: none"> -Efficient utilization of cheapest sources of fodder if pastureland available -Main working period for old animals over when fattening starts -Income obtained when cash is scarcest -Farm's own feedstuffs not affected if pastureland available (required for remaining cattle)
<p>Disadvantages:</p> <ul style="list-style-type: none"> -Moderate or low prices for slaughter cattle -Daily weight gains may be only moderate since animals in good condition when fattening starts -More than one large amount of cash brought in at same time (sale of harvest) 	<ul style="list-style-type: none"> -Shortage of feedstuffs produced by farm itself -May be necessary to buy additional feedstuffs 	<ul style="list-style-type: none"> -Labour force already being used to full capacity (field work) -Large weight loss in 1st month with pasture-based fattening -Few feedstuffs produced on the farm itself available -Old cattle still required for work 	<ul style="list-style-type: none"> -Low prices for slaughter cattle -Labour force already being used to full capacity (field work) -Shortage of feedstuffs produced on farm unless pastureland available -Necessary to buy feedstuffs unless pastureland available

1) It becomes clear from this table that these and other advantages and disadvantages must be carefully weighed up before the optimum fattening time for the conditions in question can be selected.

8. Other types of draught animals¹⁾

Although current and future measures aimed at promoting animal traction in Africa will continue to concentrate on draught cattle, the sporadically encountered use of other draught animals requires that some information should be given here on the use of equides. This appears advisable since in some areas draught cattle are in competition with horses and donkeys/mules and this may limit the intensity with which draught cattle are used. Dromedaries will not be discussed here, since these are mainly used for work in the Sahara or Sahel/Sahara zone. As a result of the varying ecologically determined regional concentrations there is little overlapping and no competition with draught cattle. The information given in this section is not intended to be the basis for planning or assessment of projects promoting the use of horses and donkeys for draught work, but is merely to be regarded as an aid for the planners and appraisers of draught-cattle projects which will help them to recognize and evaluate the advantages and disadvantages of any competitive situation. In areas where horses or donkeys/mules have long been used for agricultural draught work, e.g. in some parts of Senegal, it will not be possible to replace them from one day to the next by introducing draughtcattle. On the contrary, the combination of draught horses, donkeys and cattle may bring economic benefit.

8.1 Horses

8.1.1 Regional importance

The keeping of horses plays a traditional role in North Africa, the Sahel/Sudan zones of West and Central Africa and the Sudan as well as in Ethiopia. In these areas the horse's main function is as an animal for riding, coupled with its value as a social status symbol. Its use for transport purposes is of secondary importance, while it is called upon to perform agricultural work only in a few areas (e.g. Senegal, Mali). In East Africa, Southern Africa and Madagascar little importance is attached to the keeping of horses on smallholdings. Apart from a few animals used for transport purposes in the capital of Madagascar, horses play practically no role at all in this work or in agriculture.

1) This information is largely based on the FAO/CEEMAT study (1972): "Manual on the employment of draught animals in agriculture"

8.1.2 Selection of criteria

- 1) Strong, healthy animal
- 2) Short, straight shoulders
- 3) Straight, strong limbs (long front limbs, short, strong rear limbs)
- 4) Hard, healthy hooves

8.1.3 Breeds and weights

In North and West Africa four main groups of breeds are found which are used on occasion for draught work:

- Barb: North Africa, Maritania, Mali
Barb with some Arab blood: North Africa
Dongolow and crosses with barb: Niger, Northern Nigeria
Pony (with some Arab blood): Senegal, Chad

Table B/I/16: Sizes and weights of various breeds of horse in West Africa

Breed	Weight (kg)	Height at shoulder (cm)
Barb	300 - 450	140 - 148
Dongolow	300 - 350	140 - 145
Pony		125 - 135

Source: FAO, 1972

8.1.4 Types of work and working capacities

In addition to transportation horses are used in Senegal for the following field work:

- 1) Seedbed preparation (no ploughing or cultivating)
- 2) Sowing
- 3) Weeding
- 4) Groundnut lifting

In contrast to cattle, horses are for the most part still used singly for draught work in Africa. On account of its speed the horse nevertheless has advantages over draught cattle for light work, which has meant that horses have been retained even after the introduction of draught cattle. BIGOT and ANNE (1974) have compared the working capacities of draught cattle, horses and donkeys as follows:

Table B/I/17: Working capacities of draught cattle, horses and donkeys in groundnut cultivation in Senegal

Type of work	Time required (hours per hectare)		
	Cattle	Horses	Donkeys
Ploughing	30	-	-
Seed bed preparation	10	8	16
Sowing	9	7	9
Weeding	11	9	9
Ridging (earthing up)	14	-	-
Groundnut lifting	11	15	-

Source: BICOT and ANNE, 1974

The mean tractive effort of a horse is around 1/7 of its body weight, while the maximum tractive effort is given by the FAO (1972) as 150-160% of body weight.



Fig. B/I/8: Draught horse (wearing breast harness) being used for weeding. (Photo: GTZ Archives)

8.1.5 Feeding

Table B/I/18: Nutrient requirements of working horses

	UF	Digestible protein (g)	Dry matter (kg)	Calcium (g)	Phosphorus (g)	Water (l)
Maintenance	2+0.5 per 100 kg LW	75/UF	1.5/100 kg LW	5/100 kg LW	3/100 kg LW	30-50
Light work	1-2 in addition to maintenance	75/additional UF	2-3 per 100 kg LW	30-50 per day	20-30 per day	30-50
Medium-heavy work	2-4 in addition to maintenance	75/additional UF	2-3 per 100 kg LW	30-50 per day	20-30 per day	30-50
Heavy work	5 in addition to maintenance	75/additional UF	2-3 per 100 kg LW	30-50 per day	20-30 per day	30-50

Source: "Mémento de l'Agronome", MINISTÈRE DE LA COOPERATION, 1974

As monogastric animals horses require fodder that is readily digestible, and dry pastures are therefore unsuitable for them. Most horses are nevertheless properly fed, since the animal's value as a social status symbol means that it is usually given high-grade feedstuffs produced on the farm itself (e.g. groundnut hay, millet).

8.1.6 Veterinary aspects

Prophylactic measures should involve deworming and vaccination against African horse-sickness. Horses are not trypanotolerant and therefore cannot be used in areas infested with tsetse-flies.

8.2 Donkeys and mules

Donkeys are found throughout Africa, with the exception of areas infested with tsetse-flies. In North Africa, Ethiopia and East Africa they are used as beasts of burden and for riding, mostly among nomadic tribes (Masai, Turkana). In North, West and Southern Africa they are also used occasionally for transport purposes, although only to a small extent in agriculture (e.g. Tunisia, Senegal, Mali, Upper Volta).

Table B/I/17 indicates that donkeys have an advantage over cattle only as far as weeding is concerned. For sowing they have the same working capacity as cattle, while seedbed preparation is already too heavy a job for these light animals.

The FAO (1972) gives the average tractive effort as 1/5-1/6 of the animal's body weight, i.e. proportionally higher than for cattle and horses. In exceptional cases a donkey can even produce a tractive effort amounting to 1/4 of its body weight. The mean maximum effort is around 50%, while the absolute maximum is approximately 130-140% of the body weight.

On average, donkeys weigh between 80 and 100 kg and have a height of 70-100 cm at the shoulder. The average weight of mules is between 200 and 250 kg with a shoulder height of 120-130 cm.

The animals should not work for more than 3.5 hours (actual working time) per day.

Feeding of donkeys

Maintenance requirement	1.5 UF/day
Maintenance and light work	2.5 UF/day
Maintenance and heavy work	4.0 UF/day
Water requirement	15-30 l/day

Source: FAO, 1972

In practice, donkeys are usually left to find food on their own.

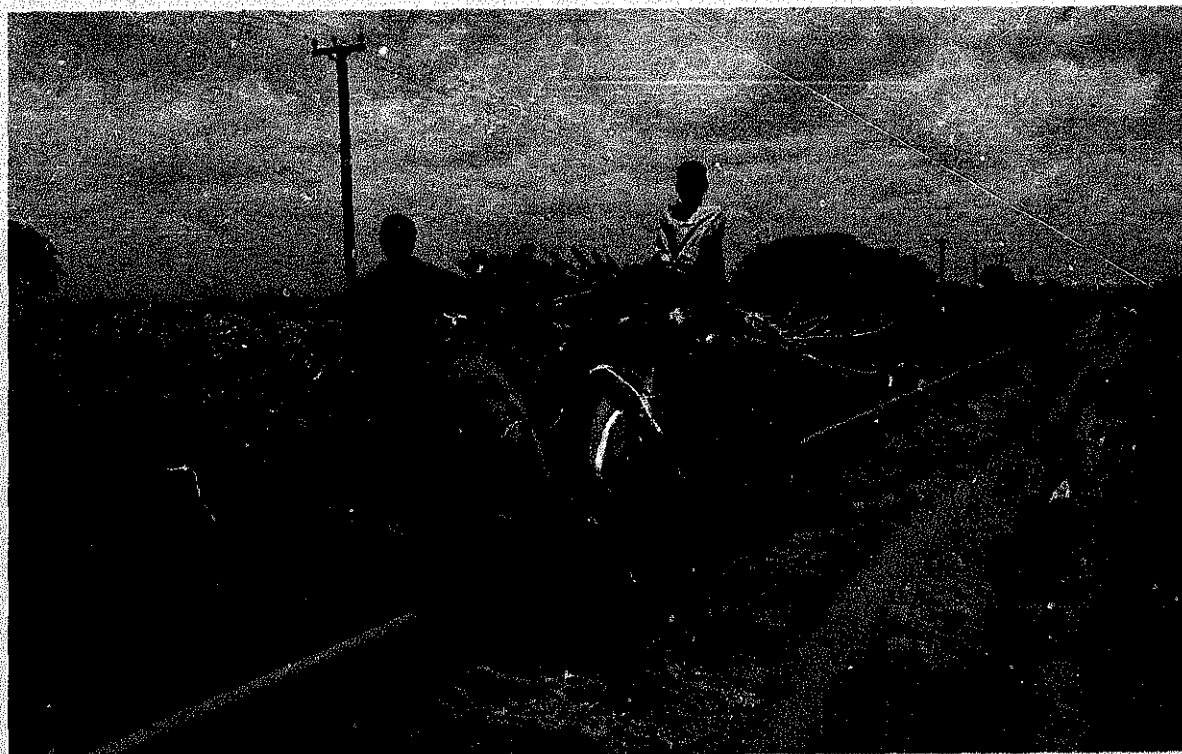


Fig. B/I/9: Team of donkeys being used to transport firewood near Embu in Kenya. (Photo: Munzinger/GTZ)

8.3 Advantages and disadvantages of draught cattle, horses and donkeys.

Table B/I/19: Advantages and disadvantages of draught cattle, horses and donkeys

Cattle	Horses	Donkeys
<p><u>Advantages:</u></p> <ul style="list-style-type: none"> -Steady, albeit slow work -Work less tiring for the farmer -Only one person required for work -Simple harnesses can be manufactured locally -Can perform heavy field work -Can perform work requiring broader implements or more than one implement -Easy to feed - Generally cheaper per pair than horses -Substantial increase in value as slaughter animal -Additional milk production for farmer's family if draught cows kept 	<ul style="list-style-type: none"> -Easy to tame, intelligent and trusting -High prestige value in many areas -Can move quickly (transport, sowing, weeding) -Easy to handle and control during work 	<ul style="list-style-type: none"> -Few special requirements -Easy to train -Quiet and patient when working -Low initial outlay
<p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> -Move slowly -Slower and more difficult to train than horses or donkeys 	<ul style="list-style-type: none"> -High initial outlay -Harness expensive and elaborate -Not trypanotolerant -Require high-grade feedstuffs -Work tiring and exacting for farmer (animals more quickly) -Too light for heavy field work - No slaughter value 	<ul style="list-style-type: none"> -Too light for most agricultural work -Not trypanotolerant - Likely to sustain injuries caused by harness -No slaughter value

B/II

Harnessing and use of implements

B/II BASIC ASPECTS OF HARNESSING AND THE USE OF IMPLEMENTS

(U. Viebig)

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1. Introduction

The productivity of agricultural holdings in developing countries can be increased to a substantial extent through the use of draught animals. However, this requires careful planning; in addition to selection of suitable implements, which must be geared not only to the crop requirements but also to the capacity of the animals, an appropriate method of harnessing is also of major importance.

The first section deals with the traction capacity of various teams of animals. Every draught animal will have a different capacity and the figures given are therefore only approximate.

The second section is devoted to the various types of harness. Suitable harnesses should be designed such that they restrict the animals' movements as little as possible and do not impose unnecessary loads on them. Badly designed harnesses or incorrect harnessing lead to premature fatigue. The harnesses used in Africa are often still simple and incomplete.

The major element of this part of the handbook is formed by the fourth section, which is intended to give an idea of the working methods to be used with draught animals under tropical or subtropical conditions, together with the appropriate implements. The descriptions are not confined to implements which are already in common use, but also extend to those which could be used in the future, possibly in a modified form. A number of machines are described, e.g. the mowers formerly used on a widespread basis in Europe, in order to give the reader a few suggestions.

A further section gives some of the data necessary for estimating working time requirements.

In conclusion, some aspects of the maintenance and supply of animal-drawn implements are discussed.

This part of the handbook does not claim to deal with all technical aspects of the use of draught animals. The diverse structure of the topics discussed permits only relatively general assertions which do not necessarily apply to each individual case. Precise analysis of the initial situation during the planning of a development project,

together with weighing-up of requirements and alternative solutions to problems, are essential and this part of the handbook can act as a basis for this work.

2. Traction capacity of draught teams

Optimum selection of implements and draught animals, together with optimum composition of draught teams, calls for highly detailed knowledge of the traction capacity of the various types of teams and the factors influencing it.

The traction capacity of teams of animals cannot be given in as simple a form as the "engine power in kW"¹⁾ of tractors. Instead, in addition to tractive effort and working speed, it is also necessary to specify the duration of the work since draught animals, unlike tractors, become tired. Moreover, draught animals cannot produce a specific amount of traction power in such a variety of different tractive effort/speed combinations as is possible with tractors by virtue of the transmission.

2.1 Sustained traction capacity

The possibilities for using draught animals on farms are often limited by the heavy work involved in tilling the soil. This requires as great a tractive effort as possible over a lengthy period, with the animals working for several hours a day at a moderate speed. Table B/II/1 gives approximate values for the sustained traction capacity (determined by sustained tractive effort, working speed and hours of work per day) of various teams common in Africa. The figures given are only reference values; they are influenced by the physical and mental characteristics of the animals, the working conditions and the type of work and are therefore subject to considerable variation.

The capacity of draught animals in many parts of Africa is often smaller than given in the table because it is precisely at the time when the heavy tillage must be carried out that the animals are in a relatively poor condition. Tillage usually takes place at the start

1) 1 kW = 1 kilowatt = 0.736 HP

of the rainy season, when the animals are for the most part weakened as a result of poor feeding during the dry season which has just ended and are, moreover, no longer used to working.

Table B/II/1: Sustained traction capacity for various teams common in Africa when performing heavy work

Team	Live weight kg	Sustained Relative ¹⁾	tractive effort Absolute ²⁾ daN=pk	Working speed km/h	Working hours per day h
1 donkey	125	20	25	2	3-3.5
2 donkeys	250	18	45	2	3-3.5
1 horse	300	12	35	2.7	5-6
1 ox	350	14	50	2.4	4-6
2 oxen	700	12	85	2.3	4-6
4 oxen	1400	10	140	2.2	4-6

1) Related to live weights

2) 1 daN = 1 decanewton = 1kp (kilopond), physical unit of force

Source: Various authors

The following factors influence the traction capacity of teams of animals:

- Animal-related factors:

Species, breed, sex, age, character, training, habit, weight state of nutrition, health, fatigue etc.

- Work-related factors:

Tractive effort, working speed, hours of work per day, type of work (peak tractive efforts), number of animals in the team, breaks, gradients, weather etc.

Some of these factors can be influenced by the farmers, e.g. weight, state of nutrition, duration of work, breaks.

The three parameters constituting sustained traction capacity, - i.e. working speed, sustained tractive effort, and hours of work per day - will now be discussed in greater detail. These factors are interrelated because, depending on the type of draught animal, there are different optimum values for each one which, if observed, will guarantee maximum daily capacity. In practice it is usually impossible to keep to the optimum values, with the result that the theoretically possible daily capacity is seldom reached.

a) Sustained tractive effort

This factor is of particular importance because it determines which types of work a team can perform. A pair of oxen tilling a medium-heavy soil with a single-share plough, for example, cannot usually plough deeper than 15 cm because their sustained tractive effort is not sufficient.

One major factor influencing an animal's sustained tractive effort is its live weight. Many animals can deliver a tractive effort corresponding to as much as 20% of their body weight for a sustained period, while African draught oxen cannot as a rule exceed 10-15% of their live weight. This figure is governed by a number of factors, some of which have already been discussed in Section B/I.

Large relative tractive efforts can be expected if the animals are well-fed and watered, healthy, well-trained and used to working. The sustained tractive effort can be improved by measures in the areas of feeding, general care and health care; better training and regular use of the animals, preferably throughout the year, will also help.

The relative tractive effort is reduced if the figures fluctuate substantially around their mean value, a state of affairs which occurs particularly if the animals are tilling incompletely cleared areas which are cultivated irregularly. It was found, for example, that a specific team of oxen produced a sustained tractive effort of 100 daN (kp), if the peak values ranged between 150 and 200 daN (kp), while with peak values between 250 and 275 daN (kp) the sustained tractive effort was reduced to 80 daN (kp) (SCHERRER, 1966).

The type of harness used has little effect on the sustained tractive effort if the most important requirements placed on the harness are met (see Section 3).

Experiments have proved that the tractive effort of an individual animal decreases as the number of animals in the team increases; the drop is around 7-10% for every additional animal, as is indicated by Table B/II/1. This can be attributed to the fact that the animals hinder one another and means that the total tractive effort produced by a team does not increase in direct proportion to the number of animals; instead, it approaches a peak and then drops again. In some parts of Africa, particularly in the south, teams are nevertheless formed using relatively large numbers of oxen (up to eight or more)(DUSEK, 1963).

b) Working speed

The average working speed of the various types of draught animal does not exhibit any major differences in the case of large tractive efforts (see Table B/II/1). It must be borne in mind, however, that depending on the tractive effort required, every animal en-

deavours to keep to a certain speed which varies according to species, breed, sex and individual characteristics, and this fact must be taken into account when combining different types of animals to form a team (e.g. donkey and horse).

Cows, for example, move somewhat faster than oxen, even when large tractive efforts are required. However, they need to rest more often, so that this advantage cannot be fully exploited for heavy work (MONNIER, 1975).

As the necessary tractive effort decreases the speed of various types of animals or breeds may increase to varying extents. When performing light work such as sowing, for example, cows and horses have a significantly higher working speed than oxen, a fact which makes them very popular for such work.

The influence of breed on the working speed during light work can be illustrated by the figures obtained for various breeds of cattle: when pulling a cart Peul zebus attained an average speed of 3 km/h, Ankolé cattle a speed of 3.5 km/h and Sahel zebus 5-6 km/h (FAO/CEEMAT, 1972).

c) Working hours per day

When considering sustained traction capacity the daily working hours of humans - which vary from region to region - should be taken as a basis when deciding upon the working period for draught animals. Oxen and horses can work for relatively long periods, whereas donkeys cannot (cf. Table B/II/1).

The potential period of time for which an animal can work is dependent on a number of factors: strain on the animals, working speed, breaks for rest and feeding (as well as for rumination in the case of cattle), weather and condition of animals.

Working hours should be kept short if the work is heavy, the temperature and humidity high, or the animals young or in poor condition. The daily working hours can be increased if the above-mentioned conditions are improved and in particular if the animals are given a long midday break or if a day of work is followed by a rest day.

A pair of oxen, for example, can work for 4-6 hours per day when used for tillage. The daily working time can also be increased for a brief period provided that the animals are in good condition

and subsequently have the opportunity to recover from their exertion and compensate for weight losses. If a day of work is followed by a rest day a pair of oxen can be used for as long as 8 hours per day.

It is reported from Senegal that N'Dama oxen are used for 7 hours a day for both light and heavy work. If they are required to work in the muddy rice fields, however, the figure is reduced to around 3.5 hours/day (CASSE, DUMAS and GARIN, 1965).

2.2 Determination of sustained traction capacity

On account of the influencing factors described in more detail in Section 2.1 determination of the traction capacity of teams of animals is not only a lengthy process but also somewhat problematic. The figures for sustained tractive effort, working speed and daily working hours determined for specific teams are not universally applicable and will not necessarily even be valid for the same team again when it is used at some other time. A large range of fluctuation must therefore always be expected.

It is therefore not advisable to run trials to determine the sustained traction capacity for a specific case. It is sufficient to make estimates which are based on the nature and weight of the team used and take into account the animals' living and working conditions.

If trials of this type are nevertheless carried out, the directions given by CEEMAT (1968) should be observed. KRÜGER (1947) describes in detail a variety of investigation methods. In addition to tractive effort, speed and working period, such studies should also record the various incidental times (e.g. setting-up and turning times), the area covered and the quality of the work, since no values of this type have yet been given for African conditions. The measuring equipment should be as simple as possible, since excessive accuracy is uncalled for on account of the large range of fluctuation of the results.

2.3 Maximum traction capacity

In addition to sustained traction capacity, the maximum traction capacity of the various teams is also of significance. The animals' maximum tractive efforts may be ten times as great as their sustained effort and are very important if moments requiring peak effort are to be successfully overcome. The maximum tractive effort also determines the necessary strength of the implements.

The corresponding values are determined by abruptly stopping the team. The animals are brought to a sudden standstill while moving

rapidly (approx. 4 km/h) with the aid of a securely anchored rope, thereby simulating impacting of the implement against an obstacle in the soil. Table B/II/2 gives the maximum tractive efforts of various African teams; it can be assumed that relatively heavy animals (donkey 150 kg, horse 350 kg, ox 450 kg) were used to obtain these figures (CEEMAT, 1968).

Table B/II/2: Maximum tractive efforts of various African teams

Team	Maximum tractive effort daN = kp ¹⁾	Team	Maximum tractive effort daN = kp
1 donkey	300	1 ox	450
2 donkeys	450	2 oxen	800
1 horse	450	4 oxen	1700

1) 1 daN = 1 decanewton = k kp (kilopond), physical unit of force

Source: CEEMAT, 1968

Donkeys and horses produce a very large maximum tractive effort in relation to their live weight, whereas for cattle the tractive effort is no greater than the animal's live weight.

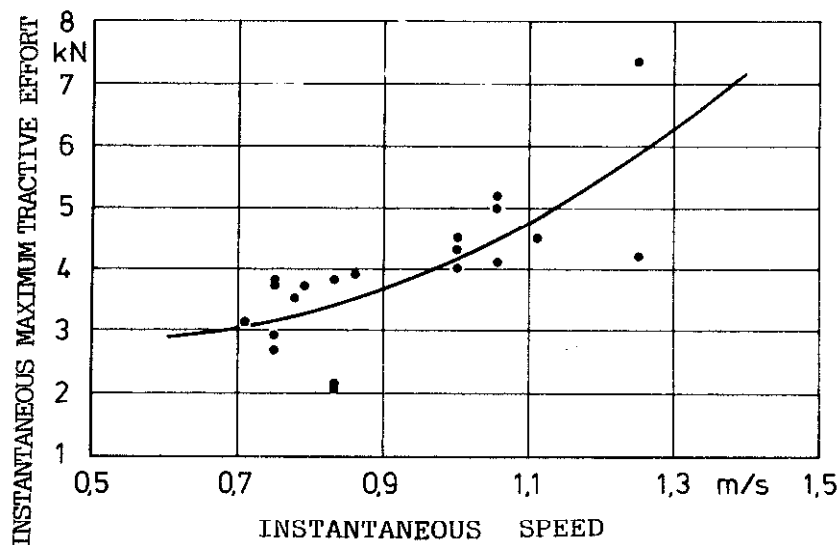


Fig. B/II/I: Instantaneous maximum tractive efforts of a 600 kg pair of oxen as a function of instantaneous speed (according to experiments by SCHERRER, 1966).

Experiments have shown that the instantaneous maximum tractive effort is determined not only by the live weight of the team but also by the instantaneous speed of the team when it is stopped. Fig. B/II/1 shows this relationship for a pair of oxen weighing 600 kg. The maximum tractive effort at 4 km/h is not 800 kg as given in Table B/II/1, but only around 500 kg or 83% of the live weight. If the animals

are brought to a standstill from their working speed (approximately 2.5 km/h) the maximum tractive effort is only 300 kg, representing only 50% of the live weight.

The figures for maximum tractive efforts given in Table B/II/2 occur only if the team is stopped abruptly while moving relatively fast. This is the case if the team is being driven inexpertly or if obstacles are to be overcome on land which is not fully cleared by increasing the impact of the team through acceleration. The point at issue here is whether the implements must always be strong enough to meet these requirements. Under good conditions it should be adequate to take the maximum tractive efforts of draught cattle as corresponding to around half of the weight of the team.

3. Harnesses for draught animals

The harness serves to transfer the animals' tractive effort to the implement being drawn. A distinction is made between the yoke (Fig. B/II/2), which links two draught animals to each other more or less rigidly and the individual harness, or single harness, (Fig. B/II/3), which also permits harnessing of each animal separately.

There are various types of yokes and individual harnesses and their regional distribution in Africa appears to be more a matter of chance. There are few differences between the harnesses as regards their efficiency in transmitting power.

When assessing the quality of a harness the following points are important. A harness should:

- not hinder the animals' natural movements, breathing and blood circulation, this being of particular importance for efficient power transmission;
- permit reliable control and directing of the animals. This requirement is of major importance in the case of poorly trained teams. However, harnesses providing particularly good control over the animals restrict their freedom of movement;
- not injure the animals. The injury risk is low if large areas of the harness rest on well-developed parts of the body and if the harness fits well and does not chafe;

- be as simple as possible to fit and remove;
- be easily adjustable to fit the animals (perhaps by means of appropriate adjustment devices) to compensate for bodily changes resulting from growth and changing states of nutrition and in order to permit one harness to be used for a variety of animals;
- permit "braking", i.e. stopping of carts and trailers by the draught animals, and facilitate reversing of vehicles and implements;
- be of simple design and permit local manufacture;
- be inexpensive. The importance of price should not be overestimated, because it is low in comparison to the price of the animals and implements. The price of the harness may become more important if, for example, several yokes of different lengths are required for one team for various types of work.

If the harnesses already in existence are unsatisfactory it is usually easier to introduce practical improvements rather than bring about a radical changeover to unfamiliar types of harness.

3.1 Harnesses for cattle

The following physical features of cattle are of importance where harnessing is concerned:

- the coarse, relatively insensitive hide; if the animals are used regularly callouses will form;
- the powerful, freely movable shoulders;
- the strong withers and relatively weak chest;
- the long, weak neck (and the hump in the case of zebus in contrast to the taurines).

Harnesses for cattle may rest on the head, neck, withers or shoulders of the animals. A distinction is accordingly made between forehead harnesses, neck harnesses, withers harnesses and shoulder harnesses (collars).

a) Forehead harnesses

Forehead yokes are uncommon in Africa and will not be discussed in detail since they have no special advantages.

The individual forehead harness (Fig. B/II/2) must always be heavily padded so that it is a good fit on different animals. For this reason it was widely used in Europe for harnessing cows since there were frequent changes of animals during work.

It has not yet been determined whether the maximum tractive effort can be produced by animals wearing this harness or whether the opposite is the case because performance is reduced by unnecessary strain on the neck muscles (DRAWER, 1959). Cattle with a short, strong neck and horns which are not too low, i.e. taurines rather than zebus, are in all events suited to the individual forehead harness.



Fig. B/II/2: Cows wearing individual forehead harnesses pulling a mower. (Photo: FAHR company archives)

One disadvantage of the individual forehead harness is that the freedom of movement of the neck and head is restricted so that the animal has difficulty in warding off flies and its natural movements are hindered. Furthermore, the small contact area of the harness may result in chafing and pressure sores during heavy draught work and can even lead to vascular congestion in the brain and to dizziness (DRAWER, 1959). Animals wearing individual forehead harnesses are unable to stop or reverse the equipment being drawn, although this is important only if the animals are used for pulling carts.

The individual forehead harness is usually made of wood, but some-

times also of metal. Particular care must be devoted to the padding.

b) Neck harnesses

Neck yokes (Fig. B/II/3) are extremely important in many African countries. They permit reliable control of the team and it is said to be particularly easy to train the animals if they are wearing this yoke. Another advantage is that it permits reliable stopping and reversing of implements (e.g. carts) if the latter are rigidly connected by means of a towbar.

Simple neck yokes are inexpensive and easy to manufacture, but the production of good-quality yokes is not easy. Particular care should be paid to ensuring that the yoke fits properly on the neck, which is frequently not the case with traditional harnesses. The yoke crossbeam must have sufficiently large notches, projections, hooks or holes to permit securing of the yoke to the horns or on the forehead by means of ropes or straps. The parts of the brow-band resting on the forehead should be padded to prevent chafing. Neck padding is recommended in some cases but not in others; well-fitting neck yokes are probably better without padding. The individual neck harnesses should be securely fitted in order to avoid chafing as far as possible. It should be borne in mind that if a team is to work on crops where the distance between the rows varies the yoke must be correspondingly wide; several yokes of different lengths are often required.

When fitting a harness rigidly, as is the case with the neck harness, it must be remembered that this restricts the animals' freedom of movement. The head and neck are forced backwards and the neck is also twisted to the side. The weight of the yoke - up to 10 kg - places an additional burden on the animals. Chafing and, more rarely, broken horns or even skull fractures may result, particularly if the yoke is inadequately secured.

Despite these disadvantages the neck yoke is repeatedly recommended for harnessing taurines. It should not be used for zebus, since these are more suited to the withers yoke (Fig. B/II/5). If the neck yoke is used the animals should always be harnessed on the same side so that they become adjusted to work on "their" side through training and corresponding muscular development.

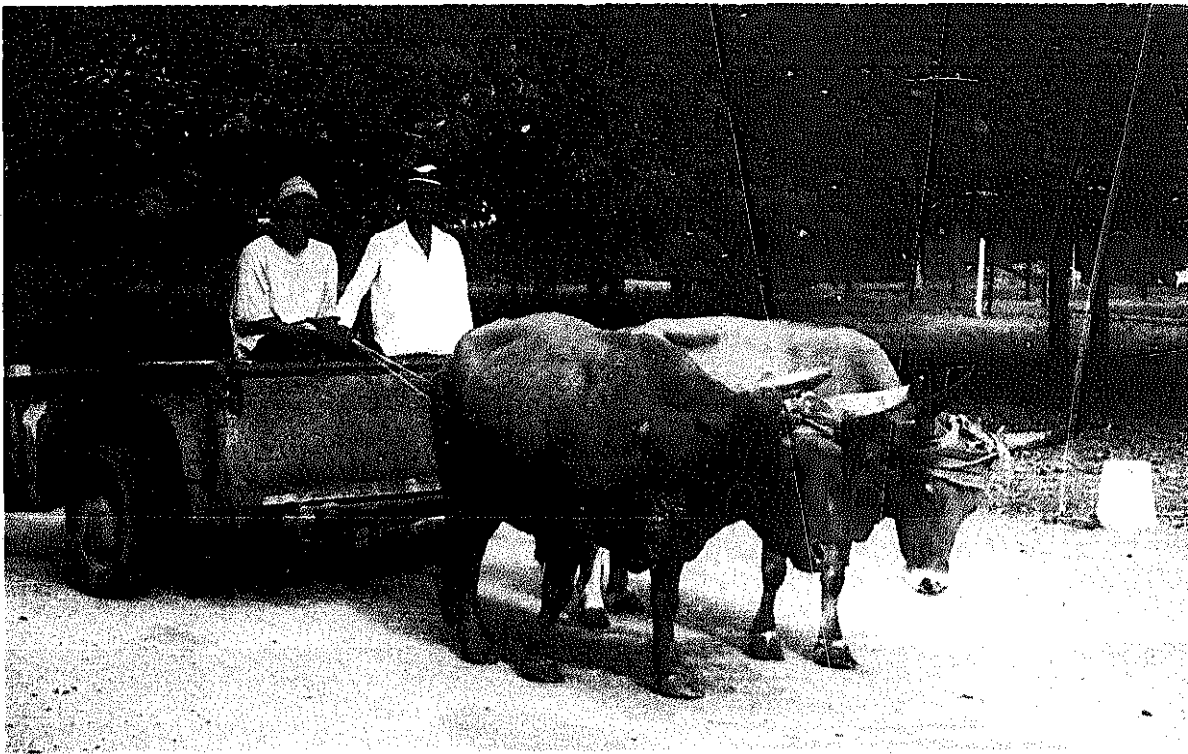


Fig. B/II/3: Djakoré cattle bred by the C.N.R.A. in Bambey, Senegal wearing a locally manufactured neck yoke for transport work. (Photo: Reh)

The stronger animal should be harnessed on the right because during ploughing it has to walk in the furrow or on the land already ploughed and thus has to work harder.

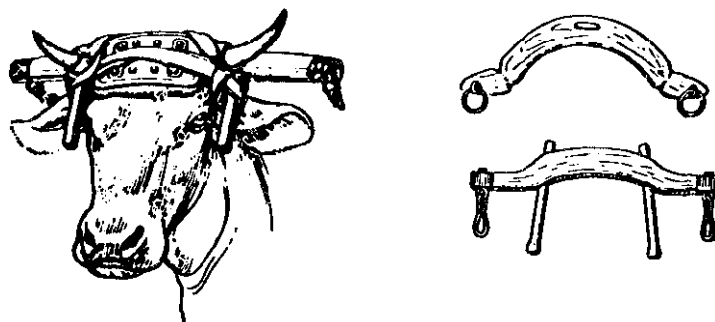


Fig. B/II/4: Individual neck harnesses for cattle (HOPFEN, 1969; DRAWER, 1959)

The individual neck harness (Fig. B/II/4) has similar advantages and disadvantages to the neck yoke (setting aside the considerations relating to rigid linking of two animals). Individual neck harnesses are mostly to be recommended for harnessing single animals wherever neck yokes are the usual method of harnessing pairs. The curved designs which have a low pulling attachment and fit closely on the neck are probably the best types of individual neck harness.

c) Withers harnesses¹⁾

The withers yoke (Fig. B/II/5) is the most widespread type of cattle harness in Africa. In contrast to the neck yoke, the withers yoke permits free movement of the animals' head and neck. The traction points are also located in a better place, i.e. lower, so that the animals' traction capacity is better utilized.

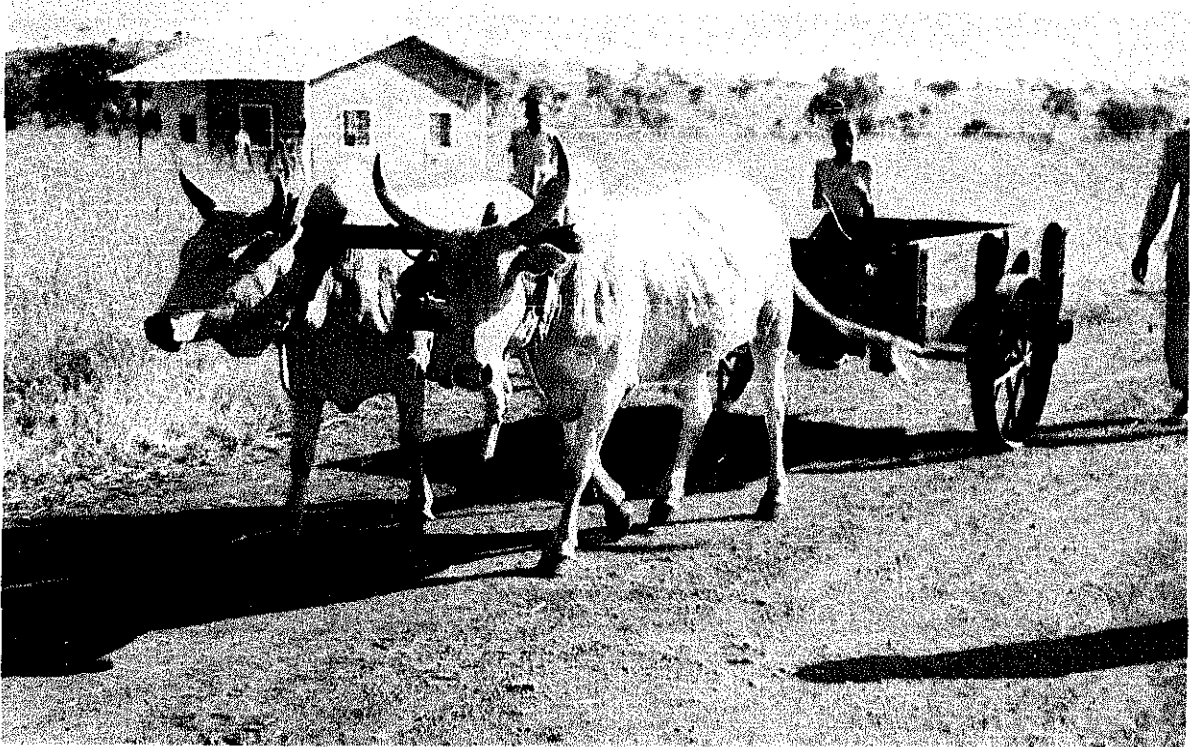


Fig. B/II/5: Team of cattle in Tanzania wearing a withers yoke and pulling the Wananchi ox-cart produced by TAMTU. The iron wheels are a help on bad roads.
(Photo: GTZ Archives)

Craftsmen and farmers become accustomed relatively quickly to manufacturing and using the withers yoke (CASSE et.al., 1965).

The disadvantage of the withers yoke is that it makes it relatively difficult to train the animals and drive the team. Braking

1) Also called "shoulder harnesses"

and reversing of implements by animals wearing the withers yoke also present considerable problems.

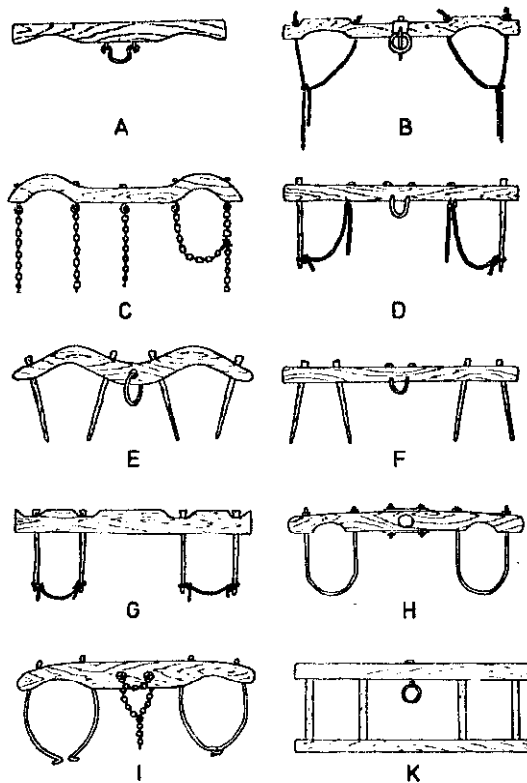


Fig. B/II/6: Various types of African withers yokes (CASSE et.al.,1965)

In its simplest design (type A) the yoke is held in place solely by its own weight, which is sometimes increased by fixing a stone on the yoke, and forced against the withers by the pull of the implement. In most cases, however, the yoke cross-beam is secured on the animal. A simple method is to use ropes or chains (types B and C) but these are highly constricting. The more rigid the yoke design, the more the animals' freedom of movement is restricted and the risk of chafing increases.

Use of narrow iron bars (type I) entails particular risks. U-shaped bars (type H) not only make the yoke difficult to fit but also mean that the animals cannot be released from the yoke quickly enough in an emergency. The size of frame-type withers yokes (type K) must be well-matched to the animal or adjustable.

With the withers yoke it should again be ensured that the contact surfaces fit properly on the body. VAUGH (1945) found contact surfaces of between approx. 180 and 390 cm² on Indian withers yokes; considerable variations are thus possible.

Individual withers harnesses (Figs. B/II/7, 8 and 54) give the animals still greater freedom of movement than withers yokes. To date they have been used for harnessing water buffaloes, which in Africa are found only in Egypt and Madagascar.

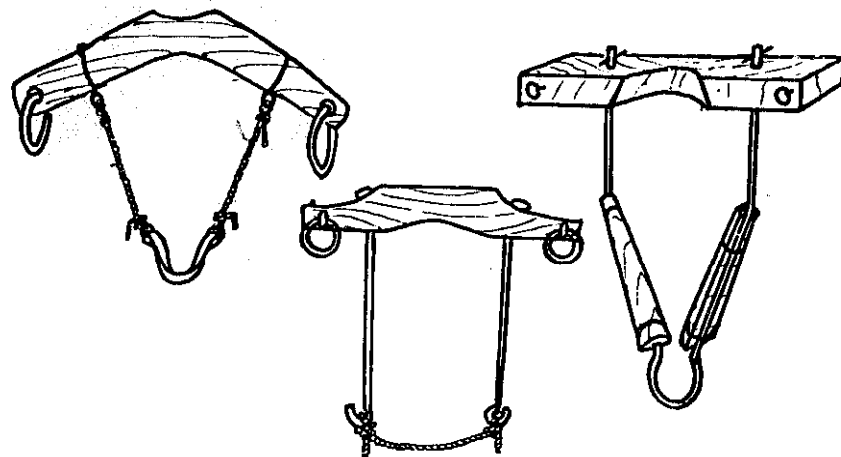


Fig. B/II/7: Various individual withers harnesses (FAO/CEEMAT,1972)

Use of individual withers harnesses should be promoted to a greater extent in the future for cattle as well.



Fig. B/II/8: Water buffalo in China wearing individual withers harness. (Photo: Stroppel)

d) Shoulder harnesses (collars)

Cattle collars are extremely rare in Africa. The advantages of the collar, particularly the three-pad collar (Fig. B/II/9), are generally regarded as being its large contact surface and its essentially somewhat rigid construction. This ensures that the animals can brace themselves properly against the harness and thereby still have adequate freedom of movement as a result of the individual flexibility of the various parts of the harness. The pulling attachment is located low down in a good position.

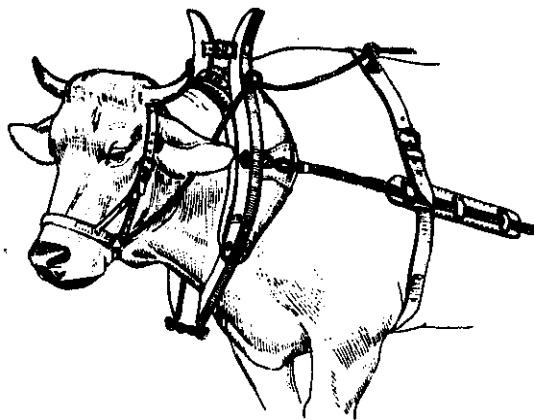


Fig. B/II/9: Three-pad-collar for cattle
(HOPFEN, 1969)

However, in view of the fact that the collar must be individually geared to each animal and since a variety of materials (wood, leather or fabric, hair) are used in its manufacture, this harness is not only difficult to produce but also expensive.

The collar is more suitable for harnessing horses than cattle, since the shoulder blades of cattle are more loosely connected to the barrel and thus require greater freedom of movement.

e) Bridles

In Africa the reins used to control and guide the cattle are often secured to nose ropes or (even better) nose rings (Fig. B/II/10). This provides an effective means of controlling the animals; the

disadvantage is that the insertion of nose rings or nose ropes involves a certain amount of expenditure, since the farmer cannot usually carry out the work himself and disinfectants are required.

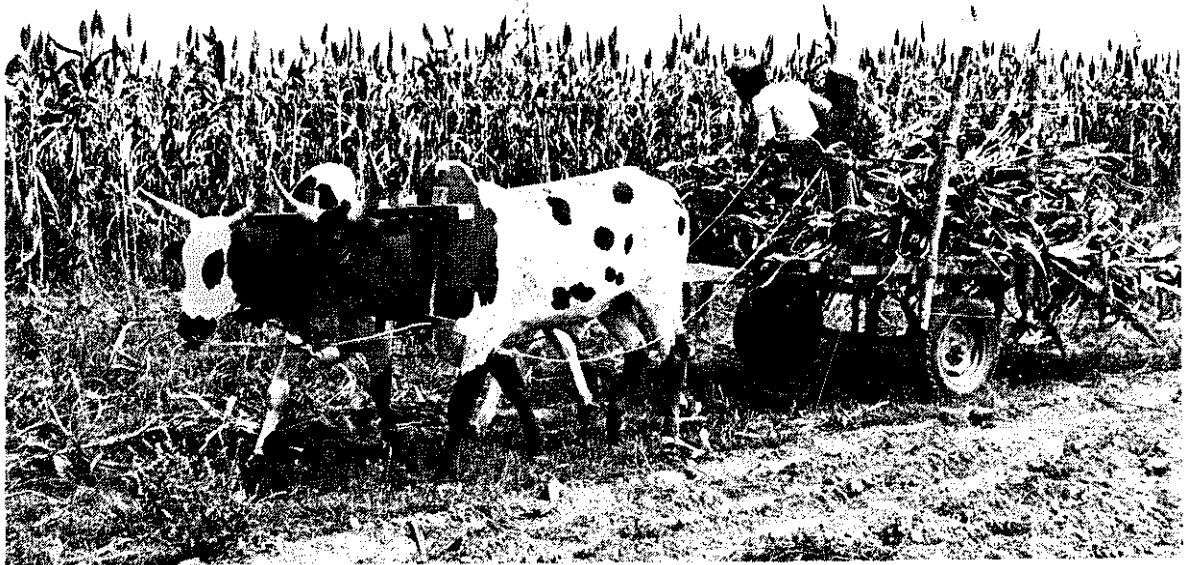


Fig. B/II/10: Even poorly trained draught cattle can be guided by means of reins which pass through nose rings. If a frame-type withers yoke is used - as shown here in Ghana - the reins can be additionally routed through the frame.
(Photo: Wessolowski)

If nose ropes are used they should be short, similar to nose rings, and preferably made of nylon or other synthetic fibres. The reins should also be supported by floating straps, eyes on the harness or similar so that the animal's nose is not continuously irritated. If the team is led from the front the reins must not be kept too taut, since otherwise the animals will not carry their heads properly and nose injuries are often an additional result (Fig. B/II/11).

The "ear bridle" has a less sharp effect on the animal than the nose bridle. As shown in Fig. B/II/12, the rein secured to one horn on the animal acts on the ear on the other side. The advantage of this system is that nose rings are unnecessary and the

injury risk low. In Europe halters like those commonly used for draught horses and donkeys were formerly used in most cases for draught cattle as well.

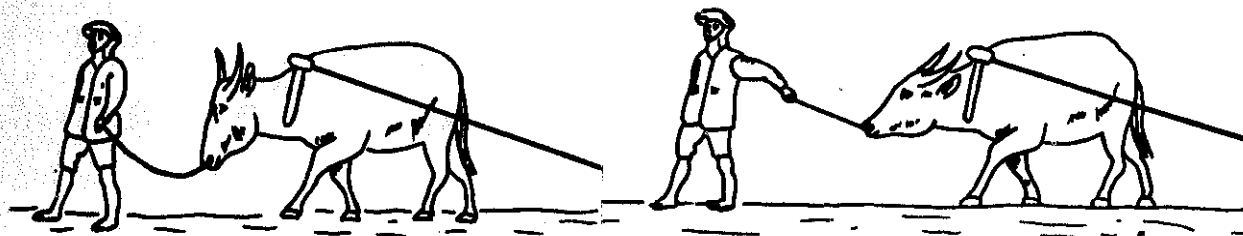


Fig. B/II/11: Correct and incorrect methods of leading an animal using a simple nose rein (FAO/CEEMAT, 1972)

Poorly trained teams must be driven by at least two people, one to operate the implement being drawn and the other to guide the animals. This practice can be frequently observed in Africa.

A third person is often required in addition to drive on the animals. If the animals are not well-trained proper work is possible only if the harness and bridle provide excellent direct control. A well-trained team, on the other hand, can be directed by means of verbal commands and no bridle is necessary.

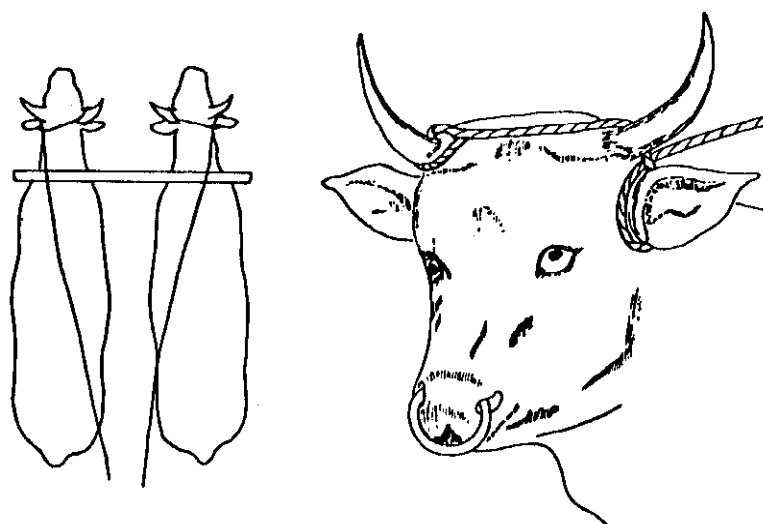


Fig. B/II/12: Bridle secured to horn and acting on the ear. (CEEMAT)

f) Accessories

Traces

These may be made of chains, leather or ropes. Although chains are more expensive than ropes they are nevertheless more durable, while leather is frequently unavailable and requires a great deal of care. In a humid climate the life of ropes can be improved by tarring them. The traces must be long enough to ensure that there is sufficient opportunity for adjustment in conjunction with the adjusting devices on the implement. The necessary length of the traces depends on the animal, the harness and the implement.

Crossbeams and swingletrees (Fig. B/II/13)

If individual harnesses are used it is necessary to have swingletrees, to which the traces are fixed. When animals are harnessed singly it is also essential to have a broad crossbeam, also called evener. The fittings on the crossbeam and swingletree should be such that their cross-sections and thus their load-bearing capacity are not reduced.



Fig. B/II/13: Crossbeam with swingletrees. (Source: FAHR)

3.2 Harnesses for horses and donkeys

Only collars or breast harnesses can be used for horses and donkeys. Yokes are unsuitable for these animals since they cause permanent damage to the sensitive withers. Fig. B/II/14 shows a collar harness for horses. The advantages of the collar already alluded to in the section on cattle collars are particularly valuable for heavy draught work. However, the collar must fit well; in view of the fact that there is little or no possibility of adjusting a collar it is usually a proper fit only on the animal for which it was made.

Breast harnesses (Fig. B/II/15) are relatively simple to manufacture and can be easily adjusted. The harness does not therefore have to be tailored precisely to fit one animal and can be used for several.

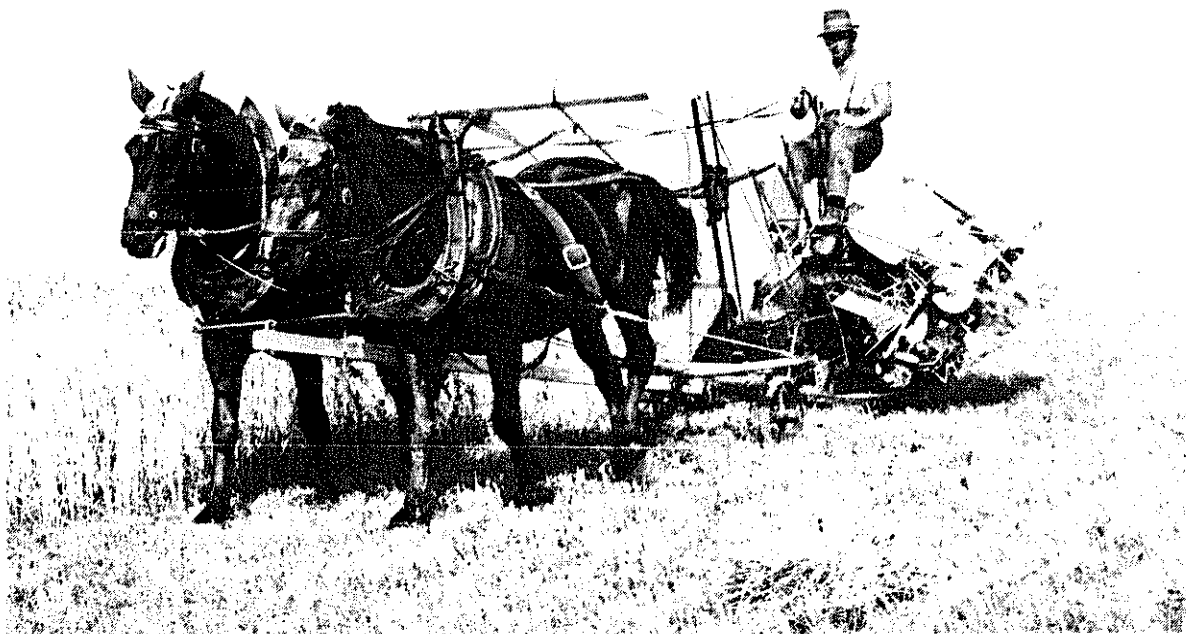


Fig. B/II/14: Team of horses wearing a collar harness and pulling a binder. (Source: FAHR archives)



Fig. B/II/15: Team of horses wearing a breast harness. (Source: FAHR archives)

During heavy draught work the disadvantage of the breast harness is that it tends to cut into the animal, restricts its breathing and circulation and compresses the chest and shoulder blades.

Both collars and breast harnesses must be held in place by a back/belly band and a terret. If carts are to be used breeching (harness around the hindquarters) or the like will permit stopping and reversing.

3.3 Manufacture of harnesses

Harnesses can usually be manufactured by local craftsmen. Possible materials include wood, leather, fabric, straw, grass and hair, together with metal in some cases.

The framework of the harness is usually made of wood. Metal is less satisfactory since it is difficult to achieve a good fit. It is a good idea, however, to use a metal element in individual forehead harnesses. The wood used in harnesses should in general be light but at the same time strong and supple. It should not first be shaped into boards or beams; it is better to obtain the unshaped pieces by chopping the wood so that the grain runs in the direction of the components, which can then resist greater stresses. In addition, they should not be weakened by notches or holes.

Breast harnesses and covers for padding should be designed such that no seams chafe against the animals' skin. Leather and strong, not too coarse fabrics are the most suitable materials. Jute sacks are too rough to be used as padding covers.

The best filling for pads is hair from a variety of animals. Leaves, grass and straw are not very resilient and quickly become worn to shreds.

3.4 Excursion: The mechanics of draught work

Knowledge of the interplay of forces within the draught team can both increase understanding of the necessary adjustments to the harness and implement and be of assistance in the evaluation of implements.

Fig. B/II/16 shows the most important forces and dimensions in an ox/swing plough combination. The heel force (F_S), the hand force (F_Z), and the tractive force (F_H) can be influenced by adjusting

the plough and harness. The plough will attain the desired working depth provided that the length of the traces (l_Z) and the coupling height (h_E) are correct. All forces are generated in accordance with the resistance force of the soil (F_R) such that the implement is in a state of equilibrium without the need for hand force (F_H). The burden on the person operating the implement can therefore be largely reduced if the implement is adjusted correctly.

The angle of traction α between traces and soil is derived from the height at which the traces are fixed to the yoke (h_A), the length of the traces (l_Z) and the coupling height (h_E), and should be between 15° and 25° . Smaller angles mean long traces and restrict the manoeuvrability of the team. A large angle is achieved with short traces; if they are too short there is a risk that the animals will hit the implement or swingletree with their hind legs and injure themselves.

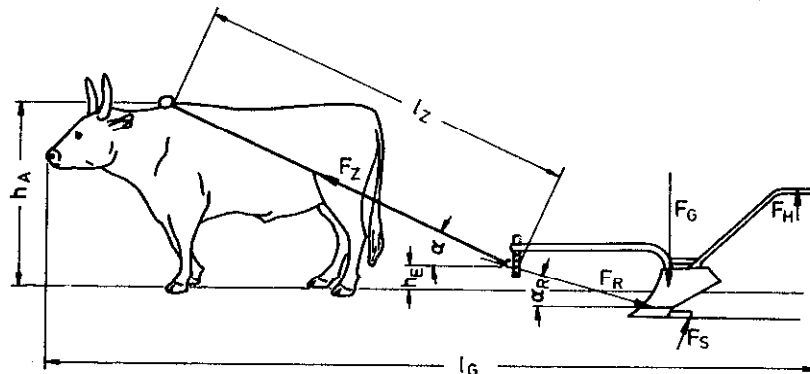


Fig. B/II/16: Diagram of forces for an ox/swing plough combination

In Table B/II/3 the most important forces are listed and described in terms of cause, direction and magnitude. In the example shown the fairly large hand force (F_H) could be avoided by means of longer traces (l_Z) or a greater coupling hook height (h_E), provided that the soil resistance (F_R) and tractive force (F_Z) remain constant.

Table B/II/3: The most important forces occurring in a combination during ploughing
(cf. Fig. B/II/16)

Abbreviation	Description	Dependent on	Direction (in example)	Magnitude in example (N) 1)
Soil resistance F_R	Acts on mould-board and share	Soil, working depth, width, speed, plough	(15°)	550
Weight F_G	Acts on centre of gravity	Implement	Vertical	350
Heel force F_S	Frictional and compressive forces at heel	Soil, implement, trace adjustment	Determined by ratio of frictional force to compressive force (0.4)	120
Hand force F_H	To be applied by person operating implement	Implement and trace adjustment, soil, animal	Vertical	110
Tractive resistance F_W	Geo. total of F_R, F_G, F_S, F_H	F_R, F_G, F_S, F_H	(25°)	650
Tractive force F_Z	Equal to F_W but acting in opposite direction	F_R, F_G, F_S, F_H	(25°)	650

1) N = Newton (physical unit of measurement)

In practice, however, continually changing soil resistance and the uneven gait of the animals cause the plough to move up and down, something which the person operating the implement tries to suppress. Despite considerable effort he is usually only partially successful, which is why the working depth of the swing plough varies continuously.

This is largely avoided on the ploughs used most commonly in Africa by means of a depth control runner or wheel.

The adjustments are made such that the depth control runner is always pressing lightly on the ground. This can be achieved by using longer traces (l_Z) or a greater coupling height (h_E) than is necessary for the desired working depth. In the example shown in Fig. B/II/17 only extremely great soil resistance will make application of hand force necessary.

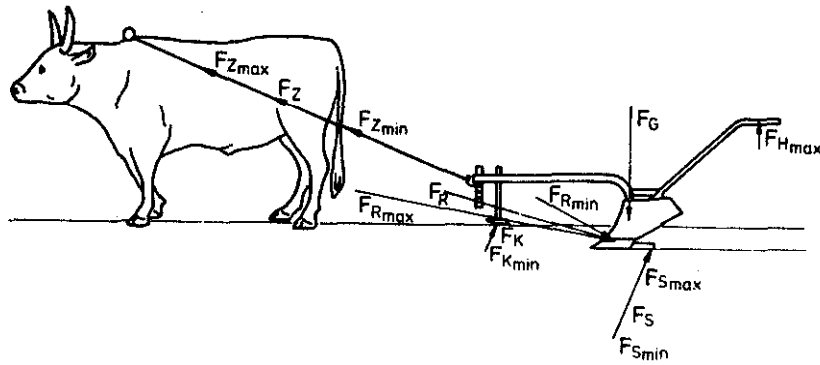
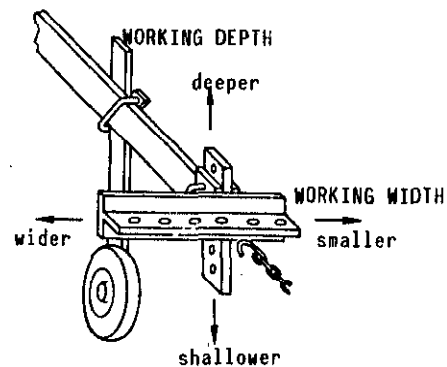


Fig. B/II/17: Diagram of forces for a Belgian plough/ox combination with varying soil resistance.

Changing the position of the coupling in the vertical plane will influence the working depth, while changing it in the horizontal plane affects the working width (Fig. B/II/18). The person operating the implement instinctively compensates for incorrect settings by tilting the plough or, to a lesser extent, by pressing down or pulling up the plough handle.

Fig. B/II/18: Device for adjusting the working width and working depth of a plough (as per DINEUR and MORRIERES, 1976)



Incorrect settings will impair the quality of the work. Fig. B/II/19 illustrates some of the hints on plough adjustment listed below (cf. MATTHEWS and PULLEN, 1976):

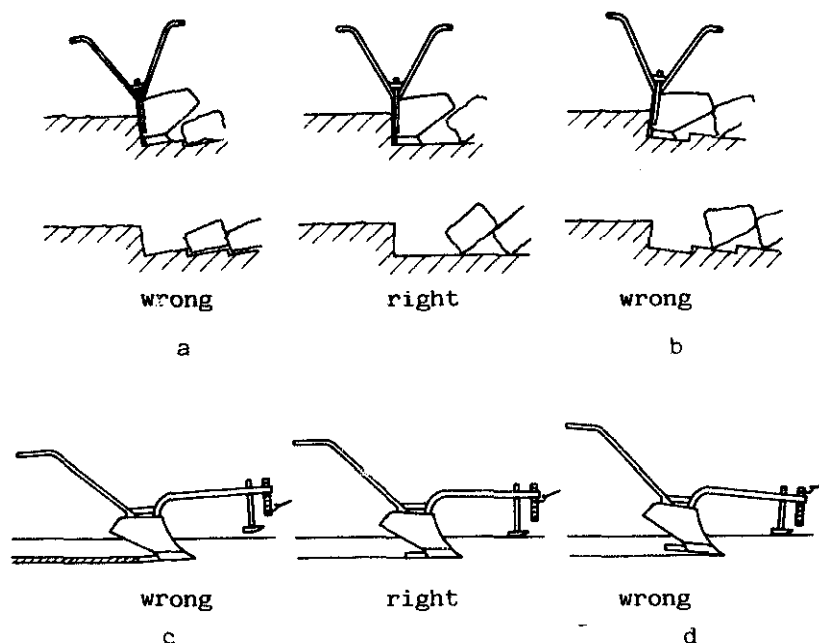


Fig. B/II/19: Diagram showing incorrect settings for ploughing.
(Source: MATTHEWS and PULLEN, 1976)

<u>Symptoms</u>	<u>Remedy</u>
Plough not upright, tilted towards unploughed land (Fig. B/II/19 (a))	Lower coupling hook or shorten traces
Plough not upright, tilted towards ploughed land (b)	Raise coupling hook lengthen traces
Excessive furrow bottom formation, depth control runner is lifted (c)	Raise coupling hook, shorten traces
Heel does not touch furrow bottom, operator has to press down on the handle (d)	Lower coupling hook,
Insufficient working depth	Raise coupling hook, lengthen traces, raise depth control runner
Excessive working depth	Lower coupling hook, shorten traces, lower depth control runner
Insufficient working width	Move coupling hook towards ploughed land
Excessive working width	Move coupling hook towards unploughed land

4. Implements to be used with draught animals

Experience in Europe has shown that animal traction can be used to mechanize nearly all types of work in crop production, from tillage, crop tending and plant protection to harvesting and processing of the various crops.

On African smallholdings, however, opportunities for mechanization (using either draught animals or tractors) are severely limited. "The small size of the holdings, the acute shortage of capital, the farmers' low standard of training, the lack of the necessary infra-structural features (maintenance facilities, repair shops, spare-part supply etc.) and the low level of market production", which, according to TSCHERSCH (1975), are prominent features of smallholdings in developing countries, mean that nowhere near all the work which can theoretically be mechanized can actually be performed using draught animals and efforts must be limited to overcoming the major peaks in the work.

Top priority is given to tillage which, if performed solely by way of manual labour, is usually the greatest direct restricting factor on the extent and intensity of production. Expansion of the area under cultivation, which is both facilitated and necessitated by the use of animal teams for soil tillage, also makes it necessary to use drawn implements to speed up tending of the crops and - particularly in areas with a short vegetation period - sowing operations. Draught animals can, however, perform little of the work associated with harvesting.

Draught animals are of great importance for transport work.

Some of the work occurring in irrigated farming - and only there - can be handled using simple drawn implements.

As a whole, it has been possible to successfully introduce animal traction in Africa to mechanize those types of work which constituted the greater bottle-necks and could, at the same time be mechanized by the use of extremely simple means.

4.1 Assessment criteria for the selection of implements

The structure of African smallholdings, their limited financial potential and the usually inadequate training of the farmers impose

numerous restrictions on the choice of implements. However, the climatic conditions, location and soil properties, together with the crops to be cultivated, also impose requirements which must be borne in mind when selecting suitable implements.

The first step in selecting implements is to establish which jobs must be mechanized in order to increase production. Consideration should then be given to the methods to be used for this work. In addition to the desired effect of the work, particular attention must be paid to ensuring that the implement is suitable in technical terms for the natural conditions determined by soil, climate and topography. It must be guaranteed that the traction power required for the chosen method does not exceed that which can be supplied by the available animals and that the method has the necessary impact. The implements chosen for the various jobs should form a practical equipment sequence.

Poor land clearance hinders the use of implements. Although light implements are easier to handle and transport (on poorly cleared land), they must nevertheless be sturdy enough to withstand the increased stress imposed on them by obstacles in the soil.

The implements should be chosen such that their adjustment, maintenance and handling are geared to the knowledge and technical skills of the farmers. Their design and construction should permit repair and maintenance work to be performed to a large extent by local craftsmen.

Economic aspects play a not inconsiderable part. A high initial outlay represents a substantial risk for the farmer who may find it almost impossible to bear it on his own.

Psychological factors must also be considered when selecting cultivation methods and suitable implements: traditional methods and implements or those which have already been introduced are more likely to be accepted than those which constitute innovations and/or necessitate changes in the land use system.

The increasing diversity of the machines and implements intensifies the problems involved in guaranteeing proper repairs and a supply of spare parts.

As high a degree of familiarity with the market as possible is required before a selection - particularly the selection of a specific make - can be made. In addition to the various implement types and models, reports of actual experiences describing the advantages and disadvantages of an implement are also of great value. In addition, it must be established whether the manufacturer can guarantee to supply spare parts throughout the projected life of the machine.

A list of manufacturers in African countries is given in Part A of this handbook. Further information is provided by BOYD (1976).

4.2 Methods and implements for rain-fed farming

The term "rain-fed farming" refers to a cultivation system which is solely dependent on natural precipitation for its water supply. One crucial function of soil tillage here is to influence the soil's water absorption and water retention capacity such that the water remains available to the crops in large quantities for as long as possible.

This results in a number of requirements as regards tillage which must be observed when selecting both the tillage method and the implements. Fundamental aspects of this topic, seen from the point of view of the crop farmer and the ecologist, are discussed in more detail in Section B/III. For further information in greater detail also refer to KRAUSE and LORENZ, 1979.

4.2.1 Soil tillage and seedbed preparation

Ards and mouldboard ploughs

Ards (Fig. B/II/20) are found in Africa only in places where the use of draught animals has a long tradition, i.e. in the countries north of the Sahara and in Ethiopia. The lengthy history of these implements has resulted in a variety of designs; originally they were made solely of wood, but later models had iron or steel shares and some are today made totally of metal.

In their method of operation they most closely resemble the cultivator and farmers used to ards are therefore most likely to accept the cultivator as its "modern" successor. Ards are simple to manufacture, use and repair, but their capacity in terms of area covered is small. It is usually necessary to till an area several times in order to produce a satisfactory seedbed.

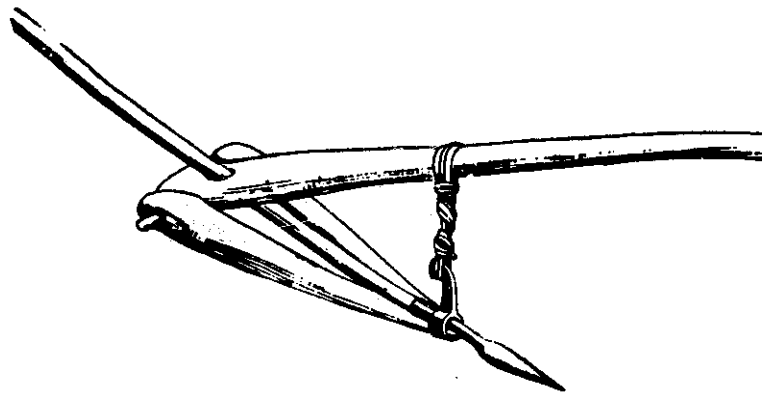


Fig. B/II/20: Example of an ard from Ethiopia (HOPFEN, 1969), (see also Fig. A/3 for method of operation)

The mouldboard plough is now also used in many parts of Africa. Its main feature is its method of operation, which involves loosening, turning, crumbling and mixing the soil and it is for this reason that it is still the standard implement for basic tillage in the humid climatic zones of Europe. The mouldboard plough is somewhat less suitable for use in arid and semi-arid climates since the way in which it loosens and simultaneously turns the soil may lead to high evaporation rates and accelerated humus decomposition (see Section B/III).

Turning the soil, however, guarantees that harvest residues, manure and weeds are properly worked in. Ploughing is in many cases the only way of coping with a heavy growth of weeds and also makes seed-bed preparation and sowing easier. These advantages are frequently offset by detrimental effects on the nutrient and water balance, and not least the risk of erosion by the wind.

The mouldboard plough exhibits a relatively high degree of tractive resistance, which precludes large working widths when draught animals are used, and the area capacity is accordingly low.

Semi-digger plough bodies and cylindrical continental or general-purpose bodies are suitable for drawn ploughs under African conditions.

Semi-digger bodies are suited to heavy cohesive soils. They break up the soil into coarse clods and turn it over well, but do not mix

it as thoroughly as the general-purpose bodies and leave a ridged surface which reduces the risk of erosion. They require 20% more tractive effort than the other two types of body, which should be given preference for lighter soils.

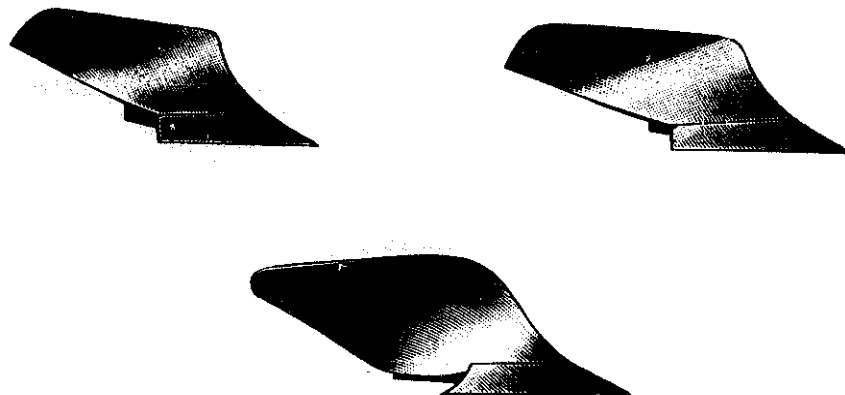


Fig. B/II/21: Plough bodies (VENTZKI)
 Top left: continental body
 Top right: general-purpose body
 Bottom: semi-digger body

Particular attention should be paid to the shares. Ploughshares are subject to severe wear, determined to a large extent by the nature of the soil.

Razor-blade shares, which do not have to be sharpened and are replaced when they become worn, are not suitable for African small-holdings on account of the problems involved in procuring them. Slip shares and plain winged shares should be used instead; they are thicker at the cutting edge and can be sharpened by being hammered down.




TYPE OF SHARE	TYPE OF SOIL
Slip share	light/medium/heavy
	
Plain winged share	medium/heavy, not excessively stoney
	
Razor-blade share	light to medium-heavy and with no stones
	
	light to medium-heavy, even if hard and stoney

Fig. B/II/22: Ploughshares (VENTZKI)

The decision for or against reusable shares must be seen in terms of the cost of procuring and sharpening them. Proper hammering-out and hardening of the shares requires a certain amount of practice on the part of the blacksmith. Badly straightened or distorted shares

can easily impair the alignment of the plough, which cannot always be corrected by adjusting the body. Particular problems arise in this respect with multi-furrow ploughs. Skilful hardening of the shares is also necessary because excessively soft shares rapidly become worn and on excessively hard or brittle shares the tips can easily break off.

Additional tools such as manure skimmers or various coulter have been little used to date on drawn ploughs in Africa. Both knife and disc coulters effectively improve ploughing; they cut the furrow wall more cleanly than the edges of the share and mouldboard. The coulters also gives the plough a better grip in the soil since it operates somewhat closer to the unploughed land than this edge does. Coulters are often rejected in Africa because they are believed to substantially increase the amount of tractive effort required. However, this applies only to poorly cleared or irregularly tilled areas, where the use of knife coulters frequently causes the plough to become obstructed. Disc coulters require a smaller tractive effort, are self-sharpening and exhibit less tendency to become clogged up.

Swing ploughs (Fig. B/II/23) are seldom found in Africa. These implements have no depth control wheel and it is therefore difficult to maintain a working depth. The continually changing soil resistance and the uneven, step-by-step tractive force exerted by the animals cause the plough to move up and down and under favourable conditions this can cause the working depth to vary by more than 50% of the desired depth. A considerable strain is placed on the operator by his continuous efforts to compensate for these fluctuations. Swing ploughs are, however, very light and are therefore easy to transport.

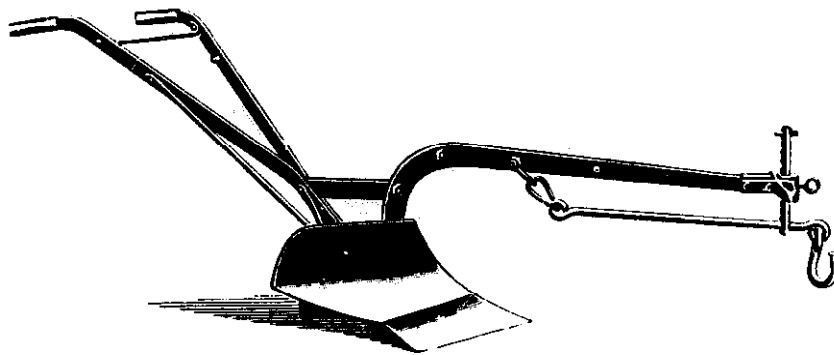


Fig. B/II/23: Swing plough (VENTZKI)

Belgian ploughs (Fig. B/II/24) are clearly the most common type of drawn plough used in Africa. By setting the coupling hook somewhat higher than required for the desired working depth the depth control device is pressed gently against the soil, thereby making it easier to maintain the working depth and reducing the burden on the operator.

Under favourable conditions a depth control wheel has a slightly smaller tractive resistance than a depth control runner. Wheels will not run smoothly on stoney or wet soils and in these cases a runner should be preferred. Runners are, moreover, less expensive and better able to withstand substantial quantities of dust and dirt.

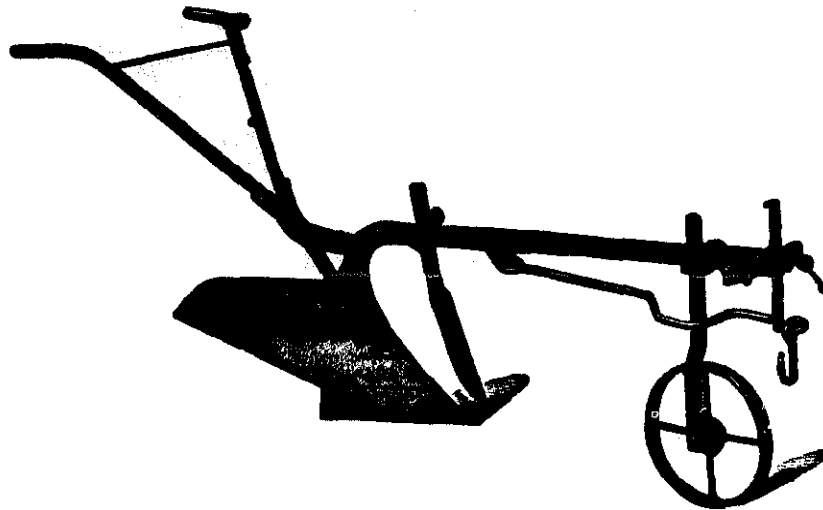


Fig. B/II/24: Belgian plough (VENTZKI)

Wheeled ploughs (Fig. B/II/25) make things a lot easier for the operator. The beam of these ploughs is supported on a two-wheeled fore-carriage and is connected to it by means of one or more chains, which cause the plough to be self-steering. The vertical movements caused

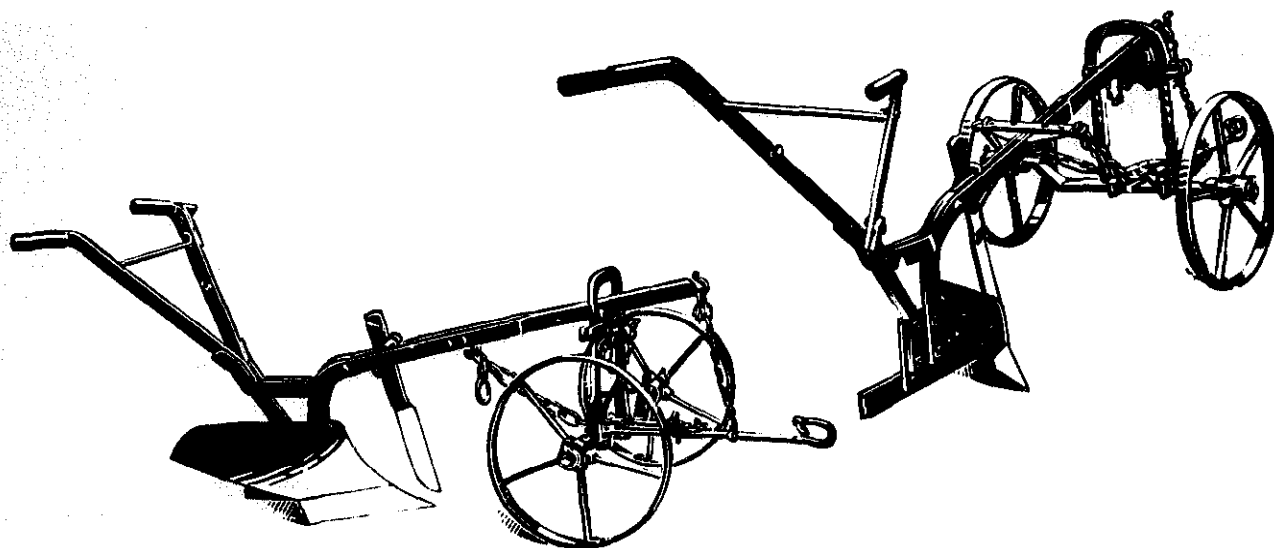


Fig. B/II/25: Wheeled plough: On the left with one chain, on the right self-steering model with two chains. (VENTZKI)

by the changing soil resistance are suppressed as in the case of the Belgian plough, while the various lateral forces are transmitted to the forecarriage and absorbed at the furrow wall via the furrow wheel.

Frame ploughs are designed as single-furrow or multi-furrow models. Common to all of them is the frame made of flat steel, which is supported by two wheels at the front and to which the bodies are bolted. The working depth is adjusted via the wheels.

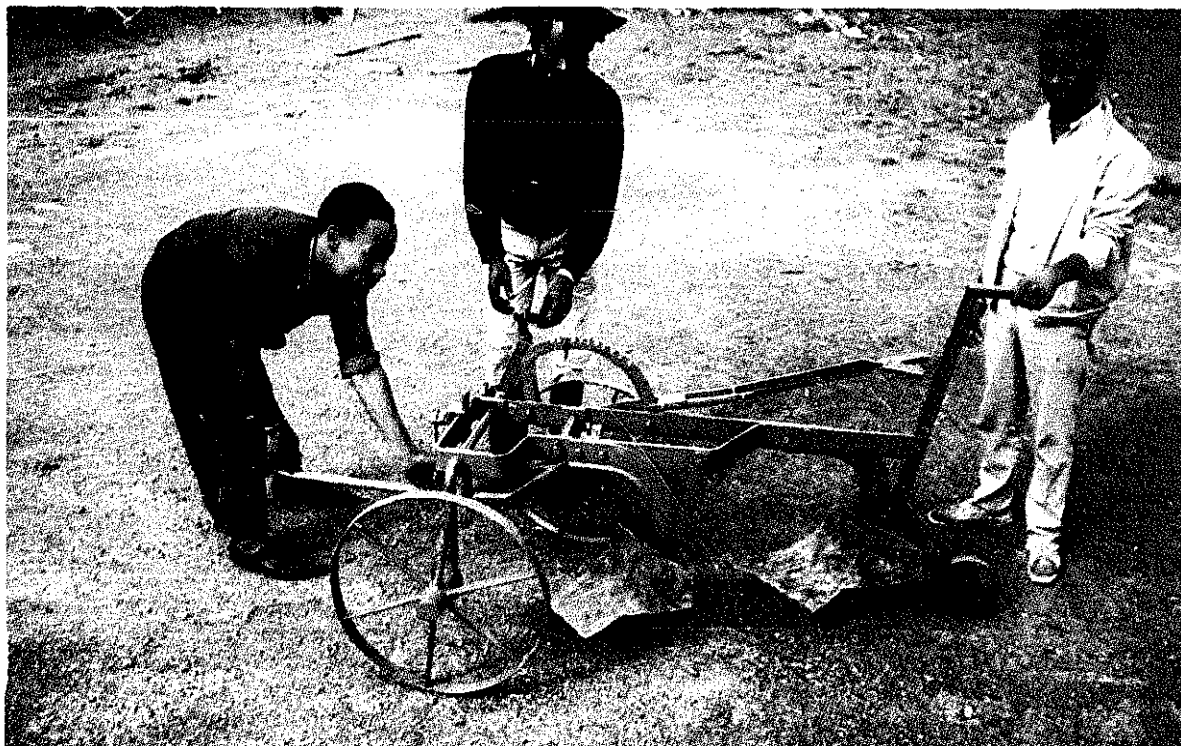


Fig. B/II/26: Two-furrow frame plough. The third wheel behind the second body is required only for transporting the plough.
(TAMTU, Tanzania)

One-way ploughs are necessary for contour ploughing, a measure aimed at restricting erosion on slopes. These ploughs make work on level ground easier, particularly on irregularly shaped plots.

In addition to the half-turn ploughs familiar from mechanized agriculture (Fig. B/II/27) there are also turnwrest ploughs (Fig. B/II/28) which can be used with draught animals and which are lighter and simpler than half-turn ploughs. Both types are used in Africa in the form of Belgian and wheeled ploughs and are in some cases available for use with multi-purpose implements.

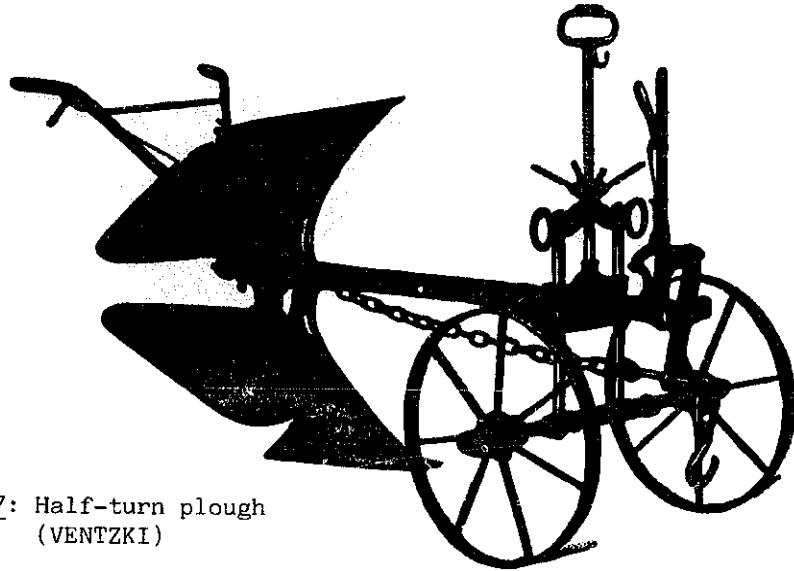


Fig. B/II/27: Half-turn plough
(VENTZKI)

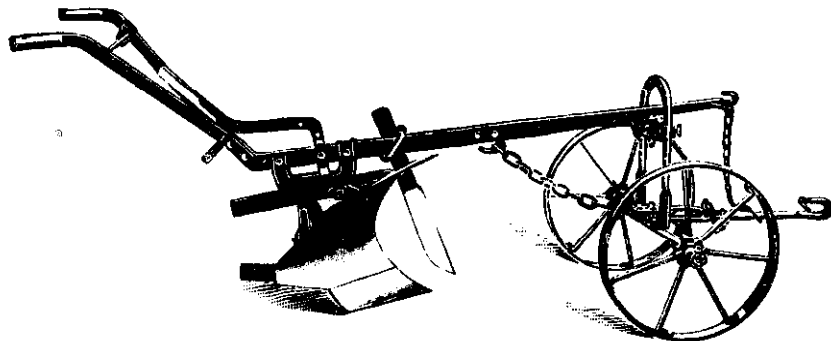
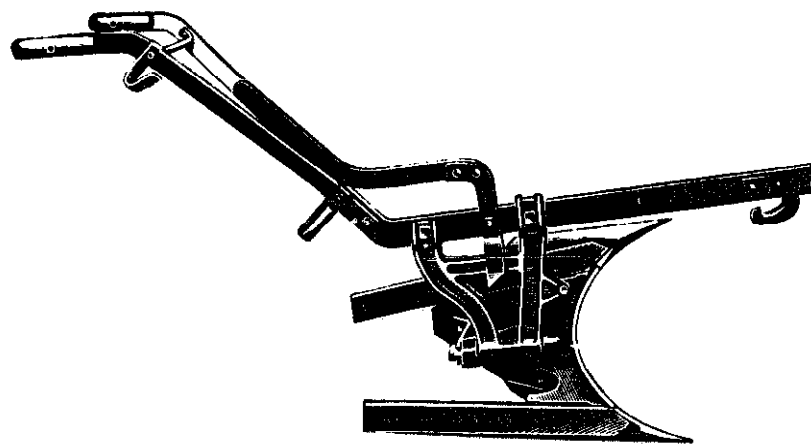


Fig. B/II/28: Turnwrest ploughs
(VENTZKI)



Asian mouldboard ploughs

The mouldboard ploughs used in Asia (Fig. B/II/29) operate in a manner which lies somewhere between that of the ordinary mouldboard plough and that of the ard: the soil is churned up and partially turned.

These ploughs, which have a symmetrical, roughly triangular share, require no landside¹⁾, since there are almost no lateral forces. They are simple to manufacture and are relatively light-weight; they require little tractive effort and are therefore particularly suitable for smallholdings (CEEMAT, 1968). A model with a multiple-element mouldboard requires less tractive effort on damp, heavy soils. However, these Asian ploughs have been little used to date in Africa.

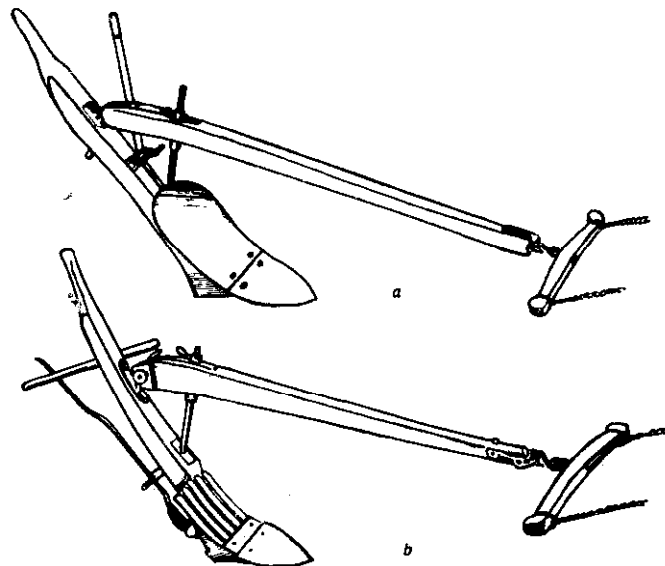


Fig. B/II/29: Common Asian ploughs
a) with one-piece mouldboard
b) with multiple-element mouldboard
(HOPFEN, 1969)

Ridgers

These ploughs leave ridges in the surface of the soil which, when located along the contour lines, provide some protection against erosion by water on slopes. The larger working width (up to over 90 cm) means that the area capacity is around twice as large as that

1) Landside = extended iron element which is trailed along the bottom of the furrows and absorbs lateral forces.

which is possible during ordinary ploughing. However, if special additional tools are used to create tie-ridges as well in order to counteract uncontrolled water runoff along the furrows the area capacity is substantially reduced. An extremely large tractive effort is necessary, particularly during primary tillage, on account of the large working width; the creation of tie-ridges increases the strain on the draught animals and also makes the work very difficult for the operator.

During primary tillage with the ridger, part of the soil (beneath the ridges) remains untouched. In these areas hard layers can form that hinder the development of plant roots, particularly if the ridges are never destroyed as is usual, for example, in parts of Nigeria. In view of the fact that the compacted layers hinder the growth of the crops and occasion a large tractive resistance during ridging it is common practice in various countries to plough the land before ridging. The amount of time required is then increased accordingly.

Ridgers are often the only animal-drawn implements used by African bullock farmers. They can be employed for primary tillage, earthing-up (e.g. for cotton) and weed control. The ridger does not turn the soil over completely and it is therefore less effective in weed control during primary tillage than the mouldboard plough. When used during tending of the crops it does not totally destroy the weeds, particularly if the earth thrown up is washed back into the furrows by subsequent rainfall, thereby unearthing the weeds again.

Moreover, in view of the fact that it is difficult to use hoes on ridge-grown crops and, if they are used, the work must be followed by reringing, the time gained during tillage may be offset as a whole by increased work on tending the crops. Among young crops heavily infested with weeds, ridgers make work easier in that the rows of plants can be readily located (CEEMAT, 1968).

Ridgers can take the form of swing ploughs or Belgian ploughs (Fig. B/II/30). If the mouldboards are adjustable it is possible to create ridges of varying shape.

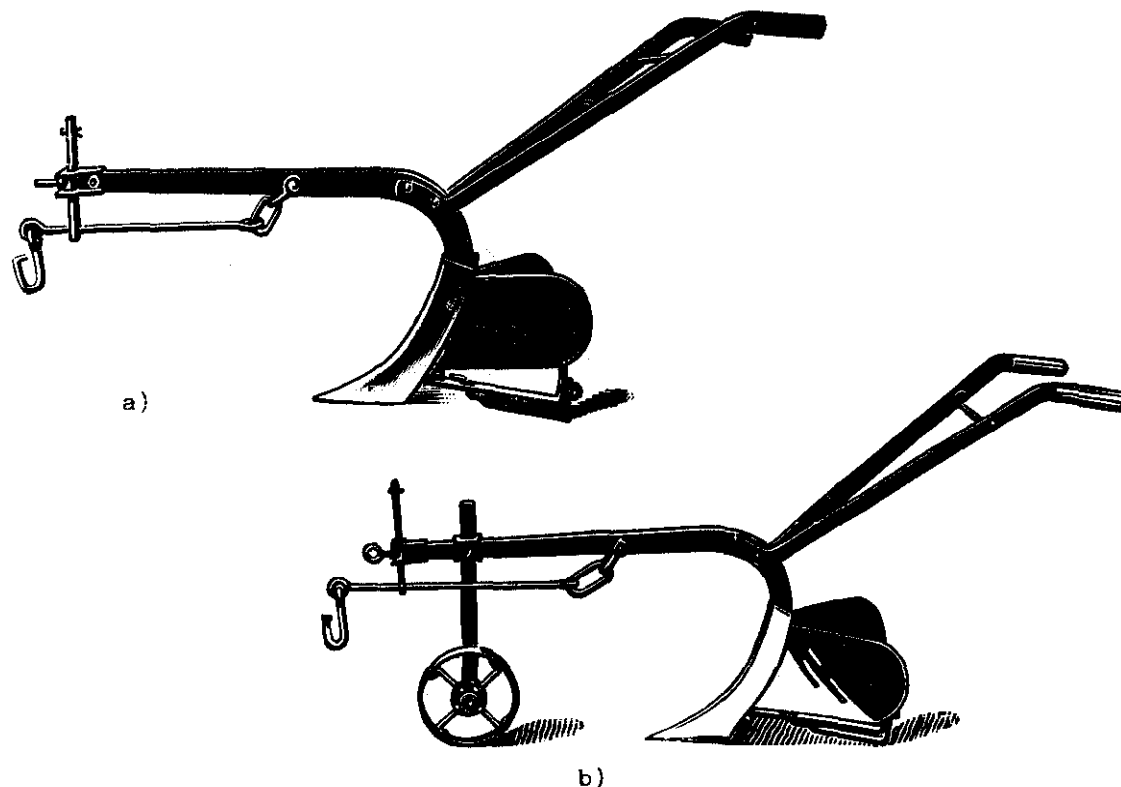


Fig. B/II/30: Types of ridgers (VENTZKI)
 a) swing plough b) Belgian plough

For crop tending and earthing-up many multi-purpose implements can be equipped with standard ridger bodies or with disc ridger bodies, both of which operate in a similar manner to the ridger itself. However, the ridger's method of operation can also be simulated using a mouldboard plough by ploughing two furrows together every time.

Cultivators

Cultivators are used for tillage and seedbed preparation, and in some cases also for weed control. Hoes, which are really intended for weed control, are sometimes also used to till the soil in the same manner as a cultivator but in this case it is seldom possible to do anything more than scratch up the surface of the soil.

Cultivator tines

The tines on animal-drawn cultivators can be subdivided into spring tines, semi-rigid tines and rigid tines (Fig. B/II/31). The trip bottoms frequently encountered in motorized agriculture are not usually found on animal-drawn cultivators.

Rigid tines are used in particular on cultivators designed for greater working depths and for this reason are less common on animal-drawn cultivators than spring tines.

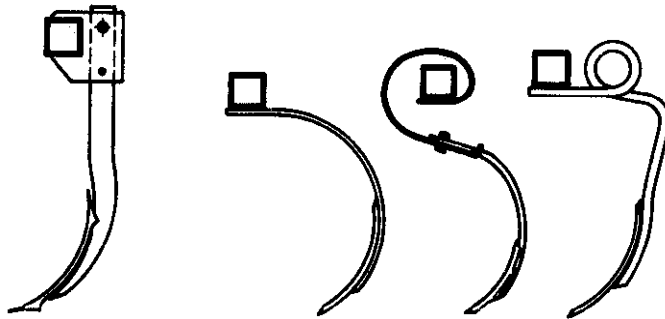


Fig. B/II/31: Types of cultivator tines

Spring tines bend to the rear and side according to the soil resistance and are thereby made to vibrate. One disadvantage is that the working depth continuously varies, whereas one advantage of spring-loaded tines is that they rebound from obstacles in the soil, thereby sparing the draught animals and reducing the risk of damage to the implement. The vibration of the tines in the soil increases the crumbling effect and brings more weed roots to the surface, where they dry up more quickly. However, spring tines cannot attack compacted soil as well as rigid tines, since the distance between the lines traced and the working depth do not remain constant.

Tine points

The various types of tine points exhibit considerable variations in width and cutting angle.

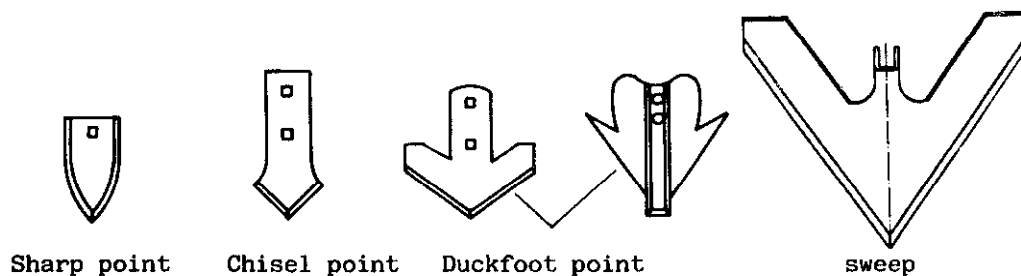


Fig. B/II/32: Various types of cultivator tine points

Narrow, sharply angled ripper points are required in particular for shallow secondary tillage and for breaking up encrusted top soil; broader points of the same type are also used for primary tillage. The characteristic feature of ripper points is their relatively intensive crumbling and mixing effect. The opposite result is achieved

by sweeps, which can be more than 50 cm wide and have a very small cutting angle. These slice off the topmost layer of the soil and the roots in it and leave the remnants of the plants on the surface. Sweeps are only effective in weed control if used in dry soils and the depth control of sweeps presents problems. Sweeps are always fitted on rigid tines. In terms of width, cutting angle and method of operation the "half-way house" between ripper points and sweeps is formed by the versatile duckfoot points.

Duckfoot points are fitted to cultivators for mostly shallow tillage (up to 10 cm with a maximum of 15 cm) and seedbed preparation; in both cases the soil must be sufficiently moist.

Subsoil looseners are sometimes used for more thorough loosening of dry soils but have not become established because the tractive effort of the animals is inadequate for this heavy work. Moreover, at the end of the dry season - the right time for this type of tillage - the draught animals are unavailable or are in poor condition. It should be pointed out, however, that even shallow tillage of encrusted soils can be beneficial at the end of the dry season, since this improves the soil's ability to absorb the first rainfall. Actual tillage and cultivation of the soil can then sometimes take place a little earlier.

Designs

Among animal-drawn cultivators it is possible to find models with and without depth control wheels, together with models which run on support wheels which can be used to adjust the working depth (Fig. B/II/33). All multi-purpose implements to be pulled by draught animals can be equipped as cultivators.

The working width may be between 30 cm and more than 2 m depending upon method of operation, team and implement. With a pair of oxen, primary tillage of soils which are not too heavy can be performed with a working width of around 50 cm.

Harrows

Harrows are used to crush clods and level the seedbed, particularly after ploughing. They can also be employed to cover broadcast seed and work in mineral fertilizers. Harrows can additionally play a part in mechanical weed control before the crops sprout and while they are very young (even if they are not sown in rows.)

Harrow tines which are pointed or curved at one end penetrate the soil more deeply if the tips point in the direction of movement and less deeply if they point in the opposite direction. The working

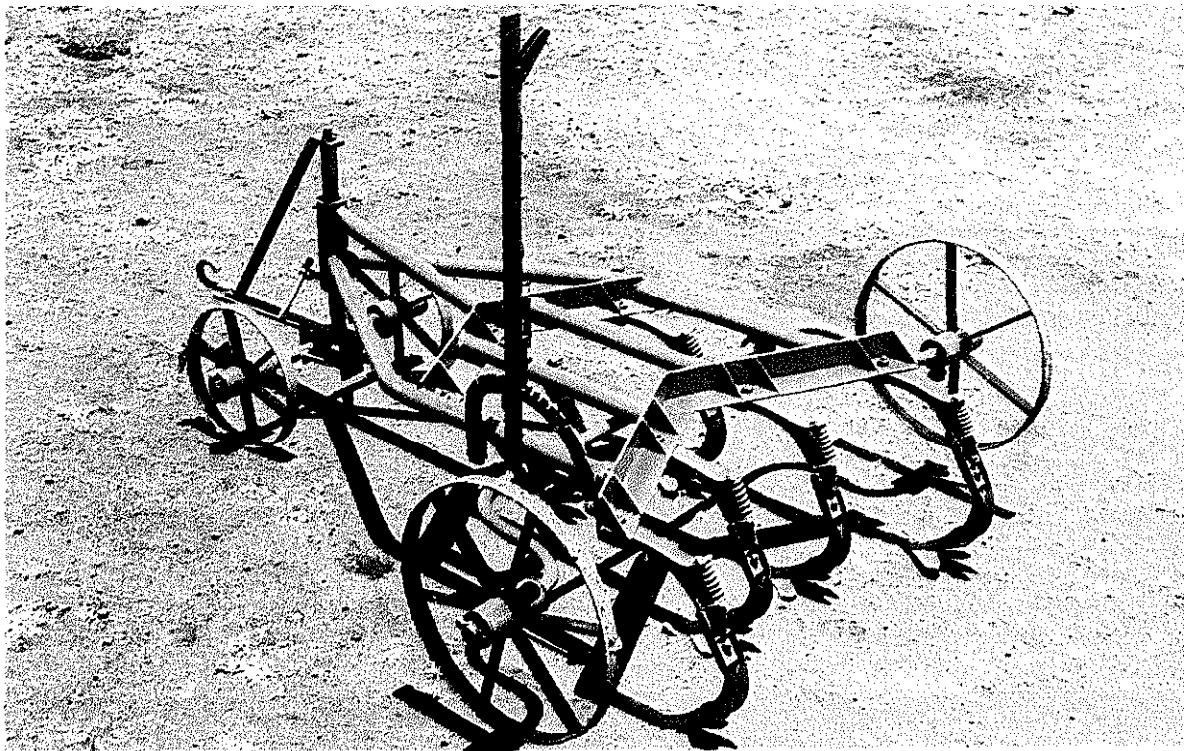
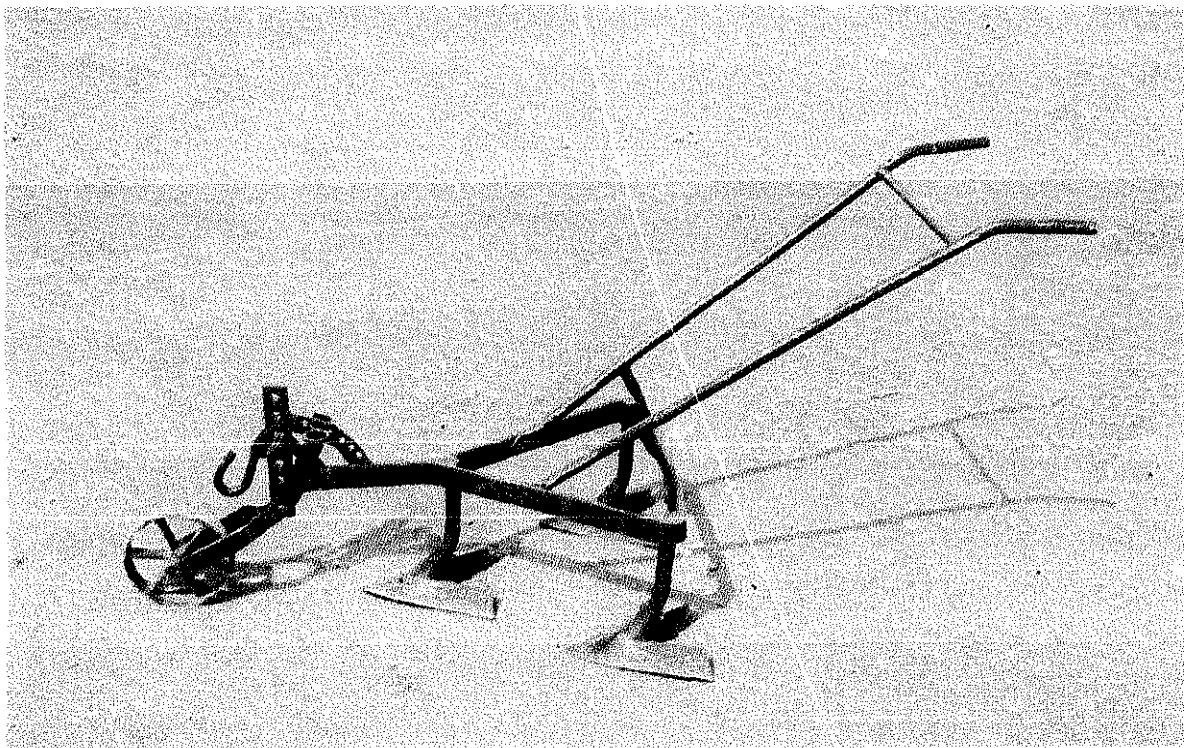


Fig. B/II/33: Various types of animal-drawn cultivators
(Source: TAMTU, Tanzania)

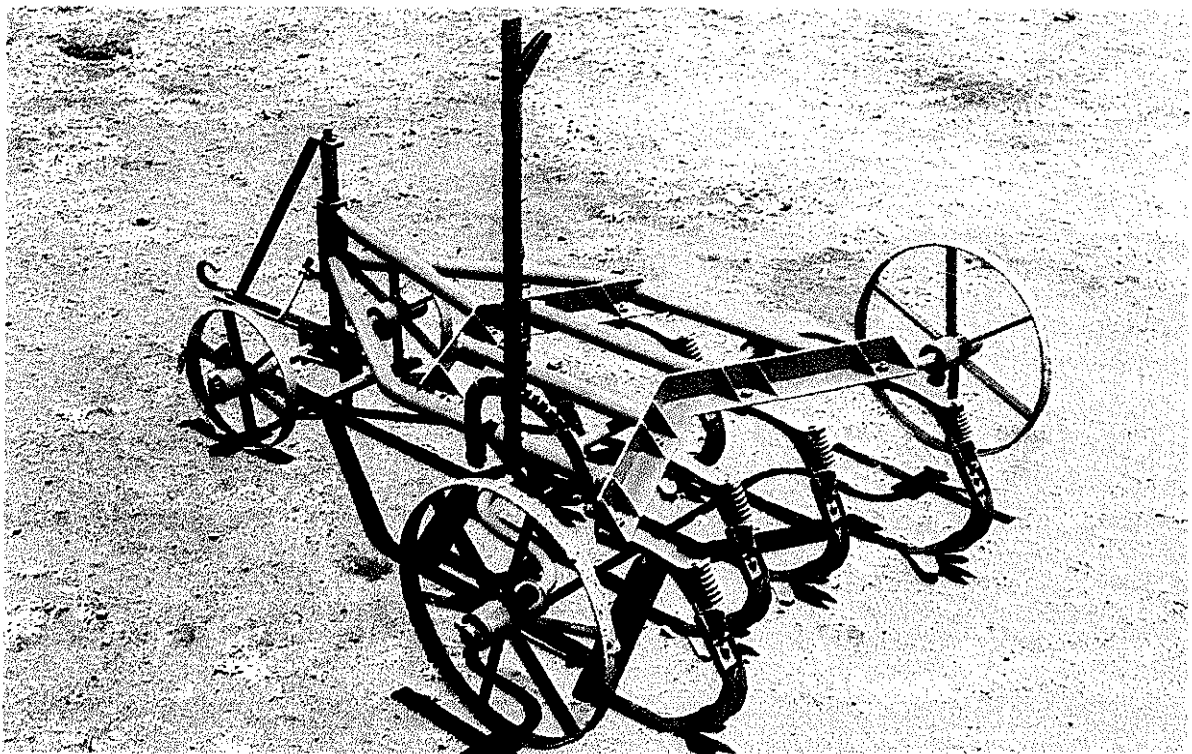
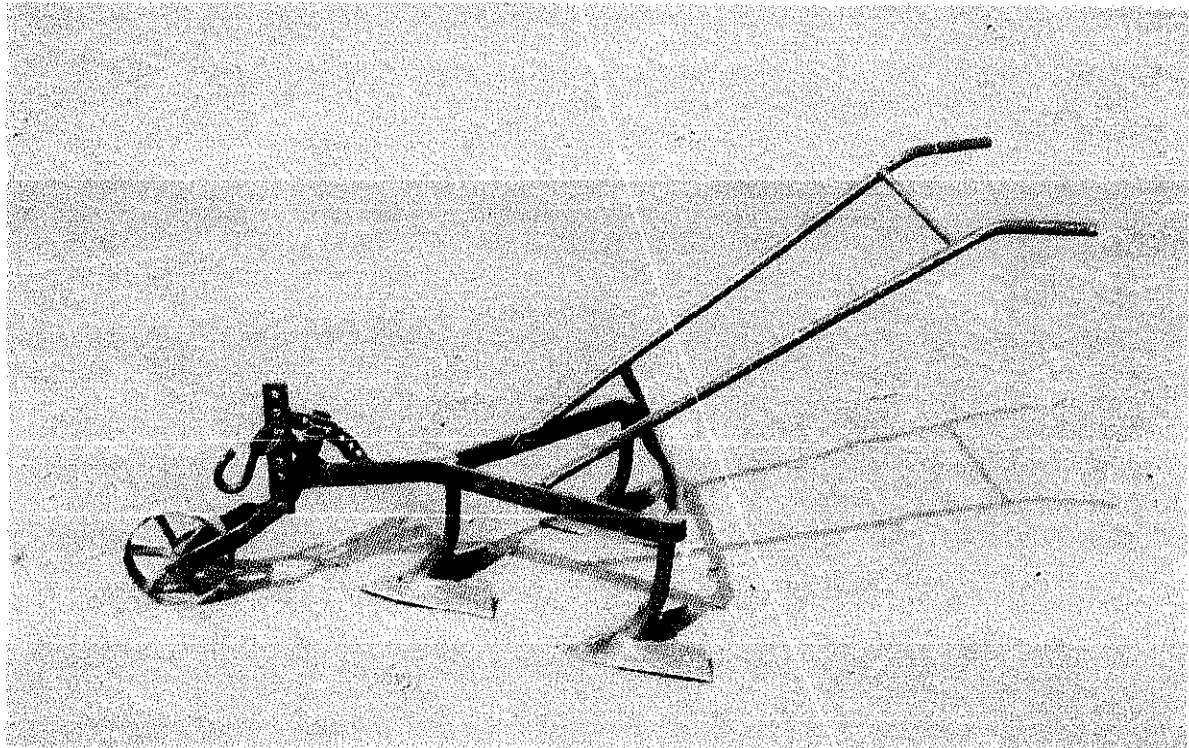


Fig. B/II/33: Various types of animal-drawn cultivators
(Source: TAMTU, Tanzania)

depth of the tines is governed not only by their shape but also by their weight and the overall weight of the harrow, as well as by the nature and condition of the soil. The distance between the lines traced varies between 3 cm (shallow working in a light soil) and 8 cm (deeper working in a heavy soil). If a tractive resistance of 10-60 N (1-6 kp) per tine is assumed (CEEMAT, 1968), the possible working width for a pair of oxen is between around 1 and 2 m. The tines must be sharpened from time to time.

The varying flexibility of the frames necessitates varying degrees of adaptation of the harrow to the contours of the surface of the soil. In addition to the rigid single-section harrows, whose wooden frames can be manufactured locally (but are then not particularly sturdy), animals can also be used to pull multiple-section harrows (with up to only two sections in the case of pairs of oxen), particularly zig-zag, flexible and chain-link harrows.

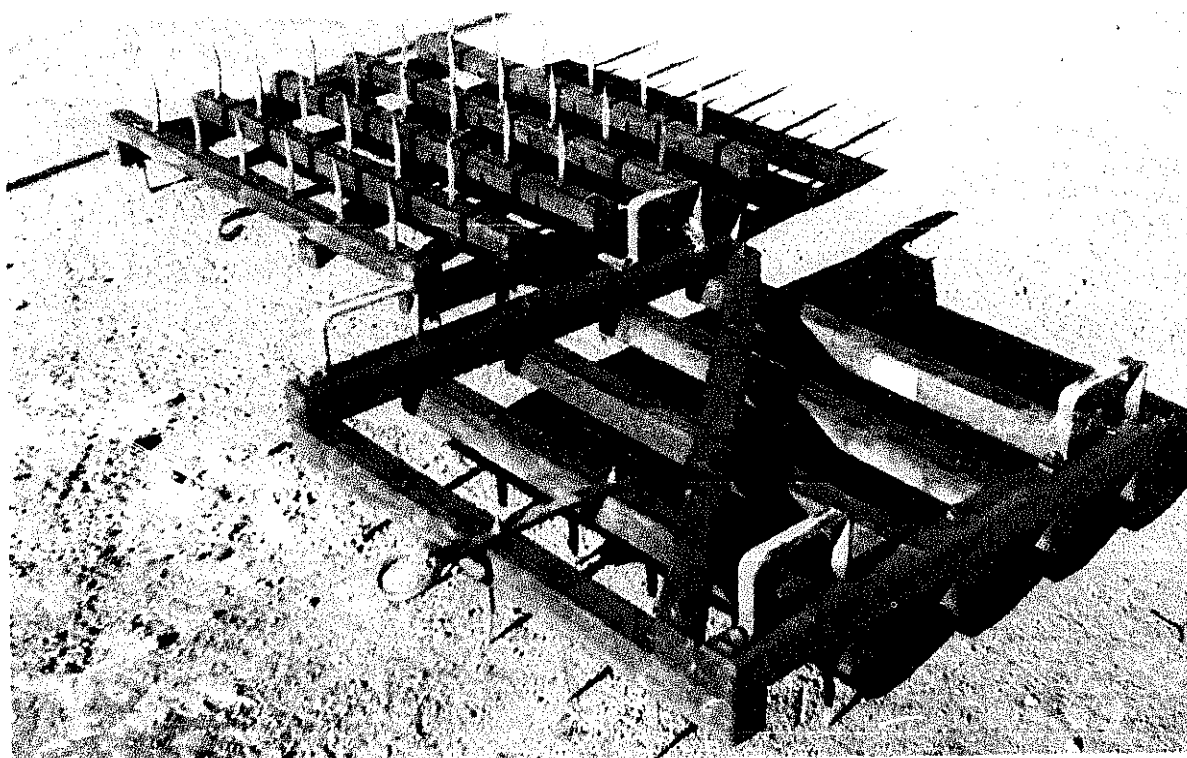


Fig. B/II/34: Harrow manufactured in a local workshop with steel and a wooden frame. (TAMTU, Tanzania)

Rigid tine harrows are primarily used for seedbed preparation; only the very light seed harrows are employed for covering the seed and - to a limited extent - for weed control.

Flexible harrows are extremely suitable for controlling weeds growing amongst young crops. They are very light and, thanks to their special design, can easily adjust to uneven terrain. They are so flexible that they can also be used without problems for ridge-grown crops.

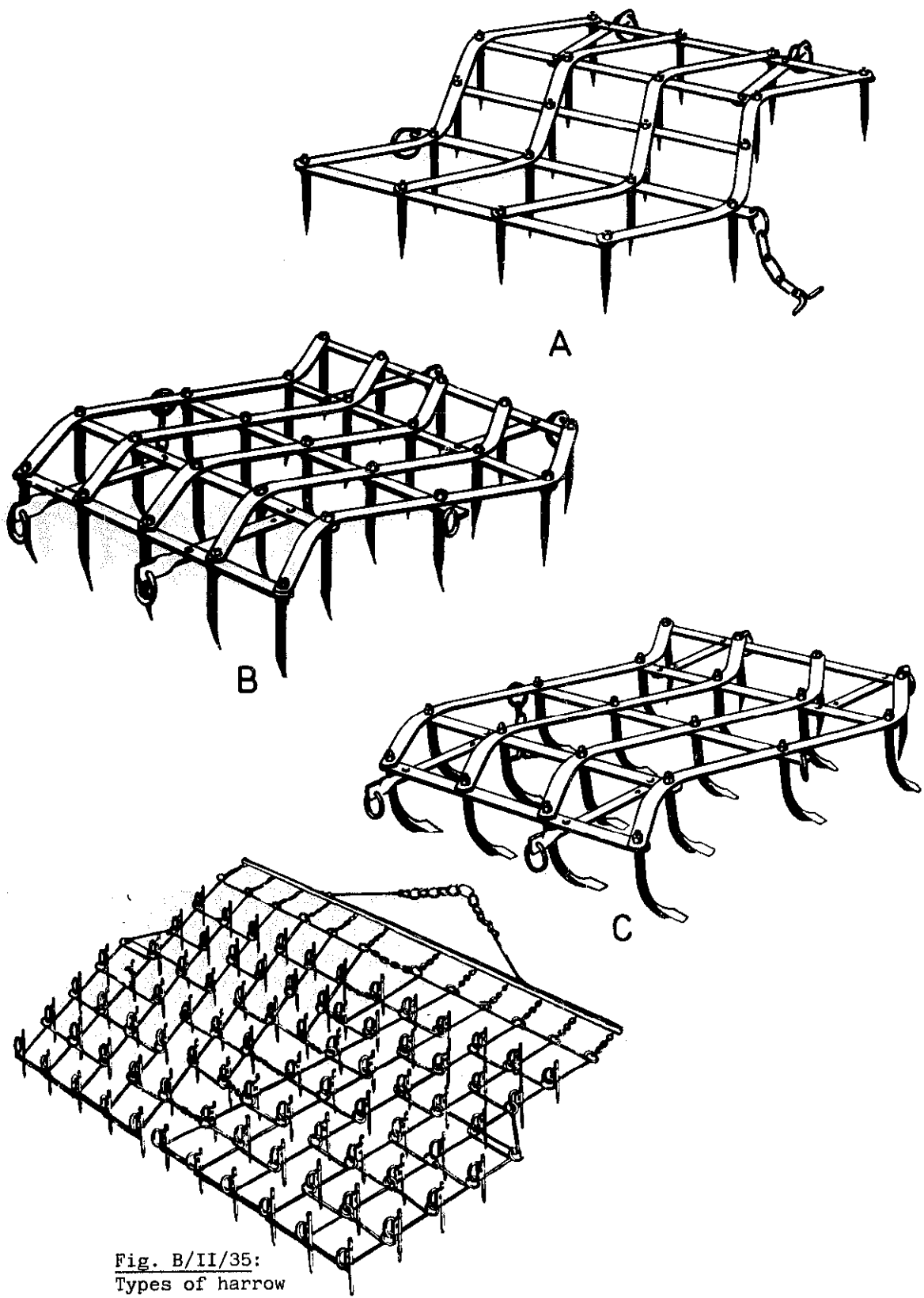


Fig. B/II/35:
Types of harrow

- A) light seed harrow
- B) heavy seed harrow
- C) chisel-tined harrow and flexible chain-link harrow

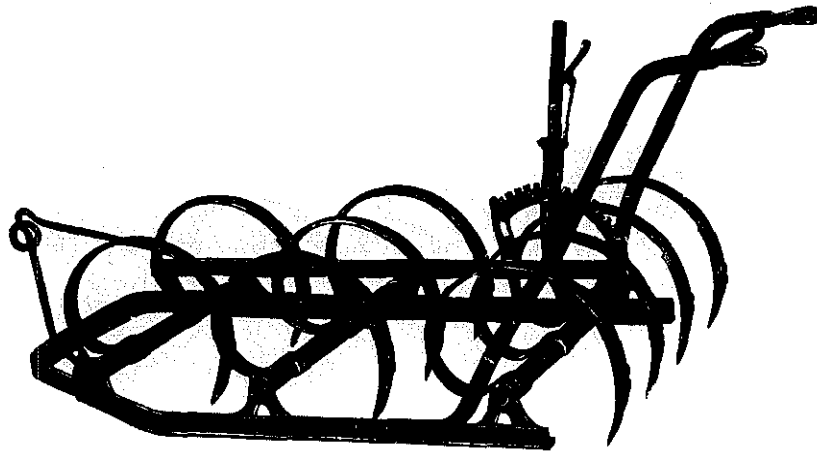


Fig. B/II/36: The spring-tine harrows occupy a special position by virtue of their design and have sprung tines mounted on a frame similar to that of a cultivator. An adjusting mechanism makes it possible to change the angle of the points and thus the intensity of the cultivation.

Disc and roller harrows, rollers

These implements are very rarely used with draught animals in Africa. Disc harrows (Fig. B/II/37) are heavy implements requiring a large tractive effort and, like the various rollers (Fig. B/II/38), they are mostly too expensive for African smallholders. Roller harrows (Fig. B/II/39) tend to pulverize rather than mix the soil.

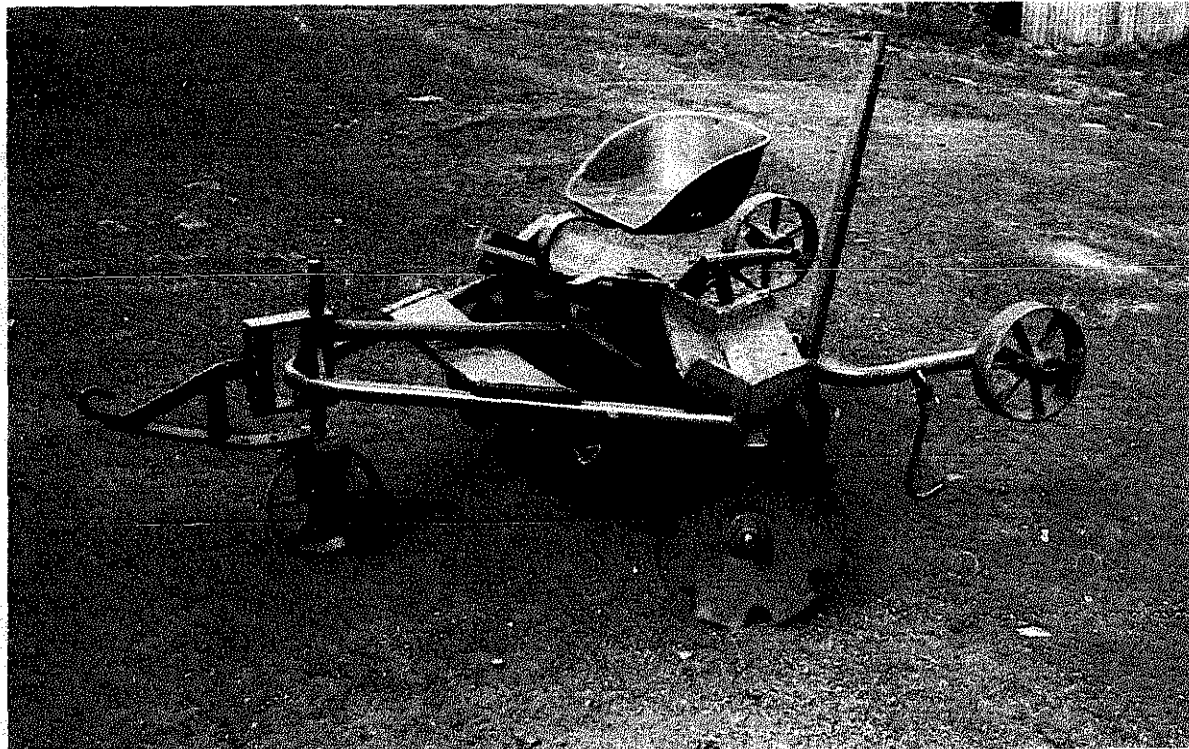


Fig. B/II/37: Disc harrow (TAMTU, Tanzania)

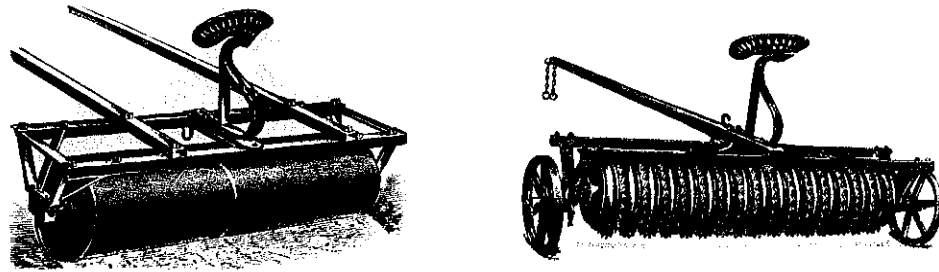


Fig. B/II/38: Rollers - left: flat roller, right: Cambridge roller

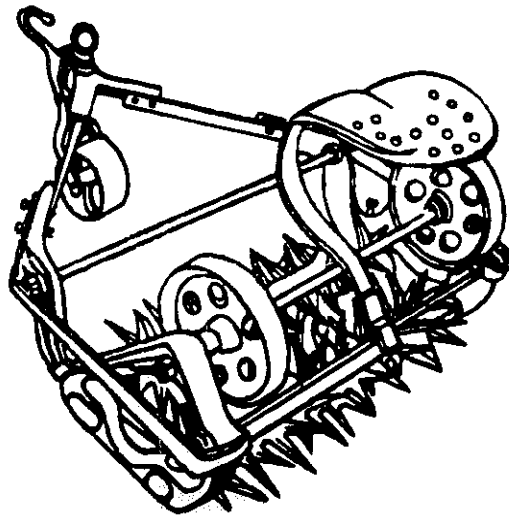


Fig. B/II/39: Roller harrow
(CEEMAT, 1968)

4.2.2 Sowing and planting

The essential tasks in sowing are to distribute the individual seeds such that each has roughly the same amount of space for growth and to place them at an optimum depth in the soil. The amount of space required for each plant and the optimum sowing depth vary depending on the crop and the type of soil and reliable means of adjusting the sowing equipment are therefore important. If draught animals are used the seed can be broadcast or sown in rows (drilling), sown at equal intervals or sown in small groups (dibbling). Whereas the last-mentioned method is still performed by hand, the others are already being carried out using drawn implements in some cases. In addition to reliable operation and quality of work, these implements

must offer a high area capacity and be extremely versatile, since they are otherwise unprofitable on account of their relatively high cost. Mechanization of sowing is an attractive prospect for farms using draught animals, particularly on account of the fact that it permits a far greater capacity in terms of area covered than manual labour. The yield is determined to a great extent by whether or not the area is tilled in time.

Seed broadcasting

Broadcast seed is not distributed evenly over the field nor is it possible to keep a specific sowing depth when subsequently covering the seed with loose earth. Fairly large quantities of seed are usually required in order to ensure an adequate crop. Mechanical weed control using animal-drawn implements can only be performed while the crops are young (e.g. using the flexible harrow).

In addition to cereals such as rice or wheat, various fodder crops are also suitable for seed broadcasting. The work is usually performed by hand; machines have been designed for this purpose but they have not yet been introduced in Africa and are often unprofitable from the economic viewpoint in comparison with other sowing equipment.

Row seeding

This method involves making parallel furrows at a specific depth in which the seeds are placed and then covered with earth. Preparations for the actual sowing can be made using "markers" pulled by hand or by animals (Fig. B/II/40). Here again, the seeds are covered over using harrows.

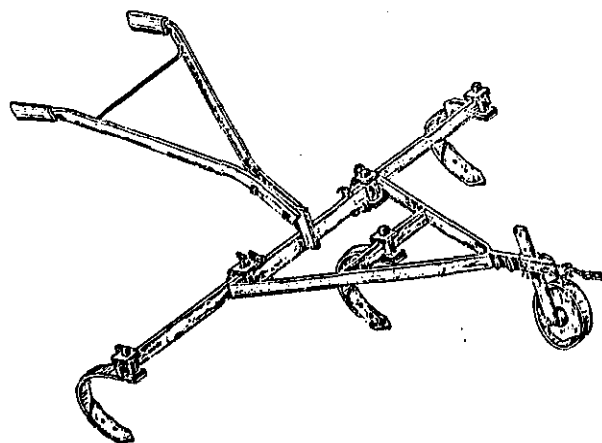


Fig. B/II/40: Multi-purpose implement equipped as a "marker" to prepare for row seeding.
(Source: ARCOMA)

Animal-drawn seed drills are highly uncommon in Africa, since on account of their high cost they are only worthwhile if used for cultivating relatively large areas.

Seed spacing

The purpose of seed spacing drills is not only to keep the space between the rows equal but also to sow the seeds at equal intervals within the rows. Animal-drawn markers can make the work easier if the seed is to be sown by hand.

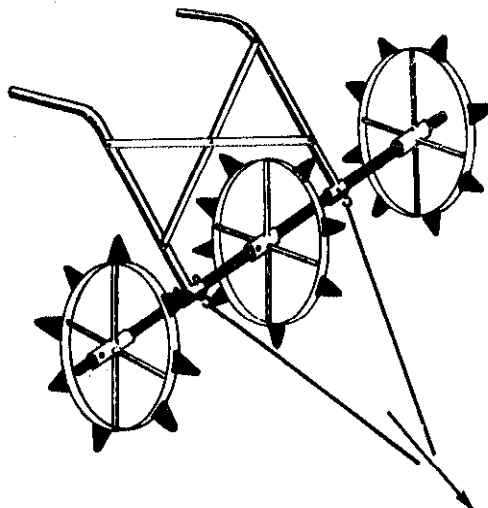


Fig. B/II/41: Marker to be drawn by draught animals

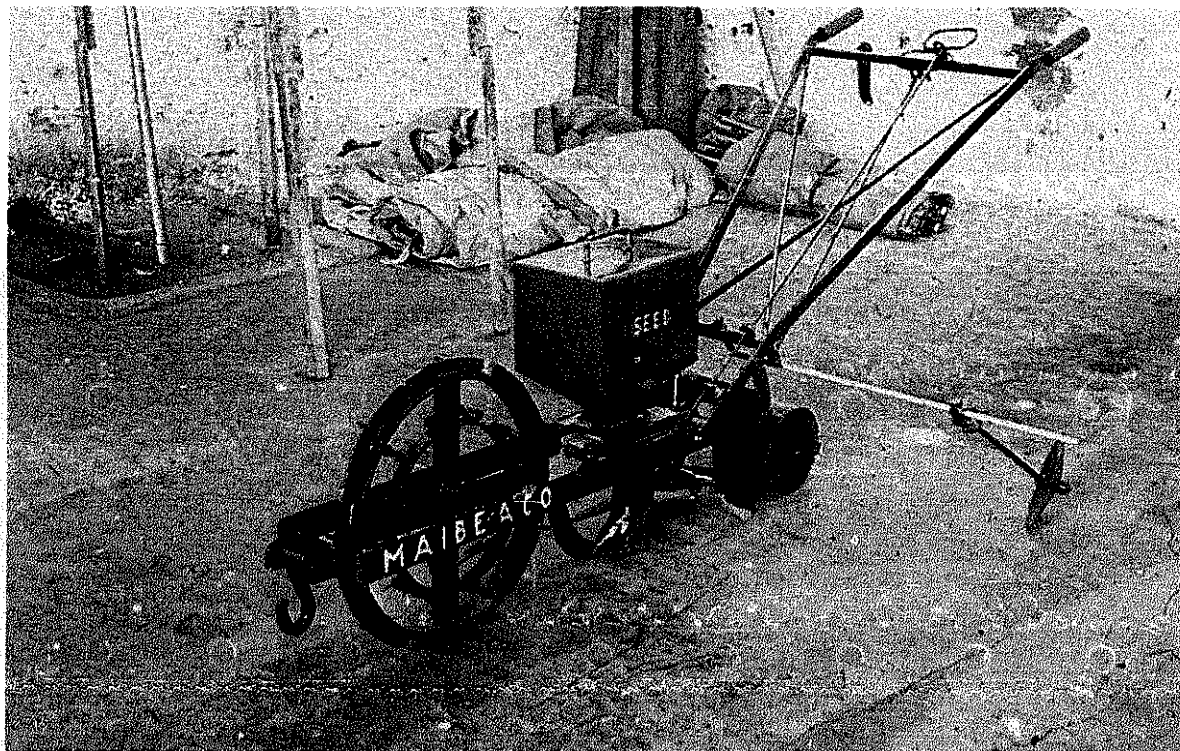


Fig. B/II/42: Animal-drawn seed spacing planters can speed up work considerably. They have already acquired a certain degree of importance in Africa since they are suitable for sowing some of the major crops (e.g. cotton, groundnuts, maize, beans).

The accuracy of seed spacing planters, i.e. the evenness of the intervals between the seeds in a row, depends on the distance which the seeds have to fall between the cell wheel and the furrow.

Fig. B/II/43 shows two sowing mechanisms for seed spacing planters. The inclined cell disc is suitable for types of seed of varying shape and size but the design means that the seeds have a long way to fall. This distance can be reduced using horizontal feed discs. The disc must match the size of the seeds and several feed discs are therefore necessary for varying types of seed.

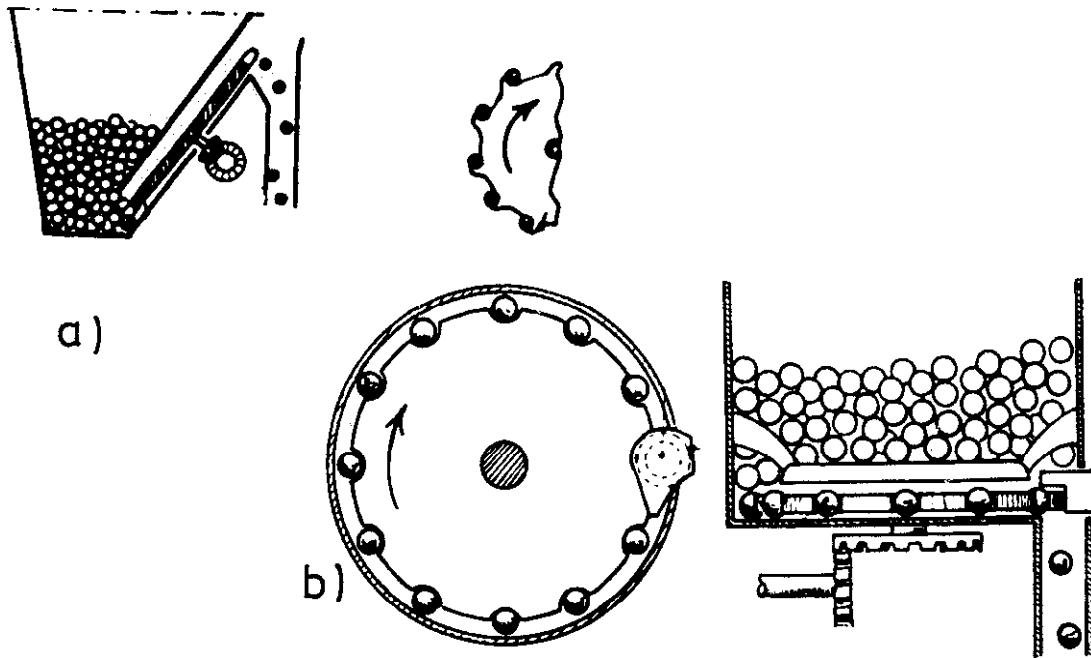


Fig. B/II/43: Sowing mechanisms for seed spacing planters. (CEEMAT, 1968)

- a) Inclined cell disc; seed size unimportant but seeds have a long way to fall.
- b) Horizontal feed disc; seeds do not have far to fall; different discs necessary depending on seed size.

Many seed spacing planters have attachments to permit simultaneous application of mineral fertilizers. There are also drills which can be mounted on multi-purpose implements. The tractive effort required for single-row sowing is comparatively small; only one animal should be used so that rows which have already been sown are not trodden down.

Two rows can be sown simultaneously if a pair of oxen are used and three in the case of certain polycultivators.

It should be borne in mind that the seed must have a sufficient germination capacity since otherwise there will be too many gaps.

Direct sowing and single-pass working

Under certain conditions it is practical to use direct-sowing equipment or combined ploughing and sowing units in order to make optimum use of the time available for tillage.

Direct-sowing equipment can be used to place the seed in the untilled field. The furrow is created by 3 disc coulters and covered over by special rollers. The equipment must be heavy so that the disc coulters can penetrate the soil. Use of direct-sowing equipment necessitates special weed control measures, usually of a chemical nature, otherwise considerable time must be expended on mechanical weed control.

Another way of speeding up cultivation at the start of the rainy season is to combine tillage by means of cultivator or plough with sowing (Fig. B/II/44). It must be borne in mind here that such combinations of tillage implements and simple seed drills may have considerable cost advantages; on the other hand, however, the quality of work is also an important factor.

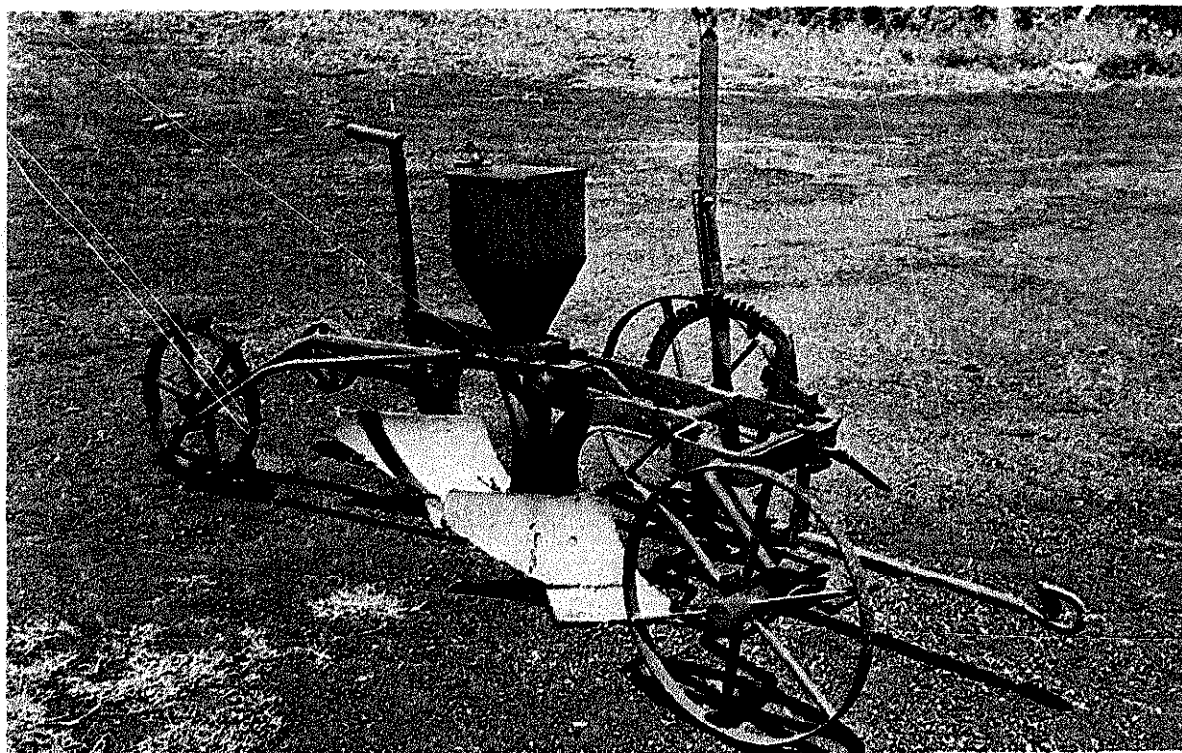


Fig. B/II/44: Two-furrow animal-drawn plough with top-mounted seed drill attachment. (TAMTU, Tanzania)

4.2.3 Crop tending

Mechanizing tillage with the aid of animals usually results in expansion of the area under cultivation and this very soon leads to a labour bottleneck in the tending of the crops, thereby necessitating mechanization in this area as well.

Mechanical crop tending often pursues two objectives simultaneously; on the one hand it is necessary to combat the growth of weeds, while on the other hand the surface of the ground is to be kept exposed so that the rainfall - which may be scanty - can be absorbed as far as possible and a minimal amount of rainwater runs off on the surface and erodes the soil.

A variety of implements pulled by draught animals can be used for mechanical crop tending. Harrows and ridgers have already been discussed in preceding sections. Weeders are unsuitable for use with draught animals, since in order to work properly they require a high working speed which the animals cannot maintain.

Of particular importance are cultivators and hoes as well as appropriately equipped multi-purpose implements.¹⁾

In addition to the tine points already discussed in the section on cultivators, so-called "weeding shares" and "wing sweeps" are used on cultivators and hoes for crop tending.

In many animal-drawn hoes the working width is adjusted to the different row spacing of various crops by moving the tines on the tine carriers (Fig. B/II/45). This also applies to multi-purpose implements. On other hoes the working width can be adjusted using spindles or levers by swivelling the tine carriers (Fig. B/II/46).

This can be done relatively quickly, even while work is in progress. Following major adjustments the tines should subsequently be re-aligned with respect to the direction of travel, a procedure which takes some time. If this is not done - which is frequently the case in practice - the quality of the work will suffer. Adjusting mechanisms accordingly make the machines more complicated and expensive.

When tending the crops a shallow working depth (a maximum of 5 cm) must always be used. In the case of many crops large working widths

1) The crops must be sown in parallel rows if these implements are to be used.

are not possible - except when the crops are young - despite the small tractive resistance, since the work cannot cover more than one row at a time on account of the height of the plants. Most animal-drawn hoes and multicultivators are therefore designed for single-row working. Careful coordination is necessary when selecting implements and establishing the distance between the rows for the various crops. If yokes are used to harness the animals the width of the yoke must be matched to the distance between the rows among the crops to be tended.

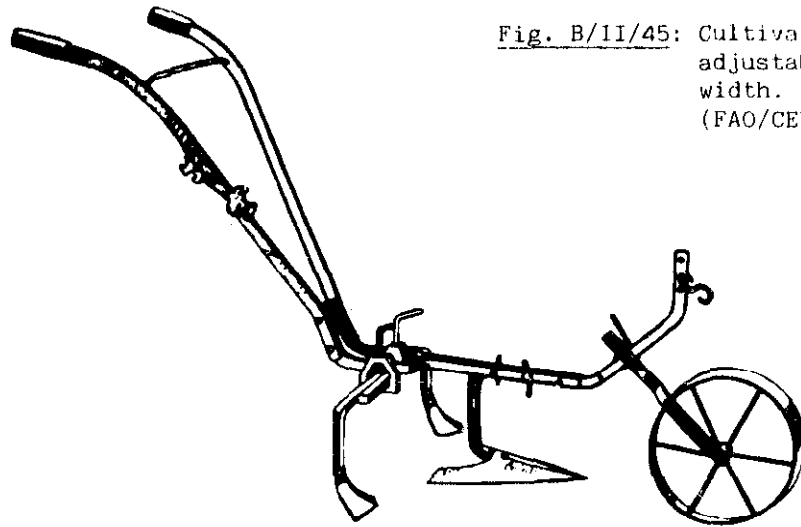


Fig. B/II/45: Cultivator with adjustable working width. (FAO/CEEMAT, 1972)

Fig. B/II/46: Cultivator with working-width adjustment by means of swivelling tine carriers. (VENTZKI)

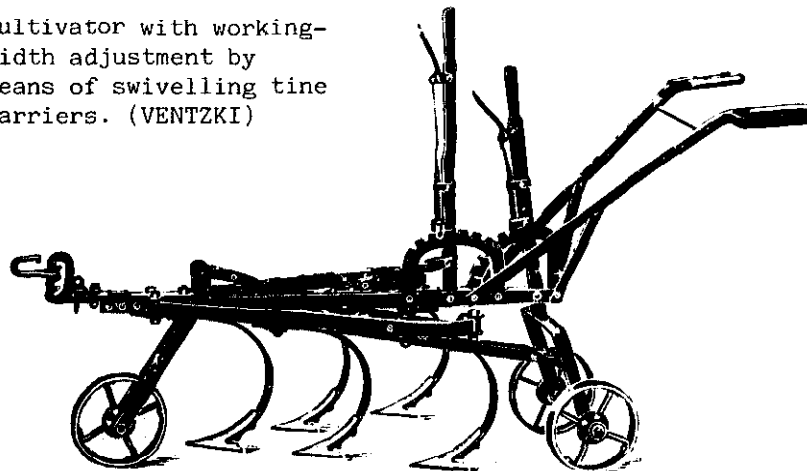




Fig. B/II/47: Multiple-row hoeing in Zambia using a locally developed hoe. (Photo: Rauch)

4.2.4 Fertilizing

Alongside correct soil tillage, optimum plant nutrition is of major importance if high yields are to be achieved. This can be guaranteed using organic or mineral fertilizers and a variety of equipment can be used to apply them.

A wide variety of animal-drawn transport equipment is suitable for spreading manure or compost. Mineral fertilizers are usually applied by hand or using hand-held implements, even on mechanized farms, and animal-drawn implements are seldom employed for this purpose.

Mineral fertilizers can either be spread using full-width fertilizer distributors (Fig. B/II/48) or placed in the immediate vicinity of the plants by means of special implements. This can be done at the same time as sowing (Fig. B/II/49), the placing of the fertilizer being controlled by means of various metering devices.

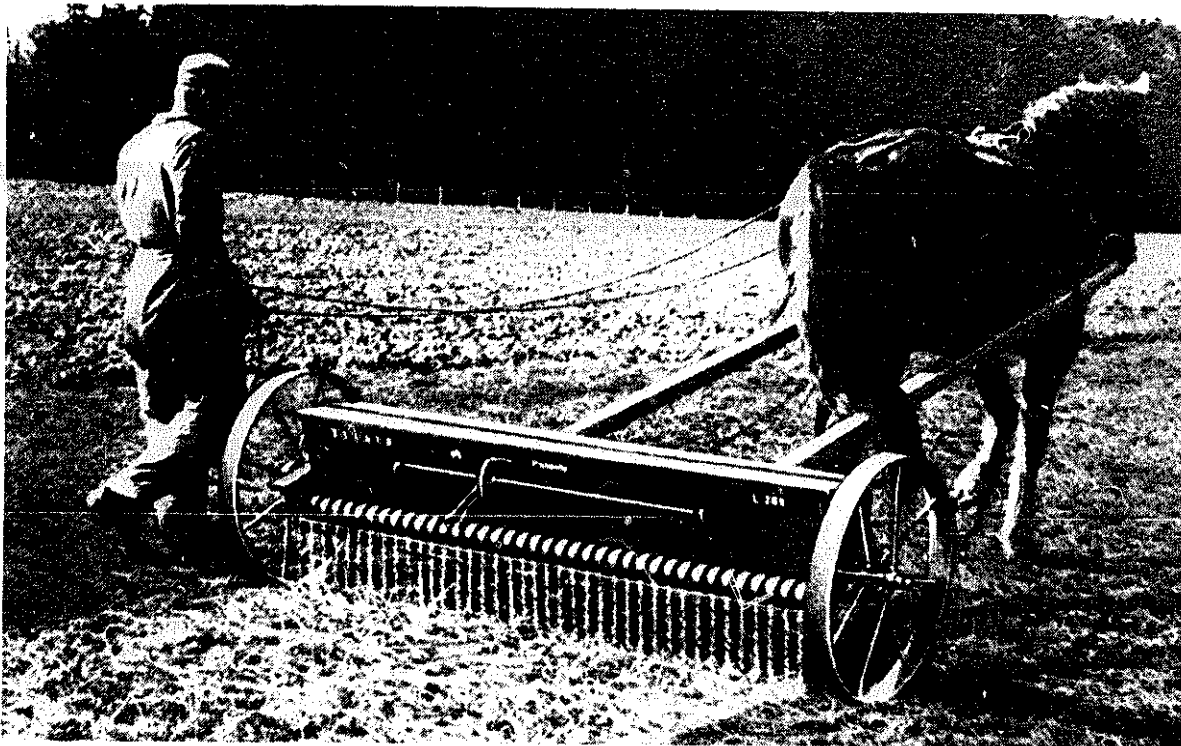


Fig. B/II/48: Full-width fertilizer distributor, once commonly used in Europe. (AMAZONE)



Fig. B/II/49: Seed spacing planter with mineral-fertilizer placement attachment. The fertilizer is accurately placed near the seed, e.g. as deep fertilizing for maize. (TAMTU, Tanzania)

4.2.5 Harvesting

The amount of harvesting work increases as cultivation is intensified and expanded, procedures which usually accompany the transition from manual labour to using draught animals. In order to retrieve the increased quantities of crops without loss it is frequently necessary to mechanize some of the work.

However, the fact must not be overlooked that under the conditions found on smallholdings in Africa comparatively little use has been made of draught animals to date for harvest work, apart from transporting the harvested crops.

Groundnut lifters

Groundnut lifting with the aid of draught animals has in particular achieved a substantial degree of importance in some parts of Africa. There are two major reasons for this. On the one hand, mechanization of this work requires only simple implements, while on the other hand the time available for harvesting is relatively limited. If the crop is harvested too early the yield can be reduced by around 1-2% per day (CEEMAT, 1968) and there may also be losses as a result of fungal diseases. If the harvest takes place too late the soil dries out very quickly and it is almost impossible to lift the groundnuts.

The actual work is performed using various lifters mounted on frames similar to those of swing and Belgian ploughs or on multi-purpose implement frames. The lifters cut off the roots below the crops and loosen the soil, working at a depth of around 5-10 cm. Whether or not the lifter can be used depends not only on the nature and condition of the soil (particularly the water content at harvesting time), but also on the extent of weed infestation, the type of groundnut grown and the cultivation system (crop grown in flat field or on ridges).

The sweep lifters (Fig. B/II/50), for instance, have a relatively good tractive resistance, are usually between 20 and 50 cm wide and can cope with even difficult conditions. Broad sweeps are particularly suitable for lifting the creeping varieties and for working on light soils, while narrow ones are better for lifting upright varieties. Sweep lifters are not recommended for use on ridge-grown crops, being very difficult to handle in this case. The cutting angle of the sweeps should have a broad range of adjustment in order to guarantee satisfactory results with different and changing soil conditions.

Straight, flat share lifters, on the other hand, are simple and sturdy implements and in the course of trials in Gambia proved to

be highly suitable for use with ridge-grown crops (MATTHEWS and PULLEN, 1975). It was impossible to achieve satisfactory results with them in dry, hard soils and in weed-infested fields (LABROUSSE and GODRON, 1965).

As a makeshift measure groundnuts can also be lifted with ards, mouldboard ploughs or ridgers.

According to LABROUSSE and GODRON, losses during lifting amount to less than 10% provided that suitable shares are used, while figures of between 2 and 23% were recorded in Gambia (MATTHEWS and PULLEN, 1975).

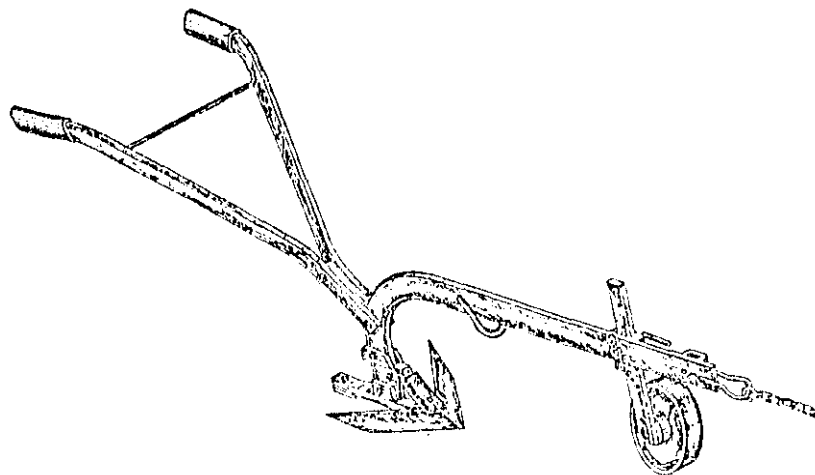


Fig. B/II/50: Multi-purpose implement equipped with a sweep for lifting groundnuts.
(Source: ARCOMA, Upper Volta)

Other harvesting implements and machines

Apart from groundnut lifters, there will be little scope in the foreseeable future for introducing other harvesting implements into draught-animal based farming in Africa.

There are various reasons for this:

- 1) In the case of tuber and root crops (yams, cassava) the tractive resistance is usually greater than the traction power of the animals.
- 2) The condition of the natural pastureland (uneven and covered with bushes) has to date made it largely impossible to use machines for recovering feedstuffs. Even in improved fodder areas grass grows in thick clumps and this makes it extremely difficult to use animal-drawn mowers.
- 3) Grain-harvesting machines such as the binder formerly used in Europe and North America (see Fig. B/II/14) are designed for har-

vesting cereals (wheat, barley, rye, oats) which are relatively unimportant in Africa, and can be used to only a limited extent for sorghum and millet. The heavy machines would soon get bogged down in irrigated rice fields. The use of binders would be theoretically possible only for upland rice.

- 4) Machines and implements for the grain and fodder harvest are complicated and expensive; at present their use would be profitable at best above single-farm level in cases where fairly large areas can be harvested during the crop season.

Notwithstanding the above-mentioned limitations imposed by African conditions a few implements are shown and briefly explained below.¹⁾

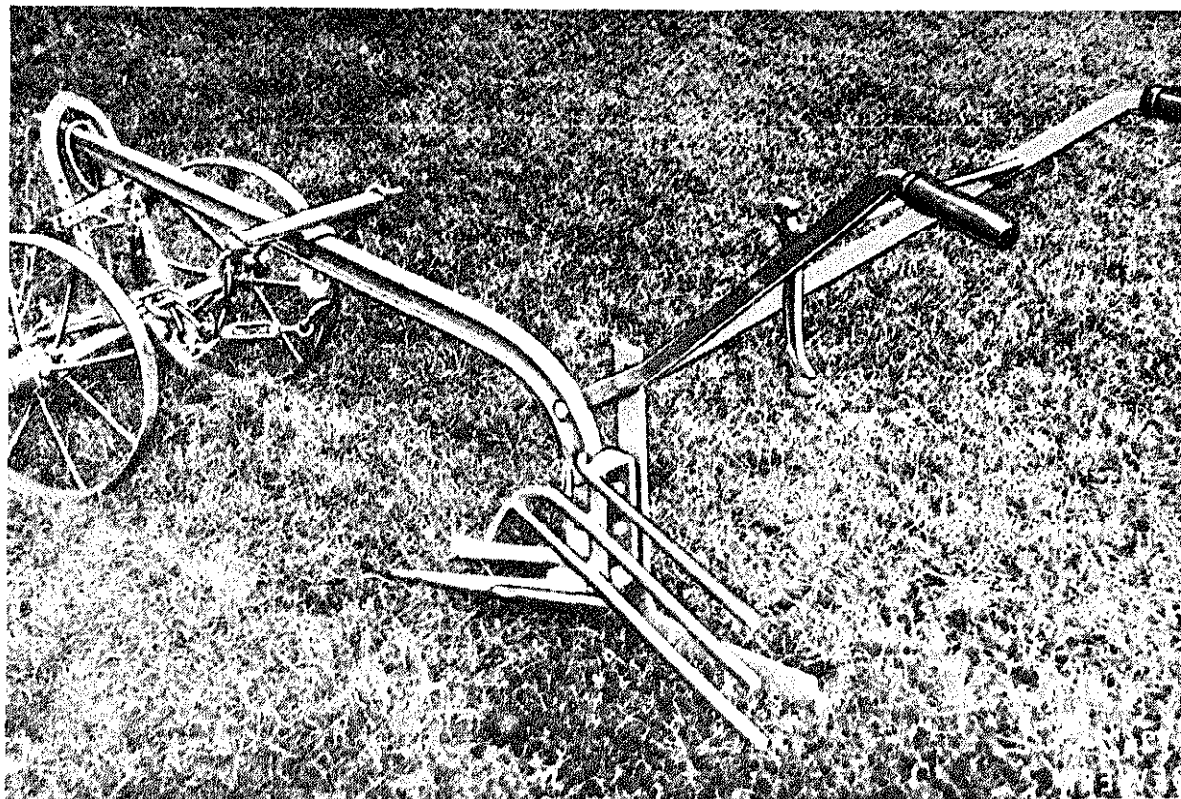


Fig. B/II/51: Beet lifter: the topped beet are lifted out of the ground by the two tines. (RABEWERK)

1) The attention of interested readers should be drawn to old brochures from European and American agricultural machinery manufacturers, which are to be found in archives, particularly at university institutes of agricultural engineering.

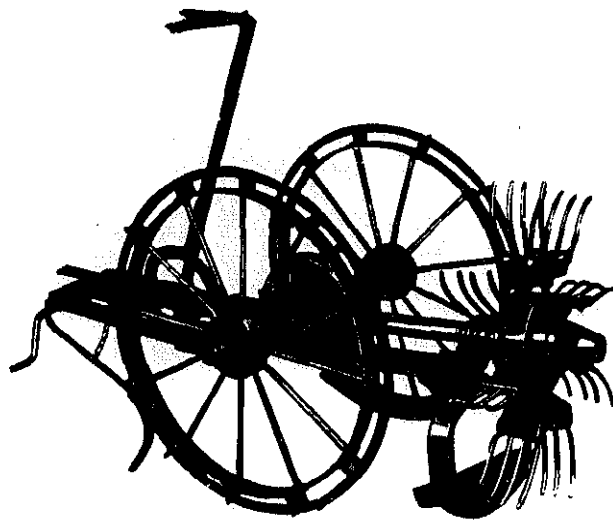


Fig. B/II/52: Potato spinner: the potatoes are lifted and thrown to the side by the rotor. These implements may become increasingly important in future for potato-growing in Africa and possibly for other root crops as well. (Source: SCHMOTZER)

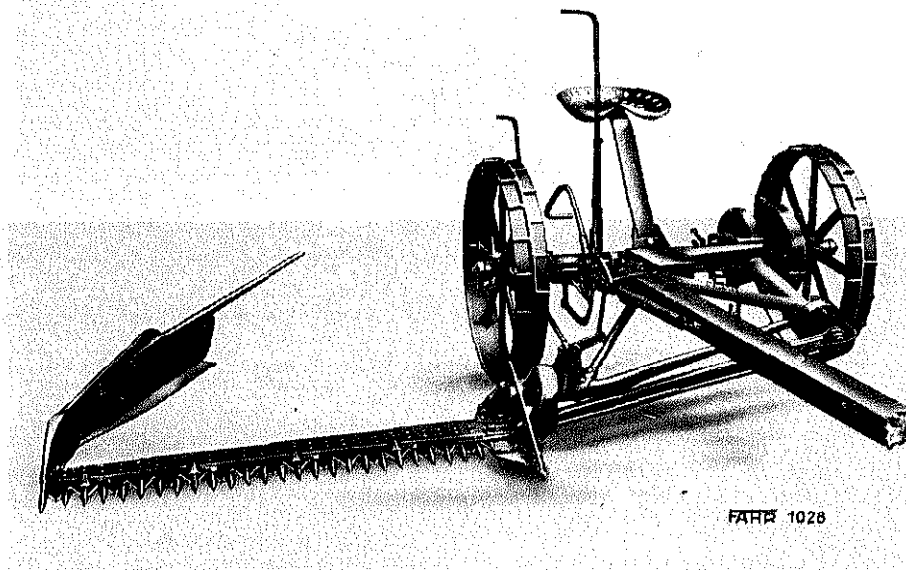


Fig. B/II/53: Mower to be drawn by two horses. The sectional wheels drive the cutter bar via a gear mechanism. Mowers have been manufactured with working widths of between 1m and 2.4m, three horses being required for the larger widths. (FAHR)



Fig. B/II/54: Rake to be drawn by one or more animals: the direction of rotation of the swath cylinder can be reversed, making the implement suitable for turning and windrowing harvested crops. Note the precise harnessing using a halter and an individual withers harness. (Source: FAHR)

4.2.6 Multi-purpose implements¹⁾

Multi-purpose implements are based on the idea of a linked sequence of operations. If possible all jobs to be done on the farm are to be accomplished using one single frame to which various tools are attached. This can substantially reduce the financial burden on the farm.

The multi-purpose implements used in Africa differ from those which were widespread during the last phase of draught-animal based farming in Europe in that they are designed not simply for cultivation and crop-tending work, but also for soil tillage.

A basic distinction can be made between multicultivators and polycultivators. Whereas the former are used solely for field work, the latter can also be fitted out as carts for transport work since their base frame is equipped with a two-wheel axle and a towbar.

¹⁾ Detailed information on multi-purpose implements can be obtained from the African manufacturers of animal-drawn implements listed in Part A.

Multi-purpose implements are expensive and can therefore be used only on farms with a sufficiently high degree of productivity. Purchase of a polycultivator in particular calls for detailed consideration of profitability aspects, since this implement's more elaborate design may make it more expensive than a multicultivator or corresponding individual implements with a separate cart.

If various jobs are to be performed in rapid succession using multi-purpose implements this requires time-consuming and sometimes difficult conversion work. This disadvantage is particularly serious in the case of polycultivators, especially if transport work (e.g. water) frequently also has to be performed during the season when the crops are grown.

The frequent conversions and adjustments on multi-purpose implements should be able to be made rapidly, easily and using no or few tools. The risk of injury or of losing parts (such as nuts or washers) should be as small as possible.

Similar demands must be imposed on unions on single-purpose implements which have to be loosened and tightened again by the farmer himself in order to adjust the implement. Out of all the possible types of unions, the nut-and-bolt connection is the least favourable. It must be borne in mind, however, that even elegantly designed multi-purpose implements call for greater technical understanding on the part of the operator than do single-purpose implements.

The aim sometimes pursued with multi-purpose implements of familiarizing the farmers with adjustment operations and the correct way of handling complex implements may be defeated by the farmers in that they do not carry out the adjustments (cf. e.g. CASSE et.al., 1965).

Multicultivators

Multicultivators can usually be equipped with plough bodies, ridger bodies, various cultivator tines, seed spacing planters and various groundnut lifting implements.

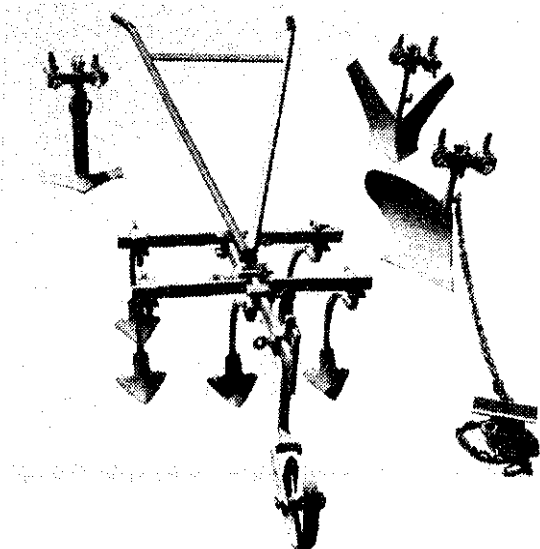


Fig. B/II/55: Example of a multi-cultivator (Houe Sine/SISCOMA): can be used in both heavy and light versions to be drawn by horses or oxen. Two seed spacing planters, among other things, can be mounted on the T-shaped frame.

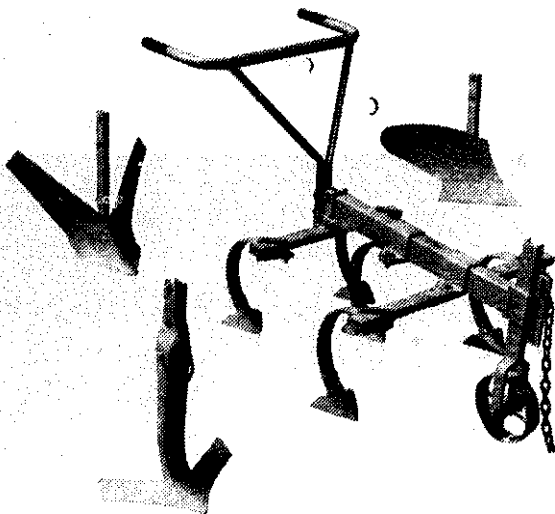


Fig. B/II/56: The "Arara" has a straight frame made of wooden sections. In contrast to the implement described above, on which the quick-action locking devices have eye bolts, a spanner is required for adjustment and conversion work on this implement, which is suitable for use with draught cattle. (SISCOMA)

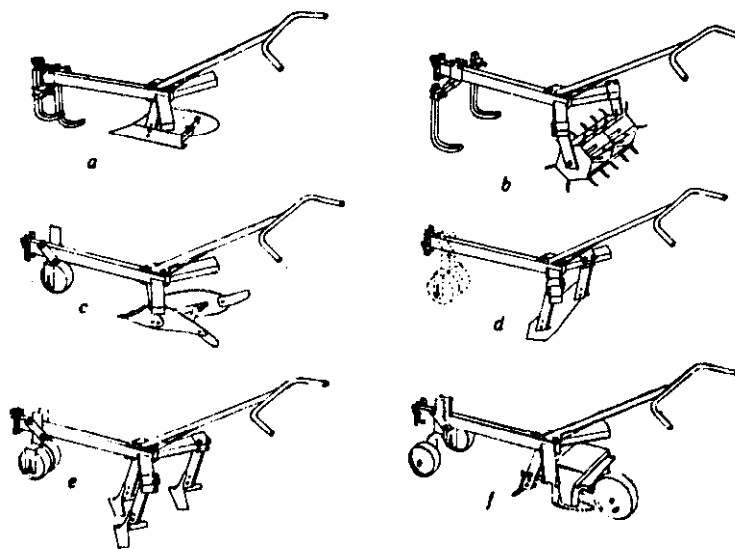


Fig. B/II/57: The "Unibar" was originally designed for use on ridge-grown crops and was therefore equipped with two depth control wheels instead of the single wheel found on the implements described above. Its Y-shaped frame is made of sectional steel. The "Unibar" comes in both light and heavy versions, both of which have adjustable handles and can be equipped with a single-row seed spacing planter. A simplified version has runners.

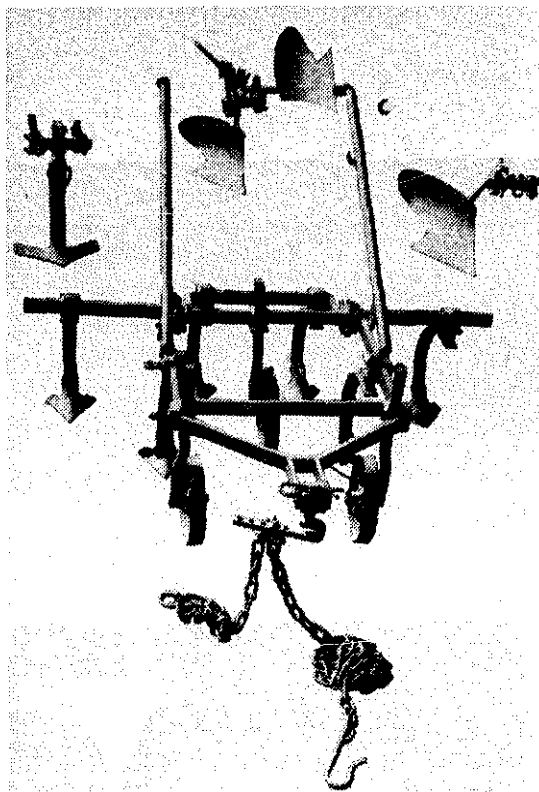


Fig. B/II/58: "Ariana" multicultivator (SISCOMA)

This implement, which weighs between 58 and 92 kg, has a rectangular frame with a V-shaped front section. The 60 cm wide frame necessitates appropriate distances between the rows if work is to be performed among older (taller) crops. The working width can be increased to 1.50 m by fitting a rail on the frame; the maximum working width of other multicultivators is usually around 90 cm. If the "Ariana" is fitted with one depth control wheel it is used for work between two rows which are fairly close together. Two depth control wheels are used for most work and give the frame additional stability, while a third wheel at the rear makes it easier to transport the implement and guarantees more even depth control during multiple-row sowing. The "Ariana" is relatively heavy and is recommended for heavy soils and rice growing. Two oxen are required on account of the large working width and the implement's weight makes it difficult to handle. As a result of its working width and weight the "Ariana" can only be used to practical advantage on flat, completely cleared land.

Polycultivators

The land on which polycultivators are to be used must be flat and properly cleared on account of the weight and large working widths of these implements. Their relatively complex design also calls for corresponding skill on the part of the farmer (MONNIER, 1965).

It is a good idea to use polycultivators if transport and field work frequently overlap. Roads and fields in poor condition will often cause the pneumatic tyres fitted on many polycultivators to be punctured.

While some polycultivators have a single straight axle and cannot be used among ridge-grown crops on account of the resultant small ground clearance, others have a sectional axle with adjustable ground clearance, facilitating work among ridge-grown crops and tending of taller crops. It must be remembered, however, that a maximum ground clearance of 70-90 cm necessitates correspondingly long tools, which are highly subject to vibration, thereby possibly impairing the quality of the work. Once crops such as maize have attained a height greater than the maximum ground clearance it is also impossible to use these implements for work covering more than one row.

Even among crops with wide row spacing polycultivators cannot be used to work between the rows. The possibility of altering the track width of the implements by moving the half-axle inwards or using telescopic half-axles (Fig. B/II/59) serves to adapt the polycultivator to the differing row spacing of various crops. Ploughs should be mounted on polycultivators on the right-hand side so that the right-hand wheel can run in the furrow during ploughing. In order to prevent lateral pull various methods have been developed for additional shifting of the coupling point of the drawbar on the yoke to the right.

Promotion of these implements is advisable only in special cases following detailed examination of the conditions under which they are to be used. In some cases it has been discovered that the technically attractive but also elaborate and expensive polycultivators are simply used as carts after a while.

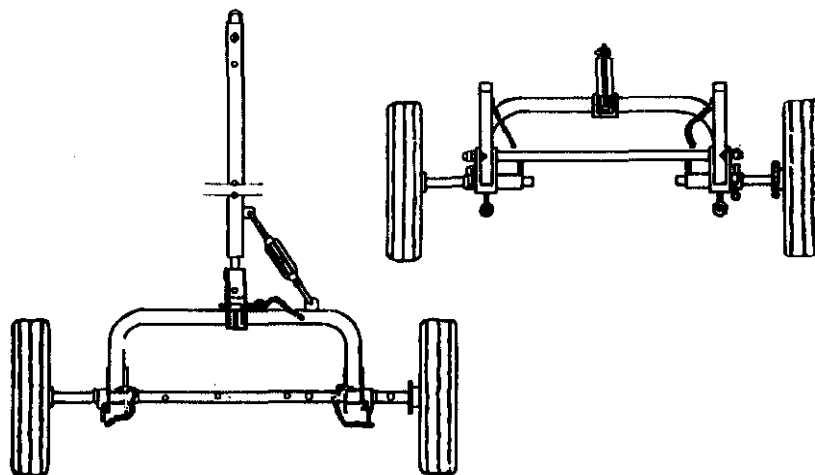


Fig. B/II/59: Chassis of a polycultivator with track adjusting device and a draw bar adjustable in accordance with the direction of pull. (MONNIER, 1973)

Fig. B/II/59 shows a polycultivator on which the drawbar is continually adjusted via a tension lever in accordance with the direction of pull. Other implements are designed such that the entire drawbar can be moved to the side. However, it is not always possible to completely suppress the lateral pull.

Many polycultivators make things easier for the person driving the team in that he can ride on the implement. Experience has shown that with the driver seated greater speeds are attained than if he walks alongside or behind the implement, with the tractive resistance remaining the same. If heavy work is to be performed, however, the driver should not ride on the implement.

The stable support given to the polycultivator by its two wheels and the drawbar results in precise depth control for the attached tools in suitable ground and thus guarantees high-quality work.

Using polycultivators it is possible to perform numerous jobs with a smaller tractive resistance than is the case with single-purpose implements or multicultivators, since the tools are supported by the smooth-running frame. Large working widths and thus large area capacities are possible, particularly for work where the tractive resistance generated by the tools is small. This must be regarded as the major advantage of polycultivators; it is certainly possible to use three-row seed spacing drills and hoes with a working width of up to two metres.

4.3 Special implements for irrigated farming

Numerous animal-drawn implements can be used in both rain-fed and irrigated farming. The latter area, however, involves a few special jobs for which particular implements are required.

It must be pointed out that mechanization based on small tractors may be more economical on irrigated land than in rain-fed farming on account of the greater yield potential; the situation becomes still more favourable if this form of mechanization makes it possible to obtain more harvests per year (cf. FAO, 1977).

Primary tillage can be carried out using the same implements as in rain-fed farming. The tractive resistance is often very great in "typical rice soils" and "technical" irrigation is often necessary to soften the soil. When ploughing it is advisable to use one-way ploughs which result in less unevenness than conventional ploughs. Belgian ploughs must be fitted with runners. If ards are used the land must be tilled up to seven times (STOUT, 1966). Particular attention must be drawn to the ploughs from East Asia, particularly the one-way ploughs with a multiple-element mouldboard, since these represent a compromise between the desired turning of the soil and the limited tractive effort of the team.

Sledges are suitable for transport work on wet land.

4.3.1 Levelling implements

Careful levelling is essential to ensure even distribution of the water. The creation of irrigated farmland means that large areas must first be levelled. Large quantities of earth must be moved in some cases, which means that a great deal of time is required if the work is performed using draught animals. In addition to carts earth scoops can be used; these have a capacity of around 50 to 150 litres and are suitable for transportation over short distances.

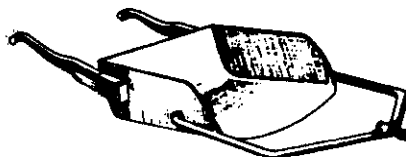


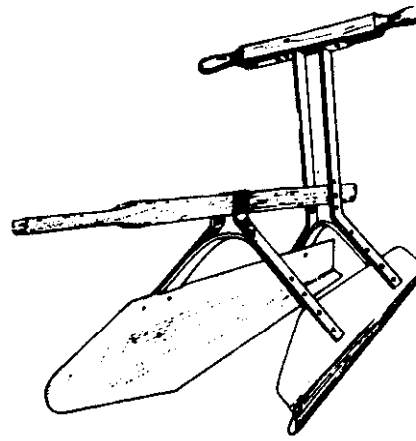
Fig. B/II/60: Earth scoop for moving earth over short distances. (HOPFEN, 1969)

The unevenness created during tillage must be eliminated before sowing takes place. Apart from harrows, which exhibit very high tractive resistances (cf. MATTHEWS and PULLEN, 1975), various types of levelling boards or beams are used for this work which involves only small areas (cf. Fig. C/III/3 in Part C of the handbook).

4.3.2 Creation of ridges and ditches

Animal-drawn implements can also be used to create small ridges marking the boundaries of irrigated areas. Most of these implements are suitable only for making small water ditches; however, ridges must have a strong bond with the subsoil in order to make them as stable and leakproof as possible. Simple implements (Fig. B/II/61), as well as mouldboard ploughs and ridgers, are suitable for creating ridges and ditches (e.g. by combining or splitting two furrows). Ridges and ditches which have been preshaped using animal-drawn implements must subsequently be finished off by hand using shovels or the like.

Fig. B/II/61: Simple implement for creating ridges.
(HOPFEN, 1969)



4.3.3 Puddling

In rice growing the land is tilled to a depth of 10-15 cm and then subjected to special treatment known as "puddling" to prepare it for transplantation of the seedling. The object of this work is to create, above a compact layer, a layer of mud which is as uniform as possible and to work in all the organic substances. The animal-drawn implements used for this purpose can be subdivided into those with rigid tools and those with rotating tools. The implements with rigid tools are for the most part single-row harrows with thick wooden tines or various harrow boards (Fig. B/II/62).

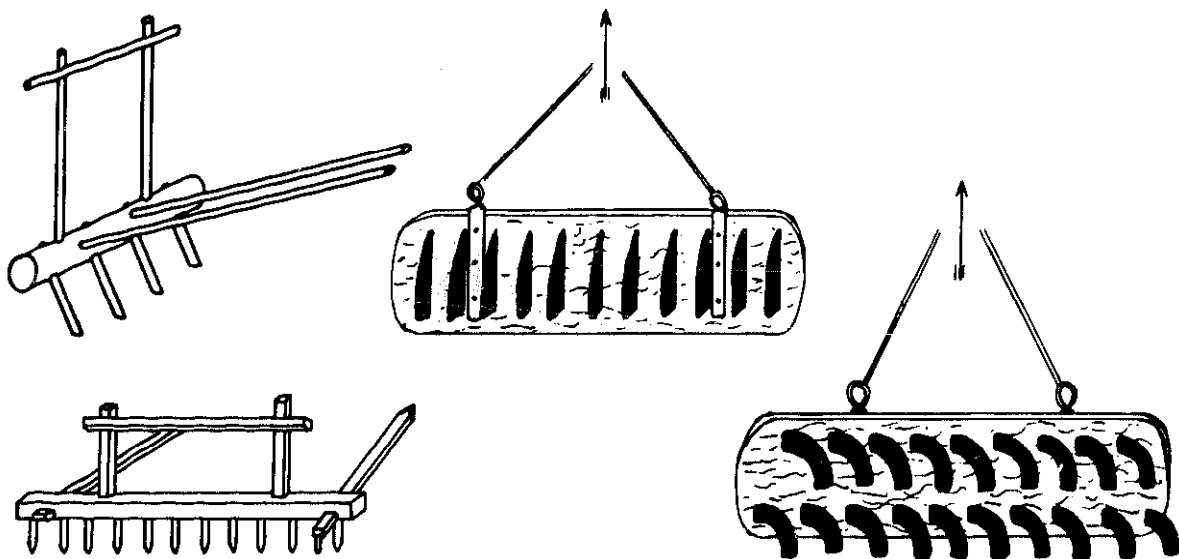


Fig. B/II/62: Wooden harrows for "puddling" in irrigated agriculture.
(CEEMAT, 1968)

The single-row harrows can also be used for levelling if the tines are removed or a beam fixed across their points.

The implements with rotating tools (Fig. B/II/63) are special roller harrows or rollers; rigid tools are often additionally fitted behind the rotating ones.

If sufficient time and animals are available draught animals can also be used for puddling without implements. Levelling boards are also used in Asia for this purpose.

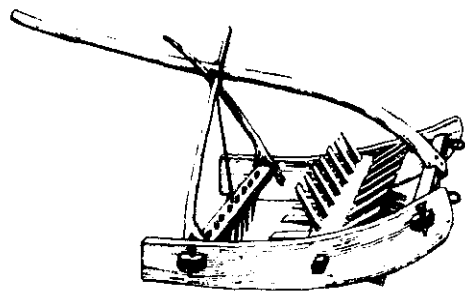
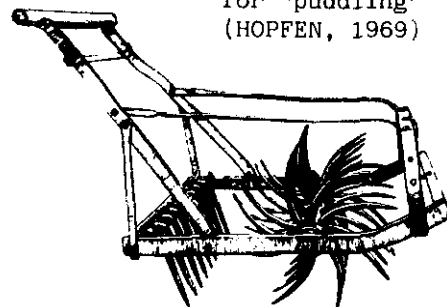


Fig. B/II/63: Roller harrows for "puddling" (HOPFEN, 1969)



4.4 Implements for powering machines and conveying water

4.4.1 Capstans

Capstans are used to convert the forward movement of the draught animals into a rotary movement.

A capstan is a gear mechanism. A beam, approximately 3 metres in length can be secured to the vertical input shaft and the draught animal is then attached to its other end. The animal moves in a circle and the slow rotation of the input shaft is converted into a more rapid rotary motion by the multi-step gear mechanism of the capstan. The output speed, which is determined by the number of gear pairs and the number of teeth per gear, is transmitted to the machines to be powered by means of the horizontal output shaft.

Wooden capstans (Fig. B/II/64) are cheap but difficult to manufacture and somewhat inefficient, particularly if fairly high speeds are to be attained.

The advantages of capstans over motors and engines are that they require no external energy supply and the animals can be used for much of the year. Furthermore, maintenance and use of a capstan do not place any particular demands on the operator.



Fig. B/II/64: Wooden capstan with one pair of gears for conveying water. (Photo: GTZ Archives)

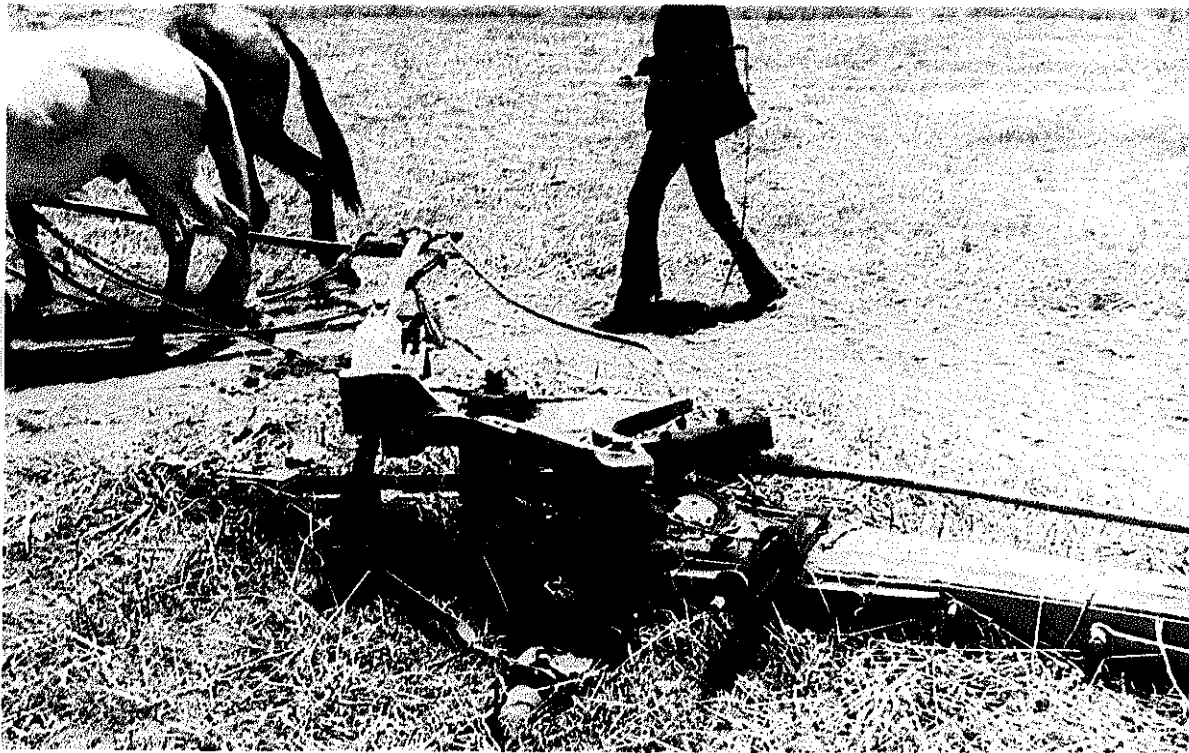


Fig. B/II/65: Steel capstans, like that shown here in Morocco, are more efficient thanks to their smooth-running bearings and the high quality of the tooth system. However, the cost of a solid capstan must be in reasonable proportion to the potential performance. (Photo: Georgen)

Capstans can be used to mechanize various jobs involved in the processing of harvested crops. It may, however, be very difficult to obtain suitable machines whose power consumption is matched to the low capacity of the animals.

It must be remembered that when a grinding mill - to give just one example - is being purchased it is necessary to procure one with a capacity roughly similar to that of a domestic machine rather than one designed for power take-off drive by a tractor.

When operating a capstan a donkey can deliver around 0.12 kW (0.16HP), a horse or a light ox around 0.18 kW (0.25 HP) and a 400 kg ox approximately 0.24 kW (0.32 HP), (CEEMAT, 1968). The efficiency of the capstan must also be taken into account. Provided that suitable gear mechanisms are used it may undoubtedly be possible to operate machines designed to be powered by tractors or other mechanical energy sources but it is probably only in rare cases that this will be economical.

It is obvious, therefore, that capstans should be used above all in places where there is no electricity supply and stationary internal-combustion engines cannot be used on account of maintenance problems. In Europe, for example, but also in Asia to some extent, these two energy sources have replaced the capstan (CEEMAT, 1968). The capstan will nevertheless regain importance in the future, particularly in Africa, as a result of the energy shortage.

4.4.2 Equipment for conveying water

Draught animals can be used in two different ways to convey water:

- Continuous delivery: This calls for a pump or a bucket wheel with capstan drive. The production costs are higher but the system has a greater capacity (Fig. B/II/66).
- Intermittent delivery: The animals pull a large vessel (e.g. hose or bucket) out of a well or river by means of a rope guided around a pulley. In this way fairly large delivery heads are possible. The method is simple, but also laborious and slow.



Fig. B/11/66: Continuous delivery of water using a bucket wheel. (Photo: GTZ Archives)

4.4.3 Methods and implements for processing harvested crops

The most important area is the threshing of cereals, particularly rice. This can be done either by simply having the animals tread out the grains with their hooves or by using various threshing sledges.

These threshing methods require a large, preferably circular area with a firm surface, where the animals can be led or driven round in a circle. The surface should be cemented or, following removal of weeds etc. and levelling of the ground, a top layer created from existing materials (e.g. clay and cattle dung) and then allowed to dry (CEEMAT, 1968). On account of the time required for preparing the area this is only worthwhile if fairly large quantities of grain are to be threshed.

The disadvantage of this method is that the harvested crops become contaminated by dung and urine, both of which should be caught in suitable containers. Fitting the animals with muzzles will stop them eating the grain.

Other operations which form part of crop processing and which can be mechanized with the aid of draught animals include the pressing of sugar cane (using vertical roller mills) and the extraction of palm oil, together with the shredding and grinding of grain and possibly also the chopping of straw and the like. In these cases, however, it is necessary to use the aforementioned capstans to drive simple machines.



Fig. B/II/67: Lentil threshing with the aid of a simple threshing sledge near Aleppo in Egypt. (Photo: Holtkamp)

4.5 Use of draught animals for transport purposes

Transportation often constitutes a major problem in Africa; adequate means of transport are frequently unavailable and even large loads are mostly still moved by hand or on foot. It therefore comes as no surprise that frequent and popular use is made of draught animals for transport purposes, both in agriculture and elsewhere.

The use of draught animals for transport work is a particularly important factor when they are introduced, for this form of use is in most cases adopted relatively quickly.

This can be attributed to the following factors, among others:

- The more intensive cultivation methods result in more transportation work. Besides additional crops it may be necessary to transport organic or mineral fertilizers.
- An additional income outside farming can often be earned by transporting firewood, water and commodities.

- It is more economical to use the animals for a longer period, possibly throughout the year, and this also helps them to remain in training.

The most common animal-drawn means of transport in Africa is the two-wheeled cart. Simpler and thus cheaper means such as sledges (Fig. B/VI/5) can often be used as well, particularly when draught animals are first introduced.

Lastly, it is important in many places that other animals (particularly donkeys) which are too light for heavy field work should be used for transport purposes, alongside draught oxen (cf. e.g. KLINE, 1969).

4.5.1 Pack-saddles and sledges

Pack animals have been common for centuries, particularly in North Africa, and are still frequently found today. Donkeys and dromedaries are used by preference but all draught animals can in principle be employed to carry loads. Simple pack-saddles are the only equipment required (Fig. B/II/68).

Sledges which slide along on runners are simple and inexpensive. They are particularly suitable for use on wet ground (e.g. during the rice harvest) where carts quickly become bogged down, but can also be employed on dry ground.

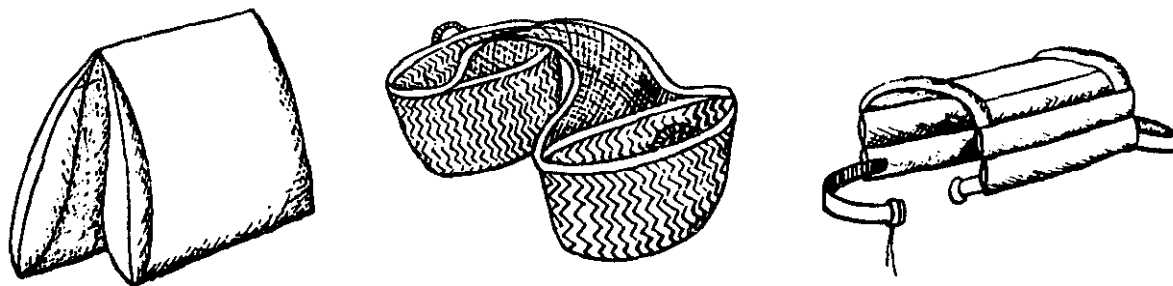


Fig. B/II/68: Various types of pack-saddle. (HOPFEN, 1969)

4.5.2 Carts

Two-wheeled carts in a wide variety of designs (e.g. Fig. A/7; B/I/9; B/IV/3) are today found everywhere in Africa where it has been possible to introduce animal traction on a permanent basis.

In addition to their limited load capacity, the major disadvantage of two-wheeled carts is that they easily become unbalanced when being pulled up or down a hill and therefore pull or press on the animals' harness.

Carts with large iron-rimmed wooden or with all-metal wheels have a large ground clearance and on account of the large wheel diameter they can cover uneven terrain relatively smoothly. Such carts are therefore more suitable for bad roads than carts with small wheel diameters. However, small-wheeled carts are often less expensive; the loading areas, by being extended over the wheels, can also be substantially wider without making the cart unstable.

On carts with rigid metal wheels it is possible to fit oil-impregnated wooden sliding bearings or metal sliding bearings.

These bearings are subject to heavy wear since the necessary lubrication is usually not performed properly.

The axles and pneumatic tyres from old vehicles are often used for carts. In addition to the reduced tractive resistance of these carts, particularly on a loose or soft surface, another advantage is that the springing effect permits a light-weight design and thus a better payload/unladen weight ratio, while at the same time the carts have a longer life. These carts are relatively expensive and there is a high risk of tyre punctures, particularly on poor roads. In view of the fact, however, that pneumatic-tyred wheels cause less damage than metal wheels on good roads, the type of wheel should be selected according to the prevailing conditions on the roads to be covered.

It is best to fit pneumatic-tyred wheels with maintenance-free rolling bearings.

Both wooden and metal wheels as well as pneumatic-tyred wheels can be fitted with block brakes which, on account of the high actuating forces, should be applied via spindles. On the pneumatic-tyred carts, however, it is also possible to find the drum brakes common in automotive engineering, particularly if old car axles have been used in manufacturing the carts.

The carts are usually equipped with simple platforms, which should have removable sideboards. High-sided bodies for transporting harvested crops as well as special equipment for carrying passengers are also occasionally found. The higher and wider the body, the greater the tendency of the cart to tilt on a slope. Carts with high loading areas make loading difficult, although unloading can be made

easier by tipping over a wider space. The load must be well-balanced, particularly in the longitudinal direction, so that the animals are not subjected to excessive strain.

Provided that good-quality carts are used, singly harnessed donkeys can pull a payload of up to 500 kg, while single horses can pull up to 1000 kg and pairs of oxen up to around 1500 kg. The possible payload is determined to a great extent by the quality of the road surface and the gradients to be overcome. The unladen weight of carts to be pulled by donkeys and horses should not be much more than 200 kg, the ground clearance should be at least 0.25 m and the loading area should measure a minimum of 2 m². The shafts should be 50 cm apart and project 1.40 m beyond the loading area. For singly harnessed cattle these values should be 0.65 m and 2 m.

Carts to be drawn by pairs of oxen should be able to take a payload of at least 1000 kg; the unladen weight should not be much greater than that of a donkey cart. The loading areas should measure between 2.5 and 4 m² and should not be wider than 1.50 m (CEEMAT, 1971; LE MOIGNE, 1971).

The quality of the carts varies depending on whether they were manufactured industrially or by local craftsmen. Locally manufactured carts frequently have a high unladen weight in relation to the payload, have weak bodies and are often poorly balanced (cf. CASSE et al. 1965; KLINE, 1969; CEEMAT, 1971). It may be possible to compensate for the difference in the level of qualifications by supplying the local craftsmen with industrially manufactured chassis which they simply have to complete.

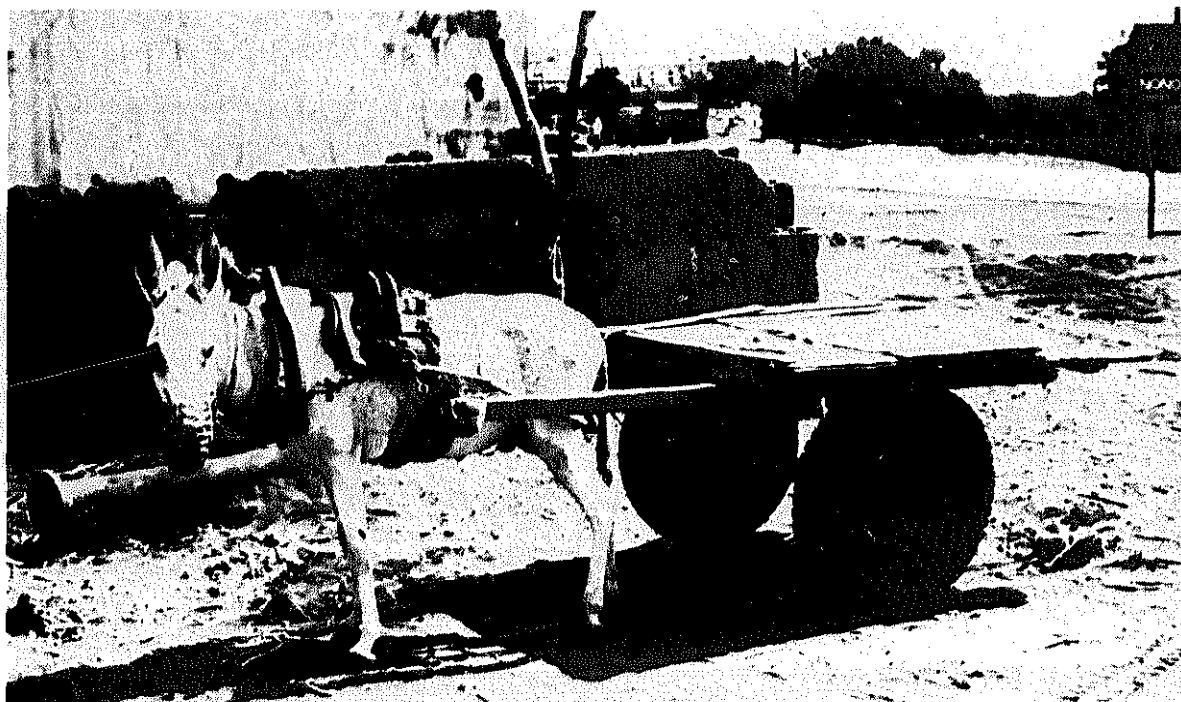


Fig. B/II/69: Two-wheeled pneumatic-tyred cart pulled via the two drawbars.
(Photo: Kütke)

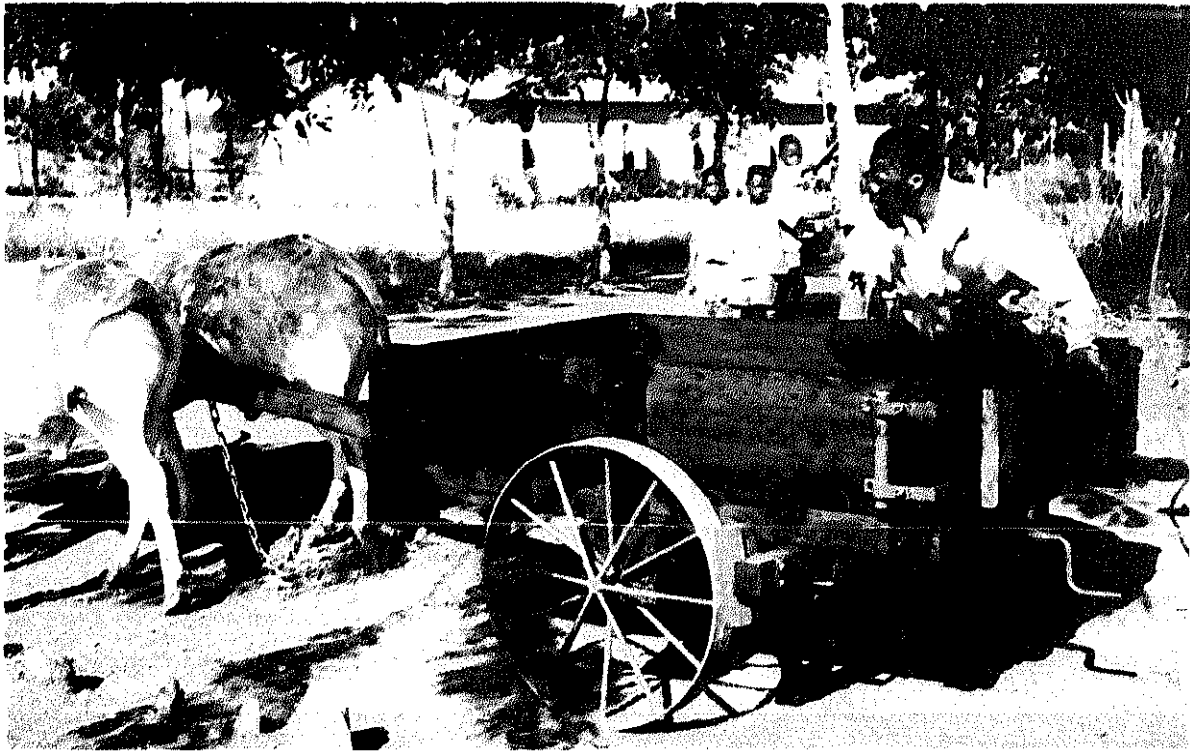


Fig. B/11/70: Two-wheeled cart with large spoked metal wheels and block brakes. The width of the loading area is limited by the wheels.
(Photo: TAMTU, Tanzania)

4.5.3 Four-wheeled farm trailers

Four-wheeled trailers to be drawn by draught animals are still a rarity in Africa but interest in them is clearly growing in some countries. The advantage of trailers over carts is that the teams of animals can use them to move larger loads which, moreover, do not need to be balanced. In hilly terrain the animals are not subjected to stress as a result of changing equilibrium as is the case with two-wheeled carts.

However, trailers are less manoeuvrable and considerably more expensive than carts and it will undoubtedly be possible to introduce them only very slowly on smallholdings in the foreseeable future.

In addition to the fifth-wheel steering (with continuous axle) which is usual in modern trailer construction and which above all improves mobility, trailers can also be fitted with Ackermann steering, which has the advantage of permitting a low loading area. The most important components can be derived from old motor vehicles.

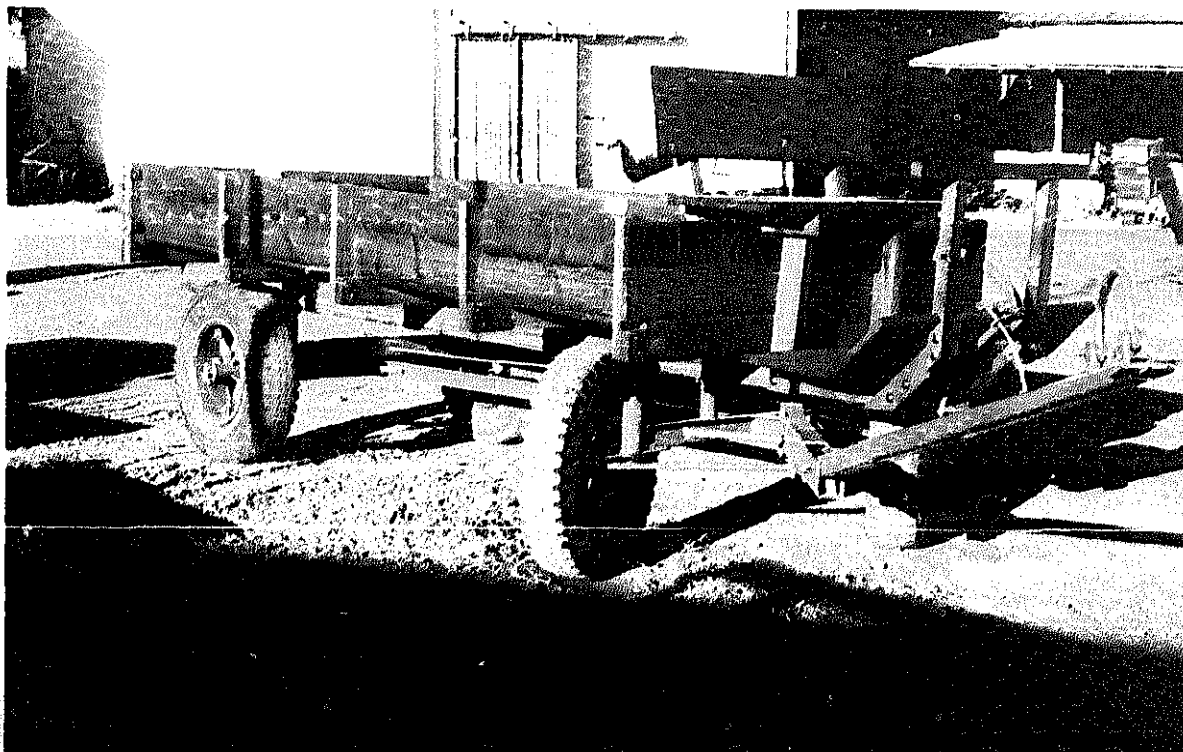


Fig. B/II/71: Four-wheeled farm trailer with Ackermann steering.
(TAMU, Tanzania)

5. Necessary tractive effort

The tractive effort required for various types of work is determined by a number of factors:

- Working width and depth of the implement.
- Type and condition of soil (e.g. moisture content).
- Condition of the fields (stones, roots, previous tillage).
- Slopes.
- Type of implement.
- "Pulling style" of the animals.

The following table gives average values for the tractive effort required for various jobs, measured in the course of tests. The figures given, which are rounded off, were recorded under widely varying conditions and give only a rough idea of the necessary tractive efforts.

Table B/II/4: Average tractive effort required for various jobs

Type of work	Implement	Tractive effort (daN = kp)
Loosening subsoil ¹⁾	Single share, 15 cm deep	210
Ploughing, 8-20cm deep ³⁾	25 cm mouldboard plough	50-150
Ploughing-in green manure, 15 cm deep ¹⁾	Mouldboard plough	70
Ploughing, 9-11 cm deep, 66 cm wide ³⁾	Ridger	100-140
Cultivating, max. 15 cm deep ³⁾	Multicultivator	
approx. 50 cm wide	with 3 tines	40-125
approx. 80 cm wide	with 5 tines	75-110
Harrowing ²⁾	1 zig-zag element	70-110
Sowing, double-row ¹⁾	Seed	
light soil	spacing	30
heavy soil	drills	40-80
Crop tending ¹⁾		
1 90 cm row	Multicultivator	70
2 60 cm rows	Polycultivator	60
2 90 cm rows	Polycultivator	80
Earthing-up ³⁾ cotton 90 cm wide, 4-5 cm deep)	Various ridgers	80-110
Groundnut lifting ¹⁾		
-upright variety, single row	Multicultivator with 20 or 35 cm sweep	40
double row	Polycultivator with 2 20cm sweeps	75
- creeping varieties, single row	Multicultivator with 50 cm sweep	80
Transport ²⁾		
Cart + 500 kg + driver	Cart	30-65

1) MONNIER, 1965

2) FAO/CEEMAT, 1972

3) MATTHEWS and PULLEN, 1975.

6. Area capacity and time requirements

The time requirement (in h/ha) is the reciprocal of the area capacity (in ha/h). The amount of time required is determined by a number of individual time components.¹⁾

1) Setting-up times for

- Getting the animals ready; fetching the animals, feeding them, harnessing them etc. may take as little as a few minutes or as much as an hour.
- Work on the implement: the amount of time for conversion and adjustment may also vary greatly depending on the farmer's training and the implement itself.

2) Travelling times will be incurred depending on the distance from the fields, gradients, condition of roads, nature of team and means of transport used.

3) Idle times: breaks, clogging up of the implements and damage will be of varying frequency and duration. They are influenced in particular by the team and the person driving it, the implement and the condition of the fields.

4) Incidental times: the frequency and duration of the turning procedure at the end of the field are of particular importance. The frequency depends on

- the working width and the distance between the rows of crops, the size and shape of the plot,
- the headland.²⁾

The time required for each turn varies according to the following factors:

- Type of team
- Skill of the person driving the team
- Type of implement
- Nature of the land on which the implement is being turned.

1) The literature studied by the author with regard to area capacities achieved with animal traction in Africa does not give any detail of the size of the individual time components and the "area capacities" given are obviously just the area-related totals of actual working time, incidental time and idle time. However, the travelling and setting-up times, which are not included, may be of considerable importance. Long travelling times, for example, may be one reason why in some cases the areas near the villages are used intensively, although suitable land is still available further away. Excessive setting-up times may be partially responsible for polycultivators being used simply as carts (as already mentioned) in some cases.

2) Headlands can be dispensed with (when ploughing so as to omit one furrow at each end of the field, which facilitates retraction) if the areas around the plot can be used for turning or if the round-and-round ploughing method is used. However, it is not a good idea to turn on land where there is thick vegetation since this takes too much time. If the plough has to be fully turned on the plot a pair of oxen will require 5-6 m.

5) Actual working time: the time required for the actual work depends on the following:

- Type of work
- Working width, distance between rows of crops
- Working depth, quality of work
- Type and condition of implement
- Nature and condition of soil
- Capacity of team

The number of manpower hours required is also governed by the number of people required to attend to the teams and implements and may be dependent on several factors:

- The animals' standard of training
- The standard of training of the person controlling the team
- The size of the team and the type of harness
- The necessary accuracy of the control of the team
- The implement

When producing work schedules it is advisable to calculate the amount of time required in team working hours per hectare.

The compilation of time requirements by RICHARD, FALL and ATTONATY, 1976 (Table B/II/5) was selected here because it not only gives different values depending on the animals and implements used and the working conditions but also takes into account the time required for manual labour, which in some cases is substantial. On account of the situation-related nature of working-time requirements these data, established in a specific area in Senegal, must be regarded only as reference values.

Table B/II/5: Average time requirements for various types of work

Operation/ crops cultivated	Manual labour		Horse and "Houe Sine" ¹⁾		Pair of oxen and "Ariana" ²⁾		Pair of oxen and polycultivator ³⁾	
	Mh/ha ⁴⁾		Mh/ha	Th/ha	Mh/ha	Th/a	Mh/ha	Th/ha
	m ⁵⁾	f ⁵⁾	m f		m f		m f	
Shallow cultivation (dry season)	-	-	15 15	15	10 10	10	16 -	8
Shallow cultivation (start of rainy season)	-	-	6 6	6	6 6	6	16 -	3
Ploughing (end of dry season)	-	-	- -	-	120 -	60	120 -	60
Ploughing (start of rainy season)	-	-	- -	-	60 -	30	60 -	3
Ploughing (end of rainy season, maize)	-	-	- -	-	80 40	40	80 40	40
Ploughing (end of rainy season, Souna) ⁶⁾	-	-	- -	-	80 80	40	80 80	40
Secondary tillage (dry season)	-	-	- -	-	8 8	8	12 -	6
Secondary tillage (start of rainy season)	-	-	- -	-	7 7	7	10 -	5
Crosswise marking (millet)	18	6	- -	-	- -	-	16 -	8
Marking (cotton)	6	-	- -	-	- -	-	- -	-
Secondary tillage (ridge-grown crops)	-	-	30 30	30	25 25	25	40 -	20
Fertilizing (dry season; 50-150-200 kg/ha)	3	2	- -	-	- -	-	- -	-
Fertilizing (NKP, start of rainy season)	2	4	- -	-	- -	-	- -	-
Applying urea	2	3	- -	-	- -	-	- -	-
Sowing groundnuts (60cm rows)	-	-	4 4	4	10 -	5	6 -	3
Sowing cotton	20	60	- -	-	- -	-	- -	-
Transplanting tobacco	45	40	- -	-	- -	-	- -	-
Sowing millet	9	9	- -	-	- -	-	- -	-
Sowing upland rice	-	-	6 6	6	12 -	6	8 -	4

/contd.

Table B/II/5 (continued)

Operation/ crops cultivated	Manual labour		Horse and "Houe Sine"		Pair of oxen and "Ariana"		Pair of oxen and polycultivator				
	Mh/ha		Mh/ha	Th/ha	Mh/ha	Th/a	Mh/ha	Th/ha			
	m	f	m	f	m	f	m	f			
Sowing, 90cm rows (sorghum, maize)	-	-	3	3	3	6	-	3	6	-	3
Harrowing di- rectly-sown groundnuts	-	-	6	6	6	6	6	6	6	-	3
Hoeing (45cm rows)	-	-	8	8	8	8	8	8	6	-	3
Hoeing (60cm rows)	-	-	6	6	6	6	6	6	6	-	3
Hoeing (90cm rows)	-	-	8	8	8	8	8	8	6	-	3
Applying herbicide (groundnuts)	3	-	-	-	-	-	-	-	-	-	-
Hand hoeing (groundnuts, sorghum)	40	40	-	-	-	-	-	-	-	-	-
Thinning, hoeing (maize)	40	40	-	-	-	-	-	-	-	-	-
Thinning, hoeing (cotton, sorghum, millet)	40	60	-	-	-	-	-	-	-	-	-
Thinning out tobacco, weeding	60	40	-	-	-	-	-	-	-	-	-
Thinning out tobacco	20	-	-	-	-	-	-	-	-	-	-
Hand hoeing (tobacco)	80	40	-	-	-	-	-	-	-	-	-
Ridging	-	-	-	-	-	8	8	8	16	-	8
Applying insecti- cide (cotton)	2	-	-	-	-	-	-	-	-	-	-
Harvesting groundnuts (lifting, placing on ricks)	-	-	38	42	12	38	42	12	40	30	7
Harvesting cotton (unploughed)	-	400	-	-	-	-	-	-	-	-	-
Harvesting cotton (ploughed)	-	600	-	-	-	-	-	-	-	-	-
Harvesting tobacco (picking, hanging up)	200	500	-	-	-	-	-	-	-	-	-

/contd.

Table B/II/5 (continued)

Operation/ crops cultivated	Manual labour		Horse and "Houe Sine"		Pair of oxen and "Ariana"		Pair of oxen and polycultivator				
	Mh/ha		Mh/ha		Th/ha		Th/a				
	m	f	m	f	m	f	m	f			
Harvesting up- land rice	160	100	-	-	-	-	-	-			
Harvesting millet, placing on ricks	40	130	+ transporting 3 tonnes								
Harvesting maize: dried on stems	45	70	+ transporting 4.5 tonnes								
for drying in sheds	45	70	+ transporting 5.2 tonnes								
bringing into sheds	-	20									
Harvesting sorghum	140	125	+ transporting 1.8-2.2 tonnes								
Harvesting sanio	80	40									
Harvesting hay on fallow land	60	40	+ transporting 2 tonnes of hay								
Collecting harvest residues e.g. straw	-	-	34	34	24	40	40	30	60	-	20
Loading and un- loading (per tonne)	-	-	12	-	3	14	-	5	14	-	5
Pulling up and burning cotton stems	80	24	+ transporting 2 tonnes of stems								
Clearing tobacco fields	40	-	-	-	-	-	-	-	-	-	-
Taking down and packing tobacco	100	150	-	-	-	-	-	-	-	-	-
Pulling up, wind- rowing and burning millet roots	-	-	35	43	24	40	50	30	30	40	20
Pulling up, wind- rowing and burning sorghum roots	-	-	35	43	24	40	50	30	30	40	20

1) Working width as cultivator 60cm, double-row sowing (45-90cm rows)

2) Working width as cultivator 90-120cm, doublerow sowing (45-90cm rows)

3) Working width as cultivator 180cm, double or triple-row sowing

4) Mh/ha = Manpower hours per hectare; Th/ha = Team working hours per hectare

5) m = male, F = female

Source: Compiled by RICHARD, FALL and ATTONATY, 1976, based on various authors
(see bibliography and country-by-country table)

7. Provision, maintenance and repair of implements

Provision, maintenance and repair of implements often present major problems wherever animal traction is used in Africa.

The reasons for this may include the following:

- No craft enterprises or industries
- Financial strength of craft enterprises and industries is low
- Inadequate tools and machines
- The poorly developed infrastructure (road system, communication, trade) creates problems in procuring raw materials and distributing products
- The market for animal-drawn implements is small and undergoing uncertain development
- The farmers have little understanding of technical matters

Provision

When animal traction is introduced the implements are initially procured by the project executing organization in many cases and then sold to the farmers. In the course of subsequent development it then becomes necessary to find or establish independent, efficient procurement and marketing organizations for implements and spare parts. In addition to local craft industries, potential assistance can be given here by governmental agencies as well as self-help organizations and projects sponsored by private or church bodies.

It is often difficult to meet the growing need for animal-drawn implements. Even in regions where the use of draught animals has long been a common feature it may become necessary to improve or reorganize the implement supply system, e.g. if previous suppliers cease to be involved.

There are various ways of meeting the need for implements and these are shown in Table B/II/6; the possibility of subjective assessment cannot be precluded.

Imports of animal-drawn implements from industrialized nations have declined. This source of equipment has been replaced by manufacturers from the developing countries who supply both their national market and those outside it (TSCHIERSCH, 1975 and Section A/3.6).

It is impossible to give a general answer to the question of whether implements should be solely imported or manufactured within the

country; the situation must be judged on the basis of conditions in the country in question.

In principle, the target should be a high degree of domestic production.

Decentralized production at local level can be aimed for if the qualification standard of the craftsmen and the available workshop equipment so permit. If these requirements are not fulfilled the more complex parts of an implement can be manufactured separately on a centralized basis in special workshops. The local craftsmen are then simply required to finish off the implement. Importing of suitable implements should only be considered if this alternative or a similar one is also ruled out. However, importing would seem to be particularly advisable if the markets to be supplied are small.

Table B/II/6: Advantages and disadvantages of various ways of meeting the need for animal-drawn implements

	Meeting of demand		Price	Flexibility/development of implements	Raw material supply	Marketing organizations	Contribution to integrated development
	Qualitative	Quantitative					
1. Importing from industrialized nations	Good	Good, large batches necessary	High	Poor, much expenditure	Not applicable	Necessary	No
2. Importing from developing nations	Good	Sometimes uncertain	Lower than for 1.	Better than for 1.	Not applicable	Necessary	No (in country doing the importing)
3. Centralized national production	Good	Good	Lower than for 1. and 2.	Good	Must be organized	Necessary	Yes
4. Decentralized local production	Less good	Uncertain, often custom production	Very low	Flexible but little innovation	Highly problematic	Not applicable	Substantial
5. Local manufacture of very simple implements (village technology)	Poor	Uncertain, often custom production	Very low	Flexible, little innovation	Not applicable	Not applicable	Doubtful

Repair and maintenance

The service life of even relatively simple animal-drawn implements is in practice often far shorter than that which could be achieved. If this state of affairs is to be changed, farmers and local craftsmen must be thoroughly trained and properly equipped so that they can repair and maintain the implements.

In the course of training and extension work the farmers should be given appropriate instruction and encouraged to

- handle the implements correctly in order to prevent unnecessary damage. The sale of implements which are new to the farmers should be accompanied by at least a brief introduction to the implement and how to use it;
- recognize damage and signs of wear which will necessitate repair, adjustment or replacement of parts. It is all too often the case that repairs are delayed until the implements have become totally unusable or can only be repaired at great expense;
- carry out the necessary maintenance, for which they must often first learn how to handle tools correctly;
- dismantle the implement after use (insofar as this is possible on the farm), clean the parts, check them and if necessary replace them and protect bolts and parts with a hardened surface against corrosion by greasing them. This guarantees that defects making it impossible to use the implement at the desired time are not discovered at the start of the next period of use or that corroded adjusting screws, for example, do not prevent correct adjustment of the implements and thereby impair the quality of the work;
- not simply leave implements which are not required lying around in the fields or in some corner of the farmyard, but to store them so that they are protected against moisture.

The reason for implements being in a poor condition may be the lack of even the simplest tools. The result of a shortage of means of transport may often also be that heavy implements are dragged along the ground and damaged during transportation.

The farmers are often incapable of performing even simple repairs and it is usually just as impossible for the supplier of the animal-drawn implements to set up an adequate marketing and repair organization as it is for government agencies to do so. It is therefore

necessary to make sure that local craftsmen can repair and service the implement.

Although there are of course regional variations, the situation as regards local rural craft industries can in general be characterized as follows:

- The craftsmen often work sitting out of doors or in low huts.
- The tool complement is often highly incomplete.
- Raw materials are often brought by the customer or have to be obtained from scrap parts (e.g. from old trucks etc.), which means that the desired quality is not always available. Many craftsmen have no stocks of materials.
- The craftsmen are unfamiliar with procedures of importance in repair and maintenance; many of them, for example, cannot sharpen ploughshares correctly.
- The craftsmen often work only to order, so that in case of need the farmer has to wait a long time for his spare part, e.g. a ploughshare.

These points clearly indicate that local craft industries are in need of strong support. The craftsmen should be placed in a position to perform a wide variety of jobs using simple aids since they cannot make a living simply by repairing and servicing animal-drawn implements.

In addition to the manufacture of simple implements (yokes, harrows, sledges, carts) and hand tools (such as wheelbarrows, hoes and knives) additional sources of income can be provided by the production of simple workmen's tools (pliers, screwdrivers, hammers) and household articles (e.g. furniture).

Moreover, the craftsmen should be able to repair and service not just animal-drawn implements but also bicycles, mopeds, pumps, locks etc.

In order to ensure that this work is carried out properly workshops must be set up and the craftsmen given appropriate training.

The craftsmen must work standing up, something which in many places is not a usual feature of traditional craft industries. The basic workshop equipment should comprise at least a smith's hearth with

water tank, a bench with a heavy-duty vice, a heavy anvil and shelves for materials and finished parts. Each craftsman additionally requires a certain amount of basic equipment including, among other things, hammers of varying weights, files, pliers and saws etc., while other tools such as blowtorches or welding equipment are required only by a few specialized craftsmen.

Some of the tools can be manufactured by the craftsmen themselves, while others must be purchased. The finances of the craftsmen are often just as inadequate for this purpose as they are for setting up the workshop and credits must therefore be made available.

Besides purely craft-based abilities the craftsmen must acquire a number of commercial skills in the areas of purchasing and selling, pricing, bookkeeping and stockkeeping.

The number of craftsmen and dealers required for selling, repairing and servicing animal-drawn implements is determined, among other factors, by the number and type of implements in the region and the skills of the craftsmen and the farmers. As a guideline, JANAUD and KELLERMANN (1967) state that one craftsman is required for every 1000 members of the population. CEEMAT (1968) maintains that a dealer should have an operating radius of 20 km; he must therefore have suitable means of transport at his disposal. Another decisive factor is the population density.



Fig. B/II/72: Complete production of animal-drawn implements from old or scrap material - as shown here in an example from Mali - calls for considerable craft skills and a basic set of forging tools. (Photo: Munzinger/near Bamako, Mali)

B/III

Crop growing and ecology

B/III FUNDAMENTAL ASPECTS OF ECOLOGY AND CROP GROWING
RELEVANT TO THE USE OF DRAUGHT ANIMALS
(K. Lippitz)

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1. Preliminary remarks

Given suitable conditions the use of animal traction in Africa may permit more intensive use of larger areas than is possible using manual labour and thus make a decisive contribution towards increasing production. In contrast to the sub-tropical arable areas of North Africa, where some of the fieldwork has always been performed with the aid of draught animals, the areas south of the Sahara have only recently experienced the introduction of animal traction, a process which has been slow and has achieved varying degrees of success. Some of the reasons for this are to be found in the unfavourable environmental conditions, the majority, however, is related to African civilization. The introduction of draught animals represents an enormous innovation. Experience has shown that it can be successful only if the crop-growing and farming systems are entirely matched to it and the technique is used in a correct and logical manner.

This section is intended to supplement the other parts of this handbook and will discuss only the framework conditions relating to ecology and crop growing which play a part in the use of draught animals in the tropics and sub-tropics, the major emphasis being focused on the use of draught oxen. Given the size and varied character of the areas under discussion, however, it is impossible to avoid a high degree of simplification; in an actual project situation it should nevertheless be possible to draw conclusions as to local conditions.

2. Ecological conditions

Even in the tropics and sub-tropics arable and crop farming are geared as far as possible to the natural environmental conditions, which are mainly characterized by climate and weather. These regions can be appropriately divided up into ecological zones on the basis of the length of the humid and arid seasons¹⁾:

1. Rain forest	0 - 2 1/2	arid months	(humid)
2. Humid savannahs	2 1/2 - 6 1/2	" "	(semi-humid)
3. Dry savannah	6 - 8 1/2	" "	(semi-arid)
4. Thornbush savannah	8 1/2 - 10	" "	(arid)
5. Semi-deserts	more than 10	" "	(arid)
6. Tropical highlands			

It is impossible to draw precise geographical boundaries between these zones, which are also certainly not uniform within themselves. Of particular importance on a local basis is the natural amount of precipitation, whether it is distributed over one or two rainy seasons and whether they occur during the warmer or cooler part of the year. Tropical and sub-tropical highlands exhibit special features on account of their exposed location and geographical latitude.

The type of ecological zone into which an area falls has a decisive influence on:

- the type of vegetation,
- the soil formation,
- the advisability of growing various field crops and
- the type of farming in the region,

and thus also influences the possibilities for keeping and using draught animals.

The crops grown in the rain forest zone are mostly perennial crops which generally require little tillage. Although good use can be made of animals for transport work, it is difficult to keep heavy livestock in these usually somewhat hot and humid areas and the efficiency of the animals is low, so that there is little chance that the practice will spread.

1) Based on: Manshard, E., 1968: Einführung in die Agrargeographie der Tropen, Bibliographisches Institut Mannheim.
Franke, G., Pätzold, H., 1978: Nutzpflanzen der Tropen und Subtropen. Band III; S. Hirzel Verlag Leipzig.

It is in the savannah regions, where the cultivation of annual crops, mostly cereals, predominates, that there are the best conditions and the greatest need for the use of draught animals.

The humid savannahs, with annual precipitation between 1200 and 1700 mm, are used intensively for arable farming. Provided that due care is taken it is certainly possible to keep heavy livestock but problems arise to varying degrees in many parts of Africa on account of the tsetse-fly.

The dry savannahs, with rainfall of between 500 and 1200 mm, have always been livestock-keeping areas and arable farming is not so widespread. Shifting cultivation is still practised where the annual rainfall is around 500 mm. About 750 mm is regarded as the limit for effective use of draught animals with conventional implements, since it is usually impossible to till the soil until the rainy season has started and the vegetation period may then easily become too short. The possibility of minimum tillage using draught animals, a topic which is undoubtedly of particular interest for these areas, is being investigated (e.g. in Botswana).

In the sub-tropics (see map, Fig. B/III/1) cereal growing is predominant only in places with precipitation exceeding 500 mm. In the drier areas with annual precipitation between 200 and 400 mm it is possible to practice so called "dry farming" with annual alternation between cultivation and tilled fallow. Draught animals are commonly kept and used in this climatic zone but there may be problems as regards regular provision of adequate feedstuffs and water.

In the tropical highlands the opportunities for using draught animals are governed by the topography, while the conditions for keeping them are good on account of the low temperatures. Animal traction has long been traditional in the Ethiopian highlands, whereas on the plateaus of East Africa it has only recently started to become more widespread.

The introduction of draught animals in the tropical and sub-tropical zones of Africa represents an extensive departure from traditional shifting cultivation and a changeover to permanent farming. This

results in widely varying conditions as regards

- preparation of the arable land (clearance etc.)
- possibilities for tillage
- maintaining of soil fertility
- cultivation techniques
- selection of crops
- guaranteeing of the fodder supply.

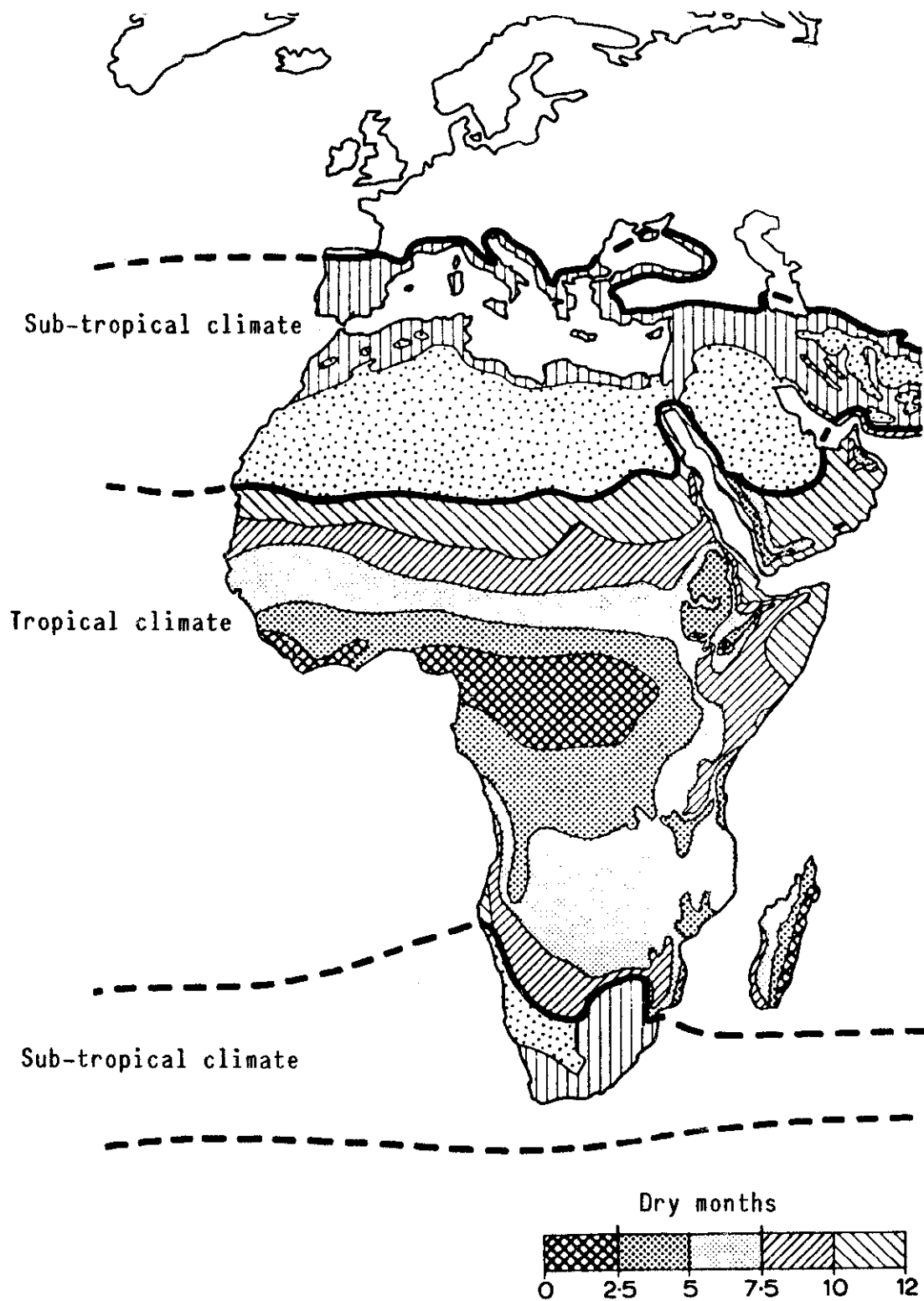


Fig. B/III/1: Map depicting the tropical and sub-tropical climatic zones of our planet (as per Walter, 1973).

3. Land clearance

In traditional shifting cultivation it is neither necessary nor desirable to strip the land of all its existing vegetation. In view of the fact that the plot will cease to be used after a few years, the tree stumps which are left will speed up the regeneration of the land by putting out shoots again. The only implements used for clearance are bush knives, axes and hoes and with this simple equipment complete clearance, including removal of tree stumps, would involve too much work. It is therefore only the undergrowth and smaller trees which are removed, while large trees are killed by means of so called "ringing" (removing pieces of bark of a specific width) and in some cases subsequently felled, usually leaving tall stumps in the field. These cause no problems if the land is tilled in the conventional manner using a hoe. The wood is burned in order to dispose of it; the ash fertilizes the soil to a certain extent provided that it remains in the ground and is not washed away by the first rain. Rapid and complete incineration also helps to create a seedbed that is free of weeds.

In savannahs where there are few trees the grass and bushes are treated in the same manner, the advantage of this type of clearance being that the topsoil, which has a high humus content, is scarcely disturbed.

If it is planned to use draught animals, however, the land must be stripped of all its original vegetation so that trouble-free ploughing is guaranteed. The vegetation below the surface must therefore also be removed.

Useful aids in this work are hand-operated winches with steel cables for felling the trees with simultaneous removal of the root balls. The winch is anchored to a neighbouring tree and the steel cable secured some way up on the tree to be felled; it is advisable to remove the undergrowth beforehand. Very wet soil is a help, since if the ground is dry the trees will easily snap and the stumps must then be removed by hand. Trees with a diameter of up to 20 cm, together with their larger roots, can be removed without difficulty. However, this equipment cannot be used for thicker trunks and it is therefore probably best to employ it primarily for clearing secondary bush.

Only limited use can be made of draught animals in land clearance work, for example for assisting in the removal of tree stumps, collecting the wood to form rows or piles (for subsequent burning) and taking away timber. Fully mechanized clearance using special heavy-

duty equipment is preferable if large areas are to be opened up. The disadvantage of fully mechanized clearance is the disturbance of the soil which it causes, i.e. possible structural changes and compaction, shifting of the topsoil with corresponding exposure of the infertile subsoil etc. This may cause considerable problems for subsequent tillage using oxen; however, if the work is performed carefully and at the right time it should be possible to avoid such damage to a large extent.

4. Soil tillage

The purpose of every type of tillage is to create and maintain optimum growth conditions for the crops. Three main tasks must be accomplished:

- Loosening the soil
- Working in organic substances
- Suppressing weeds

In comparison to manual labour, the use of animal-drawn implements not only permits more intense tillage but also improves the area capacity. Factors which may hinder or prevent the use of these implements include

- excessively shallow soils,
- excessively stoney soils,
- poorly cleared land,
- heavily weed-infested soils and
- very heavy soils

on which the animals' tractive effort is insufficient (this can be countered to a limited extent by making shallower furrows or increasing the number of animals). The desired result of the tillage can only be achieved if the implements used and the time at which the work is performed are geared to the soil and weather conditions as well as to the needs of the crop to be grown. Every form of tillage, from preparation of the field onwards, will have an effect on all the subsequent steps (including the possibilities for using various implements) right up until the harvest. The number of operations must be kept as small as possible in order to avoid damaging the soil. The varying ecological conditions in the different climatic zones are of course also of importance as far as tillage is concerned.

4.1 Forms of tillage

Primary tillage is usually performed with the plough in order to loosen and simultaneously aerate the soil. This guarantees that precipitation can be better absorbed and improves the conditions for development of the plants' roots.

In North Africa and Ethiopia the primitive hook plough is still widespread, a "universal implement" for primary tillage, seedbed preparation and making furrows and channels for sowing, drainage and irrigation (see also Fig. A/3). The hook plough breaks up the soil in coarse clods and plant residues are not worked in completely, an advantage in areas where there is a risk of erosion. Preparation of a seedbed necessitates working a field - usually crosswise - 4 or 5 times, sometimes more. Organic fertilizer is applied - if at all - after initial ploughing so that it becomes mixed with the soil during subsequent working. The seed is broadcast and then worked in during the last ploughing operation; the depth of the grains in the soil varies greatly and sprouting is therefore also very uneven. Another disadvantage is that in damp soil the growth of root-propagated weeds is promoted.

The mouldboard plough (illustrations in Section B/II; for method of operation see Fig. B/III/5) loosens the soil to a greater extent and simultaneously turns it, so that more of the soil is exposed to the elements. Through the choice of various types of share and mouldboard the work can be geared to the various types of soil so that the ground is turned over more or less completely. The mouldboard plough is a typical tillage implement in areas with a cool and humid climate, making it less suitable for the arid tropics and only partially suitable for more humid regions.

A field tilled using the mouldboard plough has no protection against erosion by wind and water. The considerable aeration and warming of the soil accelerates the decomposition of organic substances and a large amount of water is lost through evaporation. In damp, heavy soils there is the risk of plough pan formation and large, heavy clods may develop which require intensive subsequent working.

In the humid tropics the use of the mouldboard plough can be justified by the necessity of weed control and the opportunity for deeper tillage. Used in conjunction with other measures it can help to increase yields, provided that the additional organic substance produced remains in the ground and counteracts humus decomposition.

The land is tilled either by ploughing to create beds or by tilling the entire field on one level. The beds may be 20 - 30 m wide, or substantially narrower on the heavy soils if the furrows must occasionally absorb surplus water. The disadvantage of narrow beds is that the finished furrows are fairly infertile. If the beds are too wide time is wasted pulling the plough from one furrow to the next on the headland, which runs at right-angles to the beds. A field must therefore be divided up so that the furrows are as long as possible, there are as few finished furrows as possible and not too much time is wasted turning on the headland. The headland at each end of the field is ploughed last.

In bed ploughing (Fig. B/III/2) the start of ploughing is followed by gathering of furrows A and B and casting of C. During the subsequent crop season furrow C is gathered and A and B cast.

The furrow is opened and finished as shown in Fig. B/III/3.

Level tillage - round-and-round or figure ploughing - is suitable only for larger areas (Fig. B/III/4). This involves ploughing parallel to the field boundaries, working from the outside to the inside or vice versa, the starting points alternating from year to year. Level ploughing is achieved by using the one-way plough which, however, is heavier than a normal plough (see Section B/II).

The possible depth of tillage is highly dependent on the weather-related condition of the soil and on the animals' tractive effort. It is also determined to a certain extent by the depth of the topsoil. It is usually inadvisable to suddenly increase the depth of the topsoil layer substantially - supposing that the soil permits this - since this procedure requires quite a lot of work and causes too much dead soil, i.e. soil which is lifeless and contains little humus, to be mixed with the topsoil all at once, thereby reducing the quality of the latter.

A furrow with a depth of 15 cm - measured in the furrow on the still solid ground - is regarded as a shallow ploughing and sowing furrow, while around 20 cm is considered to be standard and up to 25 cm designated as deep. Deep ploughing down to 25 cm or more is usually impossible with draught animals.

If it appears necessary to increase the topsoil layer it must be done gradually according to the loam or clay content of the soil. A deep topsoil layer is generally favourable, since the ground can then absorb more moisture, the crops suffer less as a result of dryness or dampness and their roots can develop more strongly and down

to a greater depth. In order to maintain a healthy topsoil layer it is advisable to plough at various depths for different crops.

The width of the furrow is limited by the width of the ploughshare. It must not exceed the width of the share because otherwise part of the soil will not be loosened. On heavy, cohesive soils a narrower setting can be used for the single-share plough to ensure better crumbling of the soil.

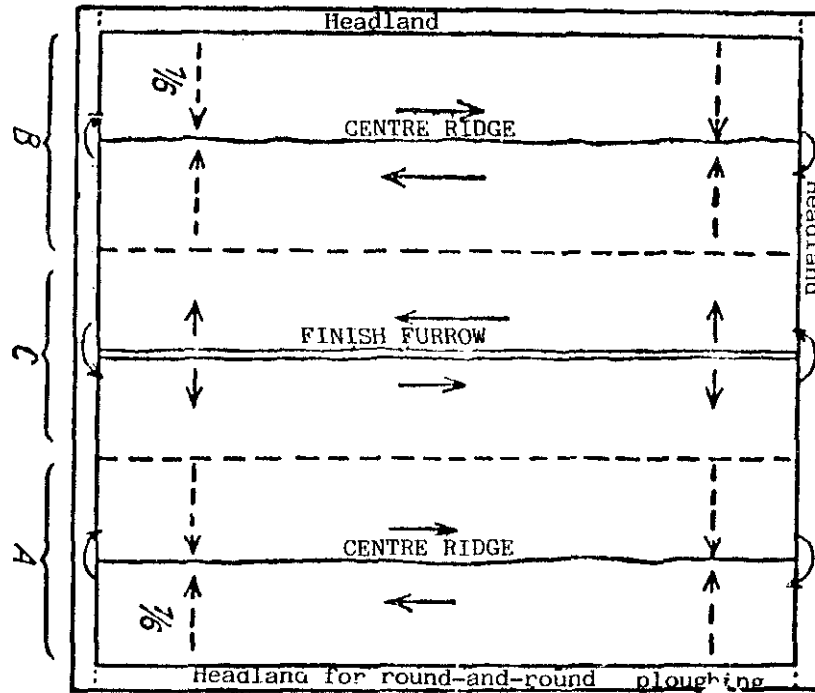
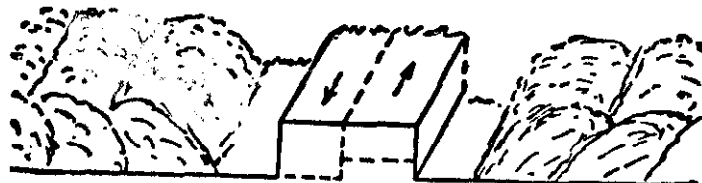


Fig. B/III/2: Division of a field for bed ploughing. The plough moves in the direction of the solid arrows. (Source: DIECKMANN)



Schematic representation: opening up



Schematic representation: finishing

Fig. B/III/3: (Source: DIECKMANN)

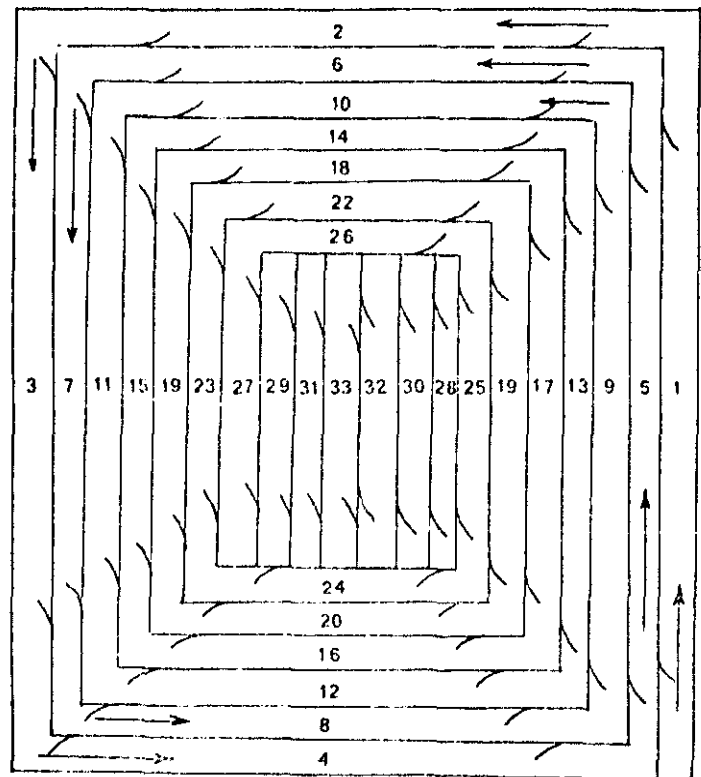


Fig. B/III/4:
 Round-and-round
 ploughing of a field
 (Source: CEEMAT, 1968)



Fig. B/III/5: Method of operation of a mouldboard plough. (Photo: Wessolowski)

The ridger is often used for primary tillage in Africa because it meets the needs of traditional cultivation on ridges. There are two common systems: existing ridges are divided using the ridger and built up again over the old furrow, thereby covering the weeds with earth and destroying them. The same is done when the ridges are reworked after heavy rainfall or if the crops have to be earthed. A cultivator tooth or spring tines can be fitted between the mouldboards in order to simultaneously aerate the soil to a considerable depth between the rows. For plant husbandry a multi-purpose implement fitted with appropriate ridger bodies is substantially more efficient. In view of the fact that ridgers are rarely adjustable they have the disadvantage that they fix a specific distance between the rows (often around 90 cm), which is too great for some crops.

In some parts of West Africa ridges which have already been created are not divided but simply reworked before planting, probably because this requires less tractive effort and is easier to do. Reworking is also repeated several times during the growth period.

Cultivators are often used on their own to prepare the fields, particularly in West Africa; their area capacity is greater than that of the plough but the depth of tillage is smaller. As with the hook plough the soil is loosened without being turned over and plant residues remain on or near the surface, thereby providing the necessary protection against erosion. The aeration of the soil and thus the humus decomposition may, however, be greater. The cultivator is highly suitable for tearing up a rough furrow, destroying weeds, aerating soil which has become muddy after heavy rainfall and working-in stubble.

The disc harrow can also be used for similar purposes, for basic tillage and for reworking up to the seedbed preparation stage. It is particularly suitable for shallow working-in of long, elastic plant remnants as well as stubble and fertilizer, mixing them thoroughly with the soil and simultaneously levelling the surface. On account of the slow working speed and the relatively low weight of the implement the field must usually be covered several times when an animal-drawn disc harrow is used. In addition to this disadvantage the spread of root-propagated weeds is also encouraged and the surface of the soil may become too fine if tillage is too intensive, which can lead to mud formation and erosion. A fairly large tractive

effort is required so that only relatively narrow implements can be drawn by a team of animals (Fig. B/II/37).

More suitable for use with draught animals is the harrow when it is used for levelling the ploughed field, weed control, seedbed preparation and working-in of mineral fertilizers and seed. As is the case for all field work, the soil must not be too moist, while if it is too dry the harrow will jump and will not be particularly effective.

It is advisable to harrow at an angle to the ploughed furrows (Fig. B/III/6), although in narrow fields it is also possible to work parallel to the furrows. When preparing a seedbed it is often necessary to harrow a second time, the path traced this time intersecting perpendicularly or at an angle with the first one. The harrow is still not very common in Africa, although use of it facilitates the mechanization of the subsequent operations. Levelling of the surface beforehand is essential above all if seed drills are to be used. Excessively frequent and intensive harrowing, however, should be avoided, since the soil structure is thereby destroyed and the excessively fine soil exposed to the risk of erosion.

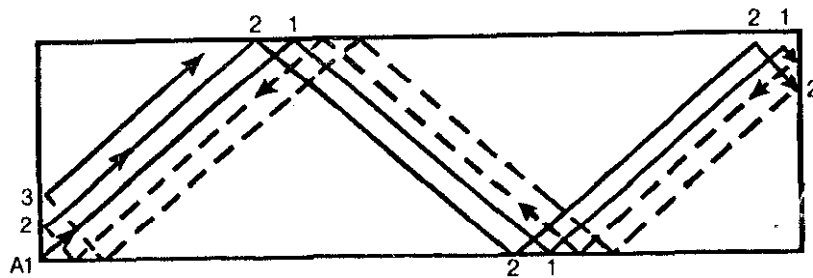


Fig. B/III/6: Crossover harrowing (starting at A1, the broken lines represent the return path). (Source: DIECKMANN)

The soil can also be levelled and crumbled using a simple scrubber, which simultaneously destroys weeds which have already sprouted. The condition of the soil is even more important here than in the case of the harrow; soil which is too damp will become very sticky. On the other hand, the topsoil may be pulverized so that it becomes too fine, thereby also increasing the risk of erosion.

For plant husbandry after sowing - harrowing in the case of cereals, hoeing or ridging for other crops - the tillage depth should be as small as possible in order not to interfere with the development of the roots or encourage erosion.

4.2 Soil tillage in the semi-humid tropics¹⁾

In this climatic zone precipitation occurs in the form of one short and one long rainy season during the warmer part of the year. The large quantities of rain and the high temperatures cause tilled soils to degenerate quickly. The aeration accelerates the decomposition of the humus and the soil can easily acidify, whereby the pH values drop to 4-5.

Heavy, shallow soils are widespread; if well aerated they dry out to a very great extent and are then subject to erosion. Permanent use of these soils is difficult and can only be successful if the pH value is increased and humus added. The soil should if possible always be covered with plants or harvest residues.

It is maintained that tillage should be reduced to a minimum in these areas in order to counteract the degeneration of the soil. However, it is almost impossible to dispense with tillage which turns over the soil in view of the fact that with the high temperatures heavy and rapid growth of weeds starts with the first rainfall. It is preferable, but usually impossible in view of the fact that the soils dry out and harden to a great extent, to perform tillage during the dry season, when there are fewer weeds and it is thus easy to suppress them. This simultaneously permits early sowing, so that the yield potential of the crops can be fully exploited and the field is rapidly covered over.

The time available for proper tillage is very short, particularly on the heavier soils which have a strong tendency to dry out and easily become sticky when damp. A considerable impact force is required, which is undoubtedly one reason why 2-3 teams of oxen are often used to pull a plough in Tanzania and Madagascar.

During the vegetation period it may sometimes be difficult to perform crop-tending work at the right time on account of the large amounts of rain, particularly if the breaks in the rain are not long enough and the fields cannot dry out so that teams of animals can walk on them and the implements used can operate properly.

1) Tillage in the humid tropics will not be discussed in view of the fact that this is of little relevance as far as the keeping of draught animals is concerned.

4.3 Soil tillage in the semi-arid and arid tropics

The water balance in these climatic zones is generally negative. Depending on the geographical latitude, the precipitation will fall during one or two rainy seasons, resulting in humid conditions for brief periods. The precipitation often takes the form of severe thunderstorms with large quantities of rain falling within a short time. The impact of this heavy rain destroys the crumb structure, particularly in the case of uncovered soil, and the surface becomes muddy and compacted. The soil is then no longer able to absorb the large amounts of rain and the water flows off on the surface, frequently resulting in erosion damage.

The main function of tillage in this case is to loosen the soil to as great a depth as possible in order to ensure that it can absorb and store the moisture required by the crops during the breaks in the rainfall. Plant residues should only be mulched-in to a small depth below the surface since they give the soil mechanical stability, reduce the impact of the rain and slow down surface runoff.

Methods of tillage which turn the soil should be used with caution and only very occasionally, since plant residues can easily be worked-in too far and this will destroy their protective effect. Turning the soil also aerates it to a considerable extent, a process which accelerates the decomposition of organic substances and can lead to water losses.

It is therefore better simply to loosen the soil so that it forms large clods. This also minimizes the area open to erosion by the wind, a major factor in dry areas, for if the soil is loosened too much the valuable fine earth particles can be easily blown away and the water retention capacity and fertility of the soil permanently damaged.

In order to permit sowing as early as possible the land should be ploughed before the start of the rainy season - if this is feasible - even if difficult soil conditions mean that the desired depth of tillage is impossible. It has been proved that yields decrease progressively the longer the period allowed to elapse between the onset of the rain and sowing. If sowing takes place early the ground is soon covered with vegetation to the extent that the effect of the rain is mitigated and the growth of weeds partially suppressed.

Some soils, however, become so hard during the dry season that it is difficult or totally impossible to till them using an ox-drawn plough. In some cases - probably more often than is absolutely necessary - tillage is therefore not started until after the onset of the rain, to be precise, when the soil has been moistened down to a depth of around 15 cm. This results in the loss of time and moisture which are valuable for the development of the crops, particularly in areas with a short rainy season and a fairly small amount of precipitation.

In a few parts of Africa at least some of the fields are ploughed at the end of the rainy season directly after the harvest when the moisture content of the soil is still adequate. One advantage of this is that the ground can thus properly absorb the first rainfall during the subsequent cultivation period, facilitating early sowing. Weeds are fairly well suppressed but weed control among the crops must be started earlier than is the case if ploughing takes place directly before or at the beginning of the rainy season.

Problems may arise if the ploughed land becomes muddy as a result of late, heavy showers or if it is exposed unprotected to the sun and wind throughout a long dry season.

The time available for permitting proper tillage of the soil is usually very short and the farmers are faced with organizational problems. At the end of the rainy season ploughing after the harvest of early-ripening crops or fallowing may be in competition with the harvest work, while at the beginning of the subsequent rainy season the same jobs compete with sowing in the previously prepared fields. One answer to this problem can be found by varying the intensity of the tillage for the various crops, i.e. using only a cultivator to till some of the land.

After sowing repeated shallow tillage is necessary until the stands close up in order to loosen the soil, which has been compacted by the heavy rainfall, and make it able to absorb subsequent precipitation. Evaporation losses are simultaneously reduced and the young crops can therefore easily survive breaks in the rain. This tillage also helps to control the weeds, the growth of which is promoted by the high temperatures and abundant moisture. If animal-drawn implements are used for this crop-tending work the plants must be grown in rows.

4.4 Soil tillage in the sub-tropics

In these areas, some of which are already classified as arid, the rainfall occurs only during the cool part of the year and is less intensive and less abundant than in the tropics. The lower tempera-

tures mean that there is less evaporation but water is nevertheless often one factor restricting successful crop growing.

Here too, tillage should aim to loosen the soil to a considerable extent so that it can absorb the precipitation and in order to do this a coarse-crumbed surface must be created, preferably before or at the start of the winter rains. The soil should not be turned over too much, since this will lead to water losses. Tillage can be relatively shallow, because the less heavy rainfall means that the soil is not usually moistened down to a very great depth. Heavy soils which dry out to a great extent or become sticky when damp are difficult to till because the most suitable period for performing this work is often limited.

Tillage at the end of the rainy season encourages erosion by the wind during the dry season and the soil should therefore remain covered with harvest residues.

The dry farming practised in parts of these regions involves repeated coarse tillage of the soil during a periodic fallow season; this not only improves water storage and reduces evaporation but also combats water-consuming weeds.

4.5 Soil tillage in irrigated farming

In irrigated farming all soil tillage measures must be considered in conjunction with the optimization of rational water use, i.e. the crops must be supplied with water at the correct time and in adequate quantities.

Primary tillage aims to create a deep, loose topsoil layer in order to guarantee a high water absorption capacity. This can be backed up by working humus or green manure into the soil. Following deep tillage the water can quickly penetrate the soil, the surface of which then rapidly dries out, so that subsequent work can be performed sooner. In the course of this work the nutrients and clay minerals washed into the soil as a result of irrigation are brought to the surface again; a mouldboard plough is highly suitable for doing this. However, the formation of compacted layers must be avoided, since otherwise the internal drainage of the soil is not maintained and the development of the crops can be hindered as a result of waterlogging or salination.

In order to ensure even water distribution with surface irrigation attention must be paid to guaranteeing level tillage as early as

the ploughing stage and creating a slight slope when the plots are levelled. Only in this way can rational use be made of the water, i.e. there is no excess in small depressions or a shortage on elevations.

Primary tillage should not be performed until just before cultivation since in a warm climate and a very moist soil mineralization and humus decomposition are very rapid processes and leaching losses are also likely. It is important that the soil should be tilled while it has the right degree of moisture, since it is almost impossible to correct mistakes.

After every application of water a loose layer of soil must be created as soon as possible by means of shallow tillage in order to reduce evaporation. This eliminates crusts which form as a result of the ground becoming muddy or through the introduction of suspended matter. In soils with a high clay content this surface tillage must under no circumstances be carried out too early in order to prevent the soil from becoming sticky, something which would result in damage to its structure.

The choice of implements for loosening the soil is governed by the type of soil, the crop, the cultivation methods, the age of the crops and the tractive effort of the animals (see also Section B/II). In the case of plants with many leaves tillage can be dispensed with altogether so that the plants form a solid block and the leaves can provide protection against evaporation.

Special tillage measures in irrigated farming for which animal-drawn implements can be used to good effect are the following:

- Creation of ridges parallel to the direction of water movement (to form the side limits of strips and basins or to distribute the water as evenly as possible).
- Ridging of furrows parallel to the direction of water movement in furrow irrigation.

The tillage of flooded swamp rice fields occupies something of a special position. Primary tillage must aerate the soil for a brief period but also maintain its structure as far as possible. The soil can either be turned or simply loosened using the cultivator or disc harrow.

An important feature is careful levelling of the fields during seed-bed preparation. The target should be a fine-grained surface with a slight slope in order to guarantee even distribution and economical consumption of water. In permeable soils the subsoil should preferably be compacted to some extent at a depth of around 15 cm. If this does not occur in the course of normal tillage special implements must be employed separately for this purpose (see Section B/II).

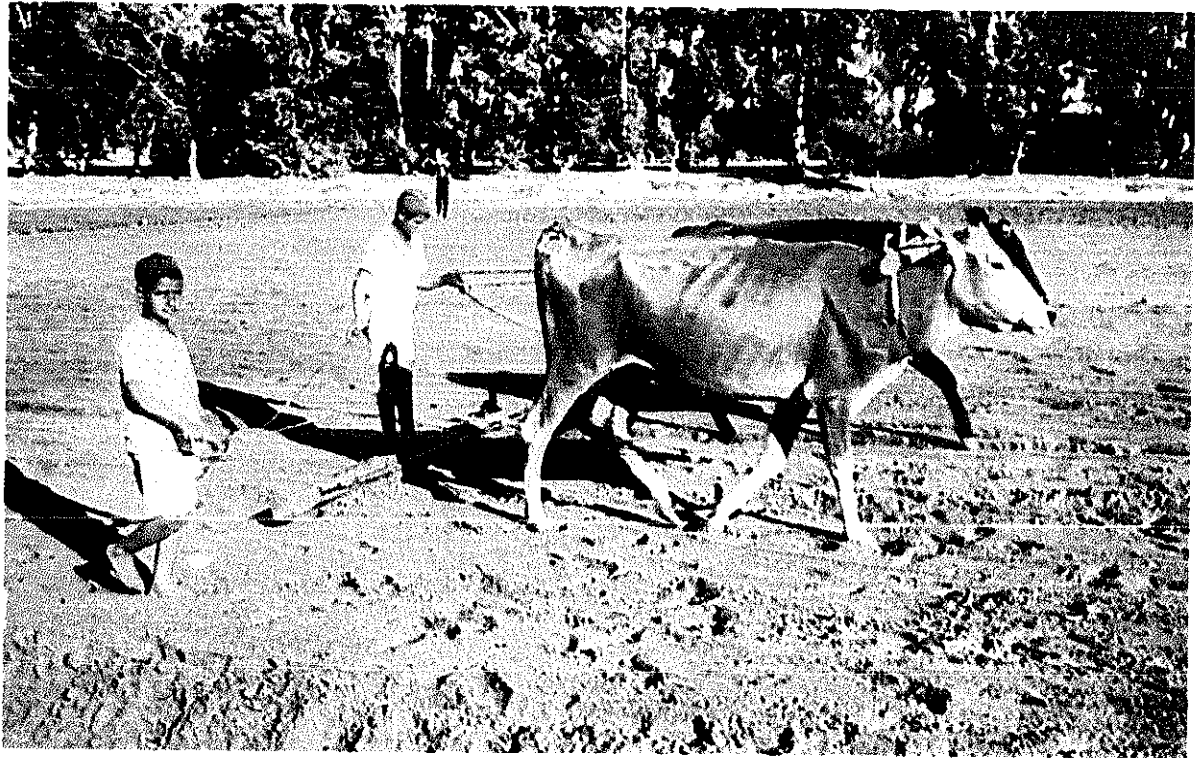


Fig. B/III/7: Levelling irrigated fields in Egypt using simple implements and draught cows. (Photo: GTZ Archives)



Fig. B/III/8: The use of draught animals in irrigated farming in Madagascar has a long tradition and the techniques used for harnessing the animals have already been developed to a fairly advanced stage. (Photo: Esche)

5. Soil erosion and soil conservation

5.1 Soil erosion by wind and water

Soil erosion is the shifting of parts of the topsoil layer or of the soil as a whole by wind or water. These processes take place continuously even under natural conditions but may be accelerated by inappropriate cultivation and in particular by incorrect use of tillage implements.

In both the humid and arid tropics there is a serious risk of erosion, usually as a result of the high intensity and unfavourable distribution of the precipitation.

In sandy soils heavy thunder showers can cause more than 200 tonnes of soil per hectare to be thrown up and moved downhill. In heavy soils with a high clay or silt content the raindrops hit the ground with a heavy impact and destroy the soil aggregates, which dissolve and are washed away by the water.

The potential extent of the erosion is determined by the inclination and length of the area concerned. An incline of only 1-2% can result in the removal of fine soil particles with a high nutrient content. On straight slopes the entire surface is often affected to an equal degree by sheet erosion, while on an irregular surface gullies will form.

Erosion losses always affect the topsoil layer with its high nutrient content and result in decreased soil fertility. Once erosion has reached an advanced stage it is usually difficult to recultivate the more or less exposed subsoil. Further use of the land may be impossible if the layers exposed are already hardened or if they become hard when they come into contact with the air.

Apart from direct soil losses, damage is also caused by deposition at the foot of the slope, where existing crops or arable land may be covered so heavily that further use of the affected land is out of the question, particularly if the material deposited is extremely coarse.

Wind erosion damage occurs in arid and semi-arid regions with high wind speeds. The minimum speed required to cause soil drifting is given as 15-16 km/h, measured at a height of 30 cm.

Depending on the particle size, the displacement may take the form of suspension, surface creep or saltation. The wind can displace the entire mass of soil or erode it on a selective basis, whereby the particles determining the soil's fertility are affected first.

The main cause of this process is the removal of the protective vegetation cover. In addition to direct soil losses, damage can also

be caused to crops by dust and sand storms as well as by drifting and dune formation on cultivated land.

5.2 Soil conservation

Good farming land is so valuable, even in the tropics and sub-tropics, that it should not be allowed to fall victim to erosion by wind or water. Erosion often occurs in densely populated areas, where it is accelerated by unsuitable permanent land use and continuous cultivation of one staple crop. The way in which the land is used must be geared to the natural conditions so as to preclude the risk of erosion altogether.

Very steep slopes (gradients of over 30°) are unsuitable for agriculture and must be left as woodland; they can be used at best as permanent pasture.

Less steep slopes (20-30°) can - depending on the amount of precipitation - be planted with permanent crops (e.g. cocoa) which form a dense "roof" of foliage and thus protect the ground against the direct effect of the rain.

Less severe slopes (10-20°) permit the growth of more open tree crops (such as coffee or citrus fruits) in combination with ground-covering low-level crops.

Gentle slopes (5-10°) can be ploughed, provided that the soil conditions are suitable, but this must be done along the contour lines.

In order to combat erosion or counteract the risk of its occurrence it is essential to collect data on the factors involved and represent them in map form. These factors include soil structure and erodibility, slope inclination, type of slope, precipitation, distribution of heavy rainfall, vegetation, type of land use, crop rotation and extent of existing erosion. Data collection and soil conservation measures must cover the entire water catchment area if they are to be truly successful. A wide variety of measures can be implemented, either separately or in combination with one another, in order to restrict the movement of wind or water and thus prevent unintentional displacement of the soil.

5.2.1 Soil conservation measures in arable farming

Soils which have been recently tilled and exposed unprotected to the rain and wind are particularly subject to erosion. The best way of preventing erosion is therefore to keep the ground permanently covered with vegetation as is achieved almost totally with tended pastureland or woodland. Arable land should also if possible be kept permanently covered with plants or plant remnants, i.e. erosion pre-

vention must be considered during all phases of cultivation. Some of the erosion prevention measures listed below can be considerably simplified or facilitated through the use of draught animals:

a) Ploughing along the contour lines or at least perpendicular to the slope

If tilled at all, the soil should always be turned over against the line of the slope. This method of tillage alone can reduce water runoff by around 70% and soil erosion by some 50%.

b) Creation of a rough ground surface

Surface runoff is slowed down and the water can seep into the ground. Freshly ploughed or loosened ground temporarily contains a large number of cavities; however, with the sudden onset of heavy rain a finer surface quickly becomes muddy and the loose soil is removed by the water as it flows away. The risk is not so great once the soil has settled again. The soil improvement achieved through tillage usually helps to inhibit erosion on its own, since soil which has been loosened down to a greater depth absorbs and retains more water and permits more vigorous root growth. A rough surface also decreases the wind speed, is therefore less subject to erosion and catches fine soil particles carried off by the wind.

c) Addition of farmyard dung or green manure

Generally improves the soil structure.

d) Creation of a mulch layer

Only some of the harvest residues are worked in to a small depth or organic material is spread on the surface. The ground does not have to be completely covered. The impact of the raindrops is mitigated, the ground prevented from becoming muddy and surface runoff slowed down, while at the same time a certain degree of protection against evaporation is provided. The decomposition of the material improves the soil's humus content and thus the water retention capacity and soil structure. Application of a mulch layer, however, requires a considerable amount of work.

e) Cultivation on ridges along the contour lines

f) Creation of compartment furrows

Suitable implements drawn by draught animals have already proved successful. The furrows are divided up by cross-walls at intervals of approx. 1.5 m and these prevent water runoff. Considerable increases in yield are achieved by storing the water in the compartment furrows, mainly in areas where there is only one rainy season; however, the erosion-inhibiting effect of the furrows has also brought success in damper regions. An advantage is that these furrows do not have to follow the contour lines exactly.

g) Sowing and planting along the contour lines

The crops should be as close together as possible and at the same time regularly spaced so that no large gaps which could be eroded by wind and water are produced.

h) Selection of crops to be cultivated

The crops themselves constitute an effective means of protection, depending on their ability to cover the ground and develop strong roots, provided that there is sufficient moisture and the ground can remain under a permanent vegetation cover, which is somewhat problematic in the case of annual crops. The opportunities for mixed cultivation, which is widespread in traditional African farming systems, should not be disregarded, since various plants, grown simultaneously or in succession, complement one another in their protective effect.

i) Creation of strips

These can take the form of "contour strips", following the contour lines, or "field strips" which simply follow the general line of the gradient if there are only small changes in the terrain. Their width is determined by the gradient, the soil, the frequency of heavy rain and the protective effect of the crops grown. The greater the incline, the narrower the strips must be; the normal width is between 20 and 50 m. Given good local conditions, a low degree of erodibility, favourable distribution of the precipitation and infrequent heavy rain, however, they can be extended to 80-100 m.

If erosion by the wind is likely the strips must be perpendicular to the main wind direction, irrespective of the incline, so as to reduce the wind speed. The width of the strips is then governed by the type of soil. On sandy soils it is advisable to keep to narrow strips between 6 and 8 m wide. The heavier the soil, the wider the strips can be; on silty/clayey loam they can be up to 130 m wide.

j) Creation of permanent grass strips

Natural or planted grass strips between the crops are necessary on soils which are at great risk from erosion. The strips are seldom wider than 1-3 m, but if necessary can also consist simply of one row of plants. Water flowing off on the surface penetrates the strips and, if these are closely planted and well tended, most of the eroded soil is retained. Gradual formation of terraces may result. Suitable plants for providing this type of protection are elephant grass (*Pennisetum purpureum*), *Vetiveria zizanioides*, *Cymbopogon* sp. and *Panicum maximum*, as well as other plants such as agaves, *Sanseveria*, bamboo, *Tephrosia*, *Crotalaria* and many others. If the incline is relatively steep and irregular the width of such protective strips inevitably varies, since tillage using animal-drawn implements is facilitated if the cultivated strips of field following the contour lines are of an even width. The protective strips can at the same time also help to provide food for the draught animals, which is of major importance in areas where there is a shortage of land.

k) Creation of windbreak hedges

Plants which provide protection against the wind are necessary mainly in dry areas, but it is difficult to maintain them without additional irrigation. Such means of protection not only inhibit the drifting of soil particles but also have a favourable effect on the climate in the vicinity of the ground as well as on the water and thermal balances. On the windward side the hedge can protect an area extending for a distance corresponding to roughly two to five times the height of the hedge, while on the leeward side the protection will cover an area extending over roughly ten to twenty times the height. Hedges comprising several rows or a combination of bushes and fast-growing fairly tall trees provide the best protection but must allow the wind to pass through them, since otherwise damage will be caused to the crops by strong eddies. The amount of shadow falling on the crops can be reduced to the unavoidable minimum through appropriate selection of plants to form the hedges. A certain amount of competition between the roots is inevitable.

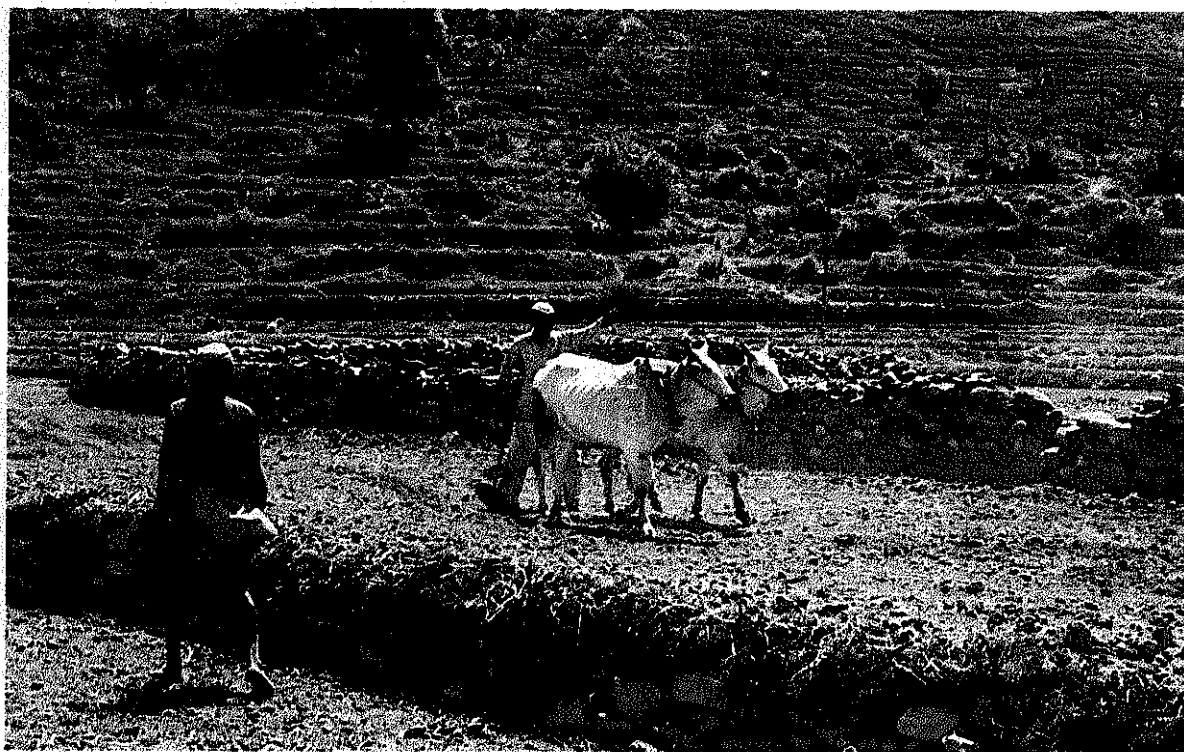


Fig. B/III/9: A wide variety of materials can be used for constructing walls to prevent erosion. These walls often simultaneously form the field boundaries.

Terraces like those which can be seen in the background are usually the result of centuries of efforts to preserve the soil and require continuous care and attention.

(Photo: GTZ Archives)

5.2.2 Soil conservation measures by terracing

The oldest method used to prevent erosion is undoubtedly the creation of terraces perpendicular to the slope along the contour lines. This divides long slopes into numerous smaller ones with the result that water running off on the surface cannot attain the high speed it requires to erode the soil. The width of the terraces depends on the gradient and the type of soil. It is possible to use steep slopes (up to approx. 40%) but it is difficult to till narrow terraces when using draught animals. The terraces must have a certain minimum width, which is determined by the size of the animals and implements used.

The creation of terraces always means that a certain amount of land is lost, since terraced slopes can be used to only a limited extent or not at all. If no masonry is constructed the terraces are stabilized by planting them with grasses which in turn can be used as fodder.

The construction of terraces usually entails the creation of a system of ditches so that surplus water can be drained off without risk. Some of these ditches are often planted with grasses which can be put to good use.

The road construction necessary in conjunction with the use of draught animals may have an effect on erosion. Badly constructed roads often cause the water to be channelled into one stream, the increased force of which then results in incipient cracks or removal of lime.

6. Cultivation techniques

6.1 Cultivation on a level surface or on ridges

Most annual (i.e. seasonal) tropical crops are grown in soil which has been loosened down to a small depth, this being favourable for tillage, sowing, tending and harvesting using animal-drawn implements. Even levelling guarantees that the successive jobs can be performed without difficulty.

Root crops are generally grown on hills or ridges; under certain conditions this method can also be applied to other crops.

It is possible to create ridges using animal-drawn implements - the ridgers or multi-purpose implements - and this method has proved

highly successful. Problems arise when it comes to mechanizing sowing on the ridges and the use of harvesting machinery may also be difficult.

Under certain conditions the use of ridges has a number of advantages:

- The roots of the plants can spread out more easily in the loosened and fairly large root area.

As has been established in the dry regions of Botswana, the roots of cereal crops scarcely extend below the tillage depth into the subsoil, even if the depth is a small one of only 10 cm.

- Harvesting is made easier if animal-drawn lifting implements (e.g. for groundnuts) are used.
- In soils which drain badly, where excess water may accumulate at times, the risk of damage to the plants as a result of waterlogging is reduced.

In some parts of West Africa where there is a short but intensive rainy season all the crops - mainly cereals, since the vegetation period is too short for tubers - are grown on ridges to protect them against an excess of water.

- Better use of precipitation

If ridges are created along the contour lines the rain-water is retained and can seep into the soil, which means that it is available to the crops for longer.

- Effective weed control

In some parts of Tanzania and Malawi the ridges are divided before the cultivation season and built up again over the furrow, whereby harvest residues, grass and weeds are worked into the soil. This intensive soil-turning tillage, which can be performed with the ridger, results in effective weed control and achieves a certain green-manuring effect.

The success of ridge-based cultivation is dependent upon a number of factors: soil, topography, quantity and distribution of precipitation, crops grown and planting or sowing time. If, for example, sowing is followed by a lengthy dry period there is a risk that the soil will dry out on account of the sizeable surface on the ridges and this impairs the germination and sprouting of the crops. On flat land, on the other hand, this is not so marked. If the soil becomes extremely moist after sowing germination may be better than in a flat field as a result of the drainage effect of the ridges.

6.2 Mixed cropping and single cropping

In traditional African cultivation systems mixed cropping is practised for almost all field crops; sometimes one field will contain

more than five different and irregularly distributed crops. Under the given climatic and economic conditions the system has a number of advantages:

- Sowing spread over a lengthy period, resulting in reduction of peak labour times:

The various crops are seldom all sown simultaneously, but rather at varying intervals depending on the plants' requirements. In areas with a short but abundant rainy season the next crops are often sown or planted among the old ones weeks before the harvest (relay cropping) in order to utilize the remaining moisture in the soil.

- Improved utilization of moisture and nutrients:

Plants with different requirements in terms of moisture and nutrients grow side by side and their varying absorption capacities result in better utilization of nutrients. (Soya, for example, has roots which reach down further than those of maize and can therefore take up nutrients which would be lost through leaching if maize were grown on its own).

- Erosion prevention and maintaining of soil fertility:

The more or less even distribution of different crops corresponds roughly to natural vegetation cover and thus provides effective protection against erosion.

The prevention of erosion and the mixed cultivation of legumes with other crops makes it possible to use a field for many years without any form of crop rotation.

The disadvantages of mixed cropping are:

- Relatively low yields
- Weed control difficult if animal-drawn implements are used
- Harvest losses

On account of the differing ripening times of the crops harvesting can be performed only gradually and extends over several weeks. Although there are consequently no extreme peak labour periods during the harvest repeated harvesting of the fields by hand often results in heavy losses.

In traditional agriculture, however, mixed cropping is an important means of reducing risks, since even in the event of unfavourable weather conditions, particularly irregular rainfall distribution, it is seldom the case that all the crops fail totally.

Single crops are easier to cultivate using draught animals than mixed crops, provided that they are grown in rows and the correct distance between the rows is observed. The disadvantages of this system - greater risk of erosion and poorer utilization of nutrients - can be offset to some extent by establishing a specific form of rotation for the various crops.

In order to continue to utilize the advantages of mixed cropping numerous attempts are being made in Africa to adapt the system for mechanization. "Organized mixed cropping" entails growing the crops in rows with a suitable number of plants per field. There are several possible methods:

- Various crops in the same row
- Alternating rows of different crops
- Alternating strips each comprising a few rows of different crops

Mechanized sowing is only partially possible in this case since sowing must take place at several different times. Tending the crops is also difficult on account of the varying development of the plants and the changed row spacing if the strip system is used. In order to mechanize hoeing at least in part the individual rows must be geared to the available implements when sowing is performed.

Mechanical harvesting of such crops is almost impossible.

6.3 Suitability of crops

If draught animals are used they should preferably be employed for all field work. Attention must therefore be paid to ensuring that the crops are suitable for this mechanization level, above all in order to guarantee that work can proceed smoothly.

All cereals and pulse crops can easily be broadcast or sown in rows using machines. Local varieties often grow very quickly if the weather conditions are good and become very tall. This may mean that only limited use can be made of animal-drawn hoes for weed control and subsequent weed infestation may occur which can only be eliminated using hand hoes. The long halms of these varieties hamper mechanical harvesting and suitable varieties must therefore be selected.

Creeping plants in an advanced stage of growth cause problems during crop-tending work, since it is almost impossible to prevent the draught animals and implements from damaging the crops. Mechanical harvesting of such varieties is usually out of the question. (Creeping beans and the creeping groundnuts sometimes found in Africa, for example, would have to be replaced by upright, bushy varieties).

Among tuber crops cassava (*Manihot esculenta*), taro (*Colocasia esculenta*), cocoyam (*Xanthosoma* ssp.), sweet potatoes (*Ipomoea batatas*) and Irish potatoes (*Solanum tuberosum*) have been successfully cultivated using draught oxen. In the case of yams (*Dioscorea* ssp.), how-

ever, it is almost impossible to use animal-drawn implements to tend the crops, since the plants have a strong tendency to climb and are usually secured to supports.

6.4 Weed control

Poor weed control is often the main cause of low yields. In the tropics, weeds develop exceptionally vigorously and compete with the crops for nutrients, water and light. In rain-fed farming their growth is usually promoted by:

- Insufficient soil preparation:

Many soils cannot be ploughed during the dry season and are then rapidly tilled at the start of the rainy season without the necessary care. The desire to make full use of the available moisture means that there is no time to work the fields again, particularly to combat the weeds before sowing. Ploughing after the harvest is frequently impossible due to a lack of time.

- Insufficient crop density:

When sowing by hand African farmers tend to space out their crops too much. If it is not the use of low-grade seed which leads to poor field cover, other possible reasons may be shortage of seed and the experience that infection is reduced with lower plant densities. The individual plants - particularly in the case of cotton, maize, groundnuts and various types of vegetables - exhibit vigorous growth and give the impression that the stands are densely packed. However, the gaps between the plants offer excellent conditions for the growth of weeds.

- Weed control carried out too late:

In view of the fact that tillage is often performed too late and sowing extends over a lengthy period it is impossible to start weed control early on; initial weeding may then be combined with singling.

Some crops such as maize, cotton and groundnuts are highly susceptible to weed infestation and it is generally important that young crops should be kept free of weeds, since later weeding cannot compensate for the inhibition of growth while the plants are young. Yields in the tropics can be increased by 100% if weed control is carried out in good time. Opinions on the detrimental effect of late weed infestation vary, but its effect is at any rate not so severe.

Using draught animals it should be possible to carry out all the field work on time, particularly the essential repeated weed control, and this fact alone makes it possible to achieve substantial increases in yield. A prerequisite for successful mechanical weed control is careful preparation of the soil before sowing, otherwise

the weeds have a substantial head start over the crops and may over-run them.

Soon after the crops have sprouted harrows can be used to tear up the weeds or at least disrupt their growth process.

Among cereal crops where the seed has been broadcast this is the only possible means of mechanized weed control, since the harrow is not restricted to a specific operating direction. However, it can only be used while the plants are not too tall.

Repeated hoeing is usually necessary, at least until the stands close up and the weeds are choked. Mechanical hoes should till the soil between the rows to a depth of only 2-3cm. This ensures that the roots of the weeds are caught, for simply cutting off the weeds on the surface, which is what happens if the soil is too dry, has no lasting effect and is more likely to help the weeds to propagate because with many types of weeds the roots and pieces which have been cut off will sprout again once it has rained. Loosening the topmost layer of the soil helps the rainwater to penetrate and promotes the growth of the crop roots.

The crops must be sown in rows with a fixed interval between the rows if subsequent weed control using various mechanical hoes is to be possible.

From the point of view of the work involved it would undoubtedly be a good idea to have the same distance between the rows for all crops. The distance would then be determined by the plant requiring the greatest amount of space and it would then be impossible to achieve the optimum density in the case of other crops. This situation can be remedied to a certain extent by creating double rows.

Excessively deep or frequent hoeing causes a drop in yield. The aeration of the soil accelerates the decomposition of the organic substances too much, thereby destroying the soil structure and leading in the long term to a loss of fertility. Loosening the soil too much will also encourage erosion by water. Surface tillage helps to save water by destroying the soil capillaries but excessive tillage will lead to erosion by the wind in dry areas.

Effective weed suppression can be achieved by ridging, either by reworking existing ridges or earthing the plants during the vegetation period. In this way the weeds are partially uprooted or covered with earth; the work often fails to be totally satisfactory, particu-



Fig. B/III/19: Sowing or planting in rows is essential in order to permit the use of draught animals in weed control as shown here with a ridger. The enormous reduction in the burden of work which can be achieved in this way led in West Africa, for example, to expansion of the areas used for cultivating groundnuts on smallholdings. (Photo: GTZ Archives)

larly if the rigid implement body does not throw up enough soil onto the ridges. Ridging work is more of a strain on the draught animals than harrowing or hoeing.

In order to prevent damage to the soil weed control must be performed at the right time, around 2 days after it has rained, once the ground has dried out sufficiently and the weeds are germinating. Problems are encountered with heavy soils which dry out only slowly; these must often be tilled when too wet and this can easily result in compaction of the soil.

Mechanical hoes can cover only the ground between the rows and the weeds in the rows themselves must be removed using hand hoes.

In the case of swamp rice direct sowing can be followed shortly after germination by weed control under water using a scrubber. The procedure is repeated about 4 weeks later with the harrow, whereby the rice is simultaneously thinned out. Animal-drawn implements can only be used later on if the rice is sown or planted in rows. Planted rice has a considerable head start over the weeds in terms of develop-

ment, but the latter must nevertheless be combatted relatively quickly. If the rice is carefully transplanted in square groups animal-drawn implements can be used to work in two directions, thereby avoiding a considerable amount of manual labour.

7. Maintaining of soil fertility

The majority of farmers in the tropics are aware of the importance of soil conservation and maintaining the fertility of the soil, and every farming system originating in such areas in actual fact contains appropriate special measures for this purpose. Such measures are often geared to shifting cultivation and result to some extent in lengthening of the period for which the land is used; they cannot be automatically integrated into a system involving permanent land use.

In traditional agriculture the increasing weed infestation which accompanies a longer period of cultivation and the growing pressure imposed by infection resulting from pests and diseases also make it necessary to change fields; the relatively rapid drop in yield, however, is a widespread feature of tropical soils. It is true that there are exceptional cases where land has been used for 10 years with no decrease in the yield, but yields sometimes drop considerably, in some cases by more than 50%, as early as the second year of cultivation. The reasons for this are as follows:

a) Increased humus decomposition as a result of tillage

In loosened and well aerated soil the organic substances will decompose rapidly provided that the ground is sufficiently moist. The plants' nutrient supply is improved since the entire nitrogen reserves and a large proportion of the phosphorus are contained in the organic components of the soil.

b) Damage to the soil structure

In tilled soils the increased humus decomposition and the direct effect of the weather will cause the soil structure to disintegrate. The porosity and thus the soil's root-bearing capacity are substantially impaired.

c) Nutrient losses through leaching

A large proportion of the nitrogen released at the start of the rainy season is washed into the subsoil by the heavy rainfall and is usually lost for plant nutrition.

In most tropical soils it is difficult for the farmers to maintain the fertility of the soil if they engage in permanent cultivation

of annual field crops using the rain-fed system. Appropriate measures in the areas of arable and crop farming are necessary, e.g.:

- a) Avoidance of erosion damage (see Item 5)
- b) Careful tillage (see Item 4)
- c) Observance of a specific crop rotation

A balanced system of crop rotation will at least slow down the rate at which the land is exhausted. An important part is played here by the varying preceding-crop values of the individual crops. Regular rotation of various types of crops in one field also has a considerable phytosanitary effect, since it prevents the development of specific pest populations and one-sided weed infestation which is difficult to combat. The form taken by the crop rotation is largely governed by the type of soil; in many cases field-specific crop rotations are to be recommended.

- d) Inclusion of fallow periods

In traditional African agriculture fallowing was previously the only available means of restoring soil fertility after a period of use of any length. In the humid forest regions the original fertility can be restored by means of correspondingly long fallow periods accompanied by reafforestation. The trees bring back to the surface nutrients from deeper layers in the soil and have a favourable effect on the physical condition of the ground. In drier areas land which has been abandoned first becomes covered with grass, followed subsequently by only a few bushes and trees. The fallow periods must therefore be extremely long if complete regeneration of the land is to be achieved.

Under a permanent-cultivation system the fallow period is usually reduced to 1-3 years and takes the form more of an element in the crop rotation. It certainly helps to regenerate the soil to a certain extent, but more important are the possibilities offered for fodder production or green manuring. Natural or sown grass has no greater effect on the regeneration of the soil structure than a cereal crop but does maintain the tillage horizon, since there is a close interrelationship between tillage and root/plant growth. The preceding-crop effect, like the fodder value, is improved if a mixture of grass and legumes or legumes alone are grown on the fallow land.

In the dry areas of the sub-tropics the fallow period preceding the cultivation year is being increasingly used to grow grain legumes (such as Cicer, Lens and Pisum) which not only require little water but also enrich the soil with nitrogen and choke the weeds.

- e) Addition of organic substances

Plants to be used for green manuring must be sown close together, for the intention is to produce a maximum amount of organic substance but only a thin stem which rots easily. Although working in the vegetable matter cannot produce a lasting rise in the humus level in tropical soils, it undoubtedly does have a beneficial effect. Green manure must be ploughed in at the end of the rainy season to prevent losses as a result of its drying out. The contact between the soil and the vegetable matter produces a porous structure with stable aggregates. The development of this struc-

ture and thus the maintaining of the tilled soil profile are directly dependent on the amount of matter added (little effect can be detected if less than 10 tonnes/hectare of dry matter are applied). The improvement in structure resulting from green manuring is retained for several years and disintegrates only slowly.

The application of farmyard dung is equally conducive to the maintaining of the soil structure. The quality of the dung varies greatly depending on the conditions under which the animals are kept and the way in which the dung is stored. It should be kept under a protective roof, since the direct action of sun, wind and rain inevitably leads to nutrient losses. The nutrient contents of the dry matter vary between around 1% and 2.2% for N, between 0.5% and 1.3% for P₂O₅ and between 2.3% and 5.5% for K₂O. The moisture content is also dependent upon the type of storage and exhibits wide variation, ranging between 24% and 70%.

Numerous experiments in the tropics have demonstrated that good yields can be achieved with most annual crops given appropriate application of farmyard dung and that the fertility of the soil can be maintained for a lengthy period if an appropriate crop rotation system is also used. The necessary quantities of dung and the intervals at which it should be applied vary depending on climate, soil, crops and quality of dung. Experience gained to date, however, indicates that it is unimportant whether small quantities are applied each year or correspondingly larger quantities every few years, since it has frequently been observed that a single large application has an amazingly long aftereffect.

Well rotted farmyard dung should if possible be spread and ploughed in shortly before sowing so that it is thoroughly mixed with the soil. Earlier application during the dry season can lead to nutrient losses if the dung is not worked in properly. Farmyard dung containing a large amount of straw can impair crop development as a result of bacterial nitrogen fixation and should therefore preferably be ploughed in at the end of the rainy season.

Dung is still of minor importance in Africa since the animals are seldom kept indoors. If the animals are kept in stalls at night with 2-3 kg of litter 3.3 tonnes of dung per animal per year can be expected, the figure rising to 10 tonnes if the animals remain in the stalls all day.

If the animals are not kept in stalls they can instead be kept in pens at night. In order to provide 50 tonnes of manure per hectare 16m² must be produced in the pens per animal per month, which during the dry season covers only a comparatively small area. Fairly large areas, however, are manured in this way with smaller quantities in the stock-breeding areas of Senegal, Madagascar and Ethiopia. Nutrient losses occur in view of the fact that the penned-in areas are exposed to the weather for long periods.

It is better to collect the dung and combine it with other organic material to produce compost. The nutrient contents are usually lower than those of farmyard dung (0.93% N, 0.52% P₂O₅) and vary depending on the basic materials used. Although compost-making involves a considerable amount of work it has the advantage that material which has already partially decomposed can be added to

the soil at an appropriate time, thereby ensuring that the nutrients are released sooner and directly aiding the growth of the plants.

f) Mineral fertilizing

The use of mineral fertilizer to replace the nutrients which have been removed or lost through leaching is one of the most important measures for long-term maintaining of fertility and increasing the productivity of tropical soils. It is uncertain whether mineral fertilizer alone can maintain productivity over a lengthy period or whether addition of a certain amount of organic fertilizer is necessary in order to maintain the soil structure.

Fertilizing has often had little effect even in places with a nutrient shortage because the water supply was inadequate or severe leaching losses occurred as a result of heavy rainfall after application.

The amount of fertilizer required depends on the amount of nutrients removed by the crops grown and on the growth conditions created by the soil, climatic influences and cultivation. It is really only possible to determine the necessary amount by means of field trials on the spot; the results of soil and crop analyses, which can be obtained more quickly, can provide valuable hints as to the soil's fertilizer requirements.

8. Pasture farming and fodder growing

8.1 Use and improvement of natural pasture

Today, draught animals derive their fodder almost exclusively from natural pasture and direct use is made of grasses, herbs and the leaves and fruits of bushes and trees.

One advantage of natural pastureland is that its plant community is optimally geared to the local ecological conditions, while one disadvantage is that the amount of fodder produced varies greatly depending on the time of year. At the end of the dry season it is usually impossible for the animals to obtain sufficient fodder from the land within easy reach of the settlements. In order to assess a natural pasture it is necessary both to carry out a botanical "inventory" and to be familiar with the local ecological conditions. The composition and capacity of natural pastures vary exceptionally widely depending on soil conditions, amount of rainfall and type of use.

In the humid savannahs yields vary between extremes of 1 and 20 tonnes of dry matter per hectare¹⁾; a standard figure is between 3

1) See Section B/I/3 for more precise definition.

and 8 tonnes. Each draught animal requires on average around 3 hectares of pasture, the figures ranging between 1 and 8 hectares depending on local conditions.

The yield level of the natural pastureland in the dry savannahs is still lower, with an average of 1.4 - 2.3 tonnes of dry matter per hectare on a yearly average, around 1 - 1.5 tonnes/hectare being produced during the rainy season and 0.4 - 0.8 tonnes/hectare during the dry season; only in depressions and on fresh soils has it been possible to achieve higher yields of up to 7.4 tonnes of dry matter per hectare. The amount of grazing area required per animal varies accordingly from around 2 hectares during the rainy season to at least 4 hectares during the dry season, whereby the availability of fodder during the latter period is the more decisive criterion.

Optimum use of natural pastureland is possible only if the stocking of the pasture is geared to the varying vegetation. This calls for effective checks which are facilitated by fencing. For reasons of cost, therefore, an advisable system is common grazing - near the village - of the draught animals owned by several different people or by the village community.

Overgrazing leads to the suppression or even the destruction of palatable and valuable plants and to excessive spreading of the undesirable vegetation which the animals will not eat. The aim of systematic pasture management must be to restrict this detrimental selective effect and to develop and maintain the growth of plants which are beneficial as far as both pasture utilization and soil conservation are concerned. The target must be to achieve a balance between plant growth and plant utilization by means of suitable grazings so that - depending on the vegetation conditions - only around 40 to 60% of the pasture plants of value for a particular location are eaten. This ensures that perennial grasses are able to survive and annual varieties are able to reach ripeness. Flexible pasture management is imperative, particularly in areas where the amount of precipitation varies and the growth of the fodder plants is accordingly irregular. Even the use of simple pasture rotation systems will have a certain influence on the vegetation and will reduce the growth of undesirable plants. This effect could be reinforced by means of regular mowing, but this has so far been uncommon in Africa.

The fact that it is difficult to maintain a balance between growth and utilization means that it is often impossible in the long term to prevent the spread of unwanted plants (which may even turn the area into bushland). Controlled use of fire is regarded as one of the most important and inexpensive means of combatting this growth.

In very dry areas, however, fire tends to accelerate the process and too frequent burning also has a detrimental effect on the sward.

If the sward is damaged as a result of overgrazing or radical bush control the only way of quickly creating a productive pasture is direct sowing of grasses and legumes. Elephant grass (*Pennisetum purpureum*) and *Stylosanthes gracilis* from the legume family are particularly suitable. Although legumes yield only half as much fodder substance as grasses they have a higher fodder value during most stages of their development and are more easily digestible. However, it is difficult to obtain good-quality seed in Africa. The germination capacity of grass seeds is often low and in the tropics many grasses are propagated by planting cuttings.

The productivity of pastureland can be substantially improved by applying fertilizer. Nitrogen and phosphorus are the main nutrients of which there may be a deficiency, particularly in dry regions. In the final analysis, however, it is economic aspects which determine whether fertilizer should be applied to pastureland or not.

8.2 Use of harvest residues

Plant remnants which are not suitable for human consumption (or sale), such as straw, stems and leaves and industrial wastes (presscake), are important in feeding draught animals during the dry season when little fodder is available.

The straw from all types of cereals is regarded as low-quality fodder and in some cases it could be better used as mulch. However, in view of the fact that the free grazing rights usually existing mean that it is nevertheless eaten by roaming livestock it is better to collect it so that it can be put to controlled use as fodder or litter.

The stems and leaves of legumes, on the other hand, provide valuable fodder. Groundnut foliage is comparable to lucerne hay and will even dry properly under conditions unfavourable for haymaking using other plants. Only small leaf losses are incurred during harvesting and drying.

Similar valuable fodder is provided by the foliage of the cow-pea (*Vigna sinensis*). It must, however, be stored in an airy place as it can otherwise be easily spoiled by mould formation.

It is not a good idea to recover the foliage of the soya bean, since such heavy leaf losses occur during threshing that only a relatively small amount of roughage is produced, the value of which is, moreover, lower than that of maize straw.

Processing-industry residues provide valuable fodder concentrate in the form of presscake (e.g. from sunflowers, groundnuts and cotton)

which is usually only readily available in the immediate vicinity of the processing plants.

The waste from other tropical crops such as sweet potatoes, sugar cane, bananas and citrus fruits should preferably be used in a direct form as livestock fodder.

The quantity of harvest residues produced depends on the productivity of the location, and processing and recovery of them frequently involves a considerable amount of labour. They must be stored in a dry, airy place to ensure that the value of the fodder is maintained. Careful use of such fodder reserves can help to ensure that the animals are adequately fed at the end of the dry season so that they can cope with the subsequent heavy field work.



Fig. B/III/11: Transporting groundnut straw in Ghana.
Harvest residues often form an important fodder basis for keeping draught animals. (Photo: Wessolowski)

8.3 Fodder-crop growing

African farmers have to date attached little - if any - importance to fodder crops since priority is given to the production of subsistence and market crops. There is therefore a certain aversion to selective fodder production, because it is often difficult to draw a dividing line, e.g. between cereals and fodder crops.

Fodder crops grown under an intensive system not only provide high-quality fodder but also permit an optimum crop rotation and improved use of fallow. The majority of plants suitable for use as fodder are grasses (including the usual cereal varieties).

Grasses should be planted or sown in a well-prepared seedbed containing as few weeds as possible and should preferably form rows in order to facilitate weed control while the plants are young. The optimum gap between the plants varies depending on type of plant, soil and climatic conditions, irrigation possibilities and cultivation system. Apart from weed control no inter-row tillage is necessary; deep tillage will damage the plants and reduce the yields.

Tropical grasses must be cut several times since young grass tends to constitute the best fodder. However, the intervals between the individual cutting times must be determined on the basis of the amount of growth and the quality of the fodder since a sufficient quantity must also be harvested. It is impossible to fix set intervals because the growth capacity of the various grasses differs and is subject to substantial fluctuation depending on the quantity and distribution of the precipitation. Cutting the plants down too frequently will weaken them and may even kill them off, and will in any case reduce the yield. Depending on the type of crop and time of year, experience has shown that the cutting interval is between six and ten weeks. Many varieties must not be cut too short, a point which must be particularly borne in mind if harvesting is mechanized.

Given favourable cultivation conditions and adequate fertilizing tropical grasses will produce exceptionally high yields. Nutrients should be supplied on the basis of the same considerations as for other crops, but grasses can make better use of substantially larger quantities of mineral fertilizer (particularly nitrogen).

Legumes are normally higher-grade fodder than grasses but produce smaller yields. When grown on their own they can yield valuable green fodder or hay but are only suitable for silage making if they are grown together with grasses. It is, however, somewhat difficult to find suitable combinations since the tall grasses easily cover the legumes and thus hinder their growth. In Australia white clover (*Trifolium repens*), for example, has been successfully grown with Kikuyu grass (*Pennisetum clandestinum*), and Rhodes grass (*Chloris gayana*) with lucerne (*Medicago sativa*) or Phaseolus beans. In general, however, adequately fertilized grasses will produce higher yields, in terms of protein content as well.

TABLE B/III/1: GRASSES FOR IMPROVING NATURAL PASTURE AND FOR FODDER-CROP GROWING

NAME	LATIN NAME	MAIN USE	PROPAGATION	BEST HEIGHT FOR CUTTING (CM)	SPECIAL FEATURES/REQUIREMENTS
BAHIA GRASS	PASPALUM NOTATUM	NATURAL PASTURE	SEED, RHIZOMES	5	PERENNIAL; AGGRESSIVE, DAMP SOILS NOT SUITABLE FOR CROP ROTATION; NO MIXED CULTIVATION WITH LEGUMES
BERMUDA GRASS	CYNODON DACTYLON	NATURAL PASTURE	SEED	SHORT	PERENNIAL; NO WEEDS ON PLOUGHED LAND
BUFFALO GRASS	CENCHRUS CILIARIS	NATURAL PASTURE, GREEN FODDER, SILAGE, HAY	SEED	5-10	PERENNIAL; HIGHLY DROUGHT-RESISTANT, 300 MM AND MORE
ELEPHANT GRASS	PENNISETUM PURPUREUM	NATURAL PASTURE, GREEN FODDER, SILAGE	PLANT DIVISION, CUTTINGS	8-30	PERENNIAL; 1000 MM RAIN; DEEP, MEDIUM-HEAVY SOILS
GUATEMALA GRASS	TRIPSACUM LAXUM	GREEN FODDER	PLANT DIVISION, CUTTINGS	10-15	PERENNIAL; LITTLE DROUGHT RESISTANCE, HUMID CLIMATE, SHORT DRY SEASON; RESISTANT TO CUTTING
GUINEA GRASS	PANICUM MAXIMUM	PASTURE, HAY	SEED, CUTTINGS	8-10	PERENNIAL; 1000 MM RAIN, NO FLOODING; LIGHT TO MEDIUM-HEAVY SOILS; MIXED CULTIVATION
KIKUYU GRASS	PENNISETUM CLANDESTINUM	PASTURE	CUTTINGS		PERENNIAL; 1000 MM RAIN; UPLANDS 1500-3000 M ABOVE SEA LEVEL; FERTILE SOILS; NOT AS PART OF CROP ROTATION
PARA GRASS	BRACHIARIA MUTICA	PASTURE	CUTTINGS	1-7	PERENNIAL; HUMID CONDITIONS
PANGOLA GRASS	DIGITARIA DECUMBENS	PASTURE	CUTTINGS		PERENNIAL; DROUGHT-RESISTANT, 500-900MM, NOT TO BE GROWN WITH LEGUMES; SUITABLE CROP FOR ROTATION
RHODES GRASS	CHLORIS GAYANA	NATURAL PASTURE, HAY	SEED		PERENNIAL; RELATIVELY DROUGHT-RESISTANT, 600MM; RELATIVELY SALT-TOLERANT; HEAVY SOILS; SUITABLE FOR CROP ROTATION
SUDAN GRASS	SORGHUM SUDANENSE	PASTURE, HAY	SEED	8-15	ANNUAL; DRY REGIONS
TEFF	ERAGROSTIS TEFF	HAY	SEED		ANNUAL; SHORT VEGETATION PERIOD

TABLE B/III/2: LEGUMES FOR IMPROVING NATURAL PASTURE AND FOR FODDER-CROP GROWING

NAME	LATIN NAME	MAIN USE	PROPAGATION	SPECIAL FEATURES/REQUIREMENTS
COW PEA	VIGNA UGUICULATA (VIGNA SINENSIS)	GREEN FODDER, HAY, PASTURE	SEED	ANNUAL; SEMI-HUMID CONDITIONS; MIXED CULTIVATION WITH MAIZE OR SORGHUM FOR SILAGE
EGYPTIAN CLOVER	TRIFOLIUM ALEXANDRINUM	GREEN FODDER	SEED	ANNUAL; COOL PART OF YEAR; IRRIGATION; HEAVY SOILS
KUDZU	PUERARIA SP.	PASTURE, HAY, SILAGE	"CROWNS"	PERENNIAL; 1200-1500MM RAIN; SHORT DRY SEASON; SLOW DEVELOPMENT WHEN YOUNG; MIXED CULTIVATION WITH GRASSES
LABLAB	LABLAB PURPUREUS (DOLICHOS LABLAB)	GREEN FODDER, PASTURE	SEED	PERENNIAL; HUMID/WARM CONDITIONS; RAPID DEVELOPMENT
LUCERNE	MEDICAGO SATIVA	HAY	SEED	ANNUAL; AREA OVER 500MM ABOVE SEA LEVEL
PHASEOLUS BEAN	PHASEOLUS LATHYROIDES	PASTURE, HAY	SEED	ANNUAL; 600-2000MM RAIN; MIXED CULTIVATION WITH GRASSES
PTIDEON PEA	CAJANUS CAJAN	GREEN FODDER, HAY	SEED	PERENNIAL; RELATIVELY DROUGHT-RESISTANT, 600-800MM
STYLO	STYLOSANTHES GUANENSIS	NATURAL PASTURE	SEED	PERENNIAL; RELATIVELY DROUGHT-RESISTANT; 600-2500MM; USUALLY IN MIXED CULTIVATION WITH GRASSES
TOWNSVILLE LUCERNE	STYLOSANTHES HUMILIS	NATURAL PASTURE	SEED	ANNUAL; 600MM RAIN; AREAS WITH SUMMER RAINS
VELVET BEAN	MUCUNA PRURIENS (STIZOLOBIUM PRURIENS)	GREEN FODDER	SEED	ANNUAL; SEMI-HUMID TO SEMI-ARID CONDITIONS; OFTEN IN MIXED CULTIVATION WITH GRASSES

B/IV

Micro- and macroeconomic aspects

B/IV ECONOMIC ASPECTS OF USING DRAUGHT ANIMALS

(P. Munzing)

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1. Introduction

The introduction of a new technology, whether it be animal traction or some other form of agricultural mechanization, has far-reaching effects for the developing country involved, the region to be promoted and the individual farms. These effects should be analysed in as much detail as possible as early as the planning stage of corresponding development projects.

The aims of this part of the handbook relate on the one hand to the need to explain the economic aspects of the use of draught animals - largely in order to supplement the other sections in Part B - and on the other hand to the idea of facilitating and improving the planning of project measures aimed at introducing or promoting the use of draught animals. This involves the following individual points:

- a) Increasing the reader's awareness of the relevant economic aspects of the use of draught animals.
- b) Discussion of the most important micro- and macroeconomic effects of using animal traction, taking into account important social effects.
- c) Presentation of empirical findings as regards the profitability of animal traction in comparison with other levels of mechanization.
- d) Demonstration of an assessment system, using economic evaluation methods and criteria in order to permit micro- and macroeconomic evaluation of animal traction in general and in comparison with other levels of mechanization.

This is not simply an attempt to discuss in general and in as balanced a manner as possible the economic advantages and disadvantages of animal traction. The aim is rather to present an instrument which makes it possible to determine these advantages and disadvantages and evaluate them accordingly.

The complexity of the overall scope covered by the economic aspects of animal traction results in a number of essential restrictions:

- a) Discussion centred on the use of draught animals in comparison with manual labour, since under African conditions "promotion of the use of draught animals" is often synonymous with "introduction of the use of draught animals".

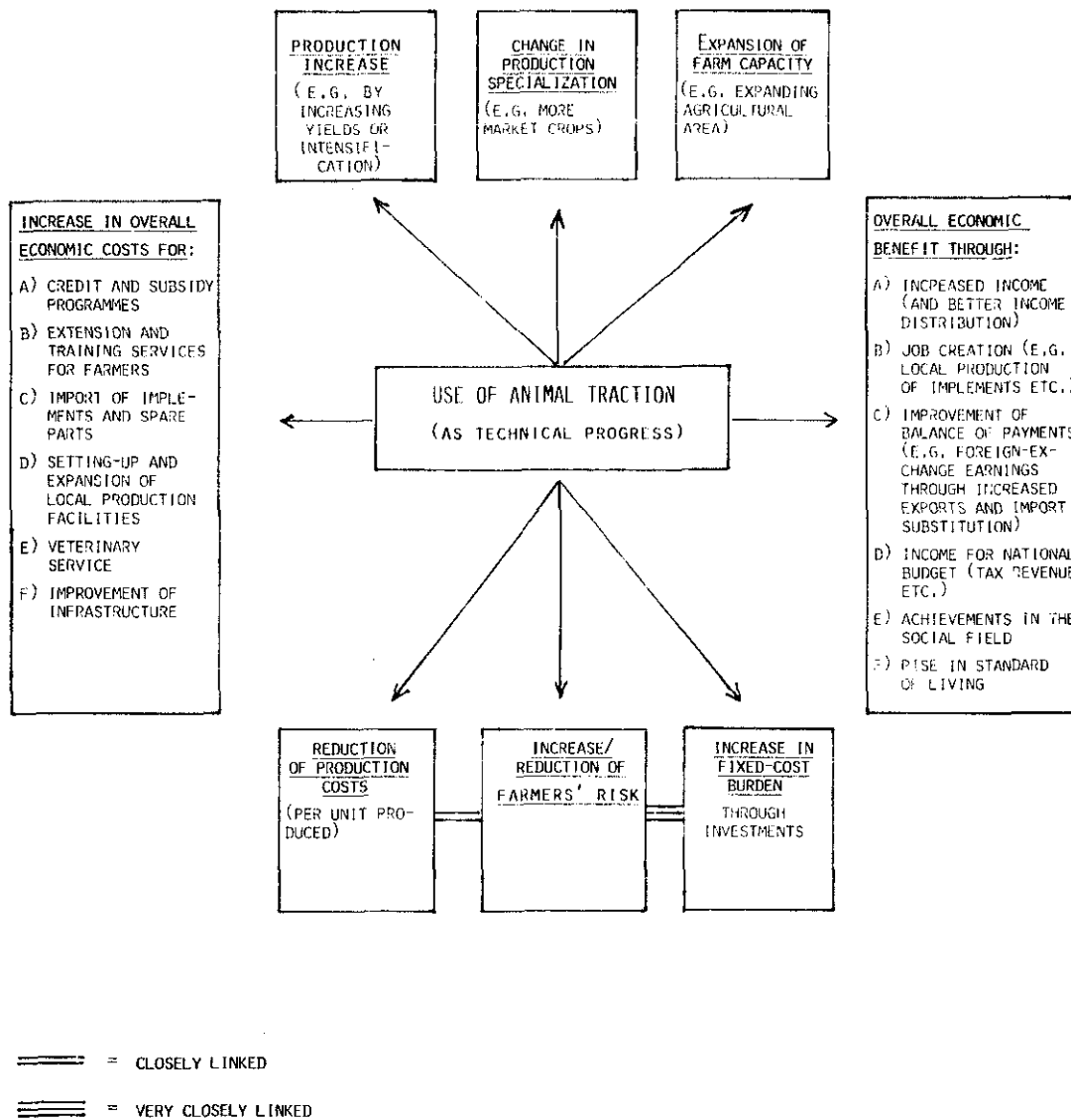
- b) Comparatively brief description of macroeconomic aspects, because here is the assessment from the point of view of farm management (= microeconomical level) that is regarded as the crucial element in the planning and evaluation of development projects involving the promotion of animal traction.
- c) Shortened description of farm-management evaluation methods, i.e. only the most important methods and steps are discussed, albeit with corresponding references to further literature.
- d) Framework conditions favouring or restricting the use of draught animals which are necessary for achieving micro- and macroeconomic targets and which must accordingly be borne in mind during planning are summarized in Part A and are also referred to in other sections of Part B. For the most part, therefore, there is no need to repeat them.¹⁾

The way in which this section is divided up is determined above all by the areas to which the individual aspects belong and a distinction is made between microeconomic and macroeconomic fields. A discussion of the aims of the farmers and of the overall economy is used to illustrate in each case the relatively broad-based effects of the use of draught animals. Available empirical findings on the profitability of animal traction are either included as examples in the discussion of effects or considered in the subsequent explanation of the evaluation methods.²⁾

It is assumed that the use of draught animals as a form of mechanical and technical progress has a specific effect on various sectors of the economic production process (see Table B/IV/1).

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- 1) It goes without saying that statements made here must be taken only within the context of the respective framework conditions surrounding them and are therefore limited in terms of generally applicable significance.
 - 2) The examples were integrated into the more theoretical consideration of the evaluation methods with the aim of providing information and instructions which are related as far as possible to actual practice. A handbook like this, however, can in no way replace the consultations of the usual textbooks on project planning methods.

TABLE B/IV/1: MICRO- AND MACROECONOMIC EFFECTS OF THE USE OF ANIMAL TRACTION



2. Microeconomic assessment

2.1 Definition and restrictions

If European farm management theory is taken as a basis for agricultural planning and assessment processes in developing countries it is important to emphasize the major differences and special features of farming in developing countries.

In management theory the three terms "holding/enterprise", "undertaking" and "household" are used to identify production and consumption processes. These permit - sometimes with the aid of further subdivisions on the basis of specific features - relatively precise classification and assignment of individual processes (e.g. "family agricultural holding" as against "hired-labour enterprise").

An agricultural holding or enterprise is characterized by three major production factors - labour, land and capital, which interact to determine the actual production process. Depending on its area of specialization, it is possible to identify individual production sectors for each holding (e.g. "cultivation of cereals", "breeding of new draught animals" etc.).

The term "production methods" is used in management theory to describe a relatively limited area of the holding or a special production sector which can be clearly defined by means of its income/expenditure ratio (see also Section 2.7.1).

The conditions prevailing in developing African countries create a number of problems as regards the use of the terminology and methods of farm analysis and assessment common in Europe:

- a) The subsistence farming encountered on African smallholdings comprises close interlinking of holding and household, which means that divided classification on the basis of production and consumption is hardly practical.
- b) Comparatively complicated land use systems (joint land ownership, shifting cultivation etc.), together with the traditional and family-based relationships (extended families, communal work etc.) make it difficult to give a precise definition of a holding.
- c) The fact that the rural population frequently uses and thinks in terms of natural units makes it difficult to evaluate a holding in monetary terms.

- d) The available data are in many cases inadequate, but it is relatively time-consuming and difficult to collect and analyse the necessary new information. In planning situations of this type, therefore, it is always necessary to consider whether the reliability of the data and the use of them in planning are in reasonable proportion to the desired result (see also Part A/Section 4.4).

2.2 Aims of the farmers with regard to an assessment of the micro-economic effects of draught animal utilization

The aims of the farmers involved must always be kept in mind in order to guarantee that agricultural innovations are assessed with due regard to the situation. When corresponding development projects are being planned, therefore, it is important to carry out as extensive a target analysis as possible, since it is the farmer's own objectives which have a decisive influence on his actions and not the aims of those who plan or implement the project measures.

It is clear from experience that the economic targets of the rural population - and thus the farming population - in Africa are highly complex and are determined by the prevailing framework conditions and level of development. If it is assumed that the farmers' objectives are, moreover, related to the major farm problems and the possibilities for improving or changing the situation, knowledge of the problem structure (and the objectives dependent upon it) can be used to obtain a rough idea of the chances which an innovation - and draught animal utilization must be regarded as an innovation in much of Africa - has of being adopted. It is thus important to consider the potential effects of using draught animals in relation to the objectives of the target group in question.

The objectives of African farmers may include the following:

a) Economic objectives

These generally involve maximization of benefits:

- Increase in net cash income
- Reduction of economic risk
- Formation of assets
- Guaranteeing of liquidity¹⁾
- Guaranteeing of subsistence (reduction of risk via guaranteeing of continuous food supply).

1) Guaranteeing (potential) liquidity is usually not so much a target set by the farmers but more one set by the project executing agency, particularly in cases where draught animals are introduced on a credit basis.

b) Non-economic objectives

These are very difficult or impossible to quantify and should be included in the farm planning processes as incidental conditions:

- Improvement of social position (prestige, power interests, increased status etc.) as a major sociological target
- Reduction of physical effort (by making work easier and/or saving time)
- Improvement in the living situation pure and simple.

In traditional African societies it is usual for the individual to often incur heavy expenditure and cash outlay for traditional obligations (funerals, dowry etc.). For the farmer this means - in addition to fulfilling the above-mentioned non-economic aims - not only that an innovation such as draught animals must bring an adequate increase in his yields but also that his priority economic target will be to increase his net cash income¹⁾ (i.e. his income which can be used for consumption purposes). The net cash income must exceed a specific "threshold" for the innovation to be accepted at all. Increases of 10%, for example, in many cases do not at all justify the expenditure needed to introduce the innovation in question.

Non-economic targets (increased prestige etc.) are often given priority over the purely economic targets among the native inhabitants. Although such objectives are often difficult to analyse and justify they should under no circumstances be ignored when corresponding project measures are being planned.

As shown in Table B/IV/1 the discussion of the economic effects of animal traction assumes that the use of draught animals is to be regarded as a form of mechanical and technical progress, principally in comparison with manual labour.

1) On European holdings, for example, the target is to increase farm income or profit. For African farmers, on the other hand, the net cash income (operating profit minus all miscellaneous expenditure and outgoings) will probably - for the above mentioned reasons - be more important, since this figure includes additional earnings from the non-agricultural sector (e.g. use of draught oxen for transport work; or fishing, weaving, pottery-making etc.). A more precise calculation of income is given in Section 2.7.

Technical progress essentially has an effect on

- production increase,
- cost reduction and/or
- capacity expansion.

The interrelationships in these three areas lend the situation a certain degree of complexity. In order to present these relationships in a more comprehensible manner, therefore, an attempt will be made to demonstrate the effects of the animal traction according to this influence on

- individual production methods on a farm,
- the farm as a whole,
- the operating risk and
- the non-agricultural sector.

In some places hints are given to aid in the economic evaluation of individual aspects in profitability calculations. Some framework conditions limiting or favouring the introduction or promotion of agricultural use of draught animals are also given but are discussed in more detail elsewhere.

2.3 Effects on production methods

The varying degree of suitability of draught animals for cultivation of certain crops leads to changes in the competitiveness of individual production methods. This can principally be explained by the fact that the use of draught animals

- a) leads to yield increases of varying size, whereby other parameters, e.g. those based on biological/technical progress, may have a complementary effect;
- b) results in cost changes which must be allocated directly to the individual production methods (= proportional special costs)
- c) reduces - to varying extents - the amount of work required for the various crops depending on the implements used.

The change in the economic importance of specific crops for an individual farm leads to modifications in the cultivation system and/or the crop rotation, i.e. cultivation of the crops which are relatively speaking more competitive is increased. This is illustrated by the considerable spread of cotton and groundnut growing in West Africa, two types of crop cultivation which can easily be mechanized with the aid of animal traction.

2.3.1 Increased yields

The increase in yield achieved with the aid of draught animals results from:

- a) improved soil and seedbed preparation
- b) observation of optimum cultivation times (tillage, sowing, weeding, harvesting)
- c) use of organic fertilizer (e.g. dung from draught animals), possibly accompanied by better utilization of mineral fertilizers
- d) observation of optimum plant spacing and precise sowing depths (by using suitable sowing implements)
- e) possible changes in the crop rotation (e.g. through the inclusion of fodder growing etc).

Furthermore, the use of animal traction often leads to general farming intensification, e.g. through achieving several harvests each year. This could be accomplished in conjunction with irrigation where draught animals can be of particular importance.

Only by precisely determining the specific intensity of the production method involved is it possible in practice to establish which of the above factors makes the major contribution to increasing the yield. The specific intensity expresses the ratio of production input (e.g. dung, ploughing work, irrigation water) to production volume (e.g. cotton or millet yield). For this purpose, however, it is necessary to know all the coefficients of the production function on which the specific intensity is based.¹⁾ Here it is sufficient to point out that the use of draught animals generally entails a change (increase) in specific intensity. Attempts at precise determination of this intensity often throw up problems regarding clear-cut allocation of the effects noted, since other factors (e.g. mineral fertilizers, new varieties etc.) usually exert a greater influence than the use of draught animals.

Relatively few research findings on this topic have so far become available for Africa. The major consideration in such studies is always inclusion of the climatic influences and specific locational factors. Distinctions must also be made among the crops which can be cultivated with the aid of draught animals.

LE MOIGNE (1979) discussed research carried out by the I.R.A.T. in Senegal, the Ivory Coast and Madagascar, where the use of animal traction led to the following increases in yield over purely manual labour (however, he does not specify the duration of the investigation; nor is it possible to cumulate the percentages):

1) cf. e.g. DOPPLER, W. (1978) and the literature referred to there for questions concerning specific intensity and determination of same. The so-called "organizational intensity" should also be considered in this context.

- Through quicker and more precise sowing: 50% for groundnuts and sorghum and up to 20% for millet varieties
- Through (semi-) mechanical crop tending: 50% for groundnuts and up to 175% for millet varieties
- Through better seedbed preparation (ploughing and harrowing): up to 112% for upland rice, up to 73% for maize and between 20 and 30% for sorghum, cotton and millet.

He stresses that these significant increases can be clearly attributed to the use of animal traction. At the same time, however, he points out that these figures were achieved under trial conditions and that the yield increases on typical African smallholdings are usually nowhere near as great.

According to CASSE et.al. (1965) use of animal-drawn aids alone has no direct effect on the increase in the yield. Clearly positive results have, however, been obtained wherever farmyard dung produced by the draught animals is used correctly, e.g. in many parts of Mali (HAG, H. and I., 1979).

Irrigation makes an important contribution to improving yields. In parts of North Africa it has been traditional for centuries to irrigate the land using water pumped out of wells with the aid of draught



Fig. B/IV/1: Availability of sufficient irrigation water is a decisive criterion for yield improvements and thus also for profitable use of draught animals. In places where the use of draught animals is traditional in irrigated farming - as shown here in Madagascar - the techniques employed (e.g. for harnessing) have been developed to an advanced stage. (Photo: Kütke)

animals, along water-courses or in oases. Table B/IV/2 gives a few performance data as a rough guideline. The contribution which such irrigation measures can make to improving farm income depends in each case on the prevailing framework conditions (water losses through evaporation and seepage, crops grown and their price/cost ratio, water distribution system etc.).

Table B/IV/2: Performance data for irrigation systems operated by harnessed animals

System	Discharge head m	Average delivery m ³ /h	Features
1. Water wheel			
500 cm dia.	1.8	36	Direct drive via capstan, 1 animal, 2-4 revs. per minute
400 cm dia.	1.3	51	
300 cm dia.	0.8	75	
200 cm dia.	0.3	114	
2. Capstan with pump	10.0 20.0	2.2 1.1	Operated by 1 donkey (approx. 0.11 HP (DIN))

Source: 1. HOLTkamp et.al., 1978
2. MINISTERE DE LA COOPERATION, 1974

In order to permit economic evaluation of yield increases it is essential to know how permanent they will be, for all economic model analyses work on the basis that the productivity of the soil will be maintained. This factor is particularly relevant for ex-ante farm planning, where calculations should be based either on long-term averages or changes in yield which could actually occur. A lack of empirical data may lead to evaluation problems (incorrect assessment etc.), which is why calculations should be made on the safe side.

A number of investigations performed following the introduction of animal traction (e.g. REMY, 1972) exhibited an increasing drop in yields after the initial increases. The possible causes are discussed in more detail in Part B/III)

2.3.2 Change in proportional special costs and fixed factors of production

It is important for the farm planner to know the proportional (= variable) special costs of keeping draught animals in order to be able to quantify the major cost-cutting effects which use of draught animals have on the production process and in order to make production methods with and without draught animals comparable at all.

These costs comprise:

(1) Maintenance and repair costs for implements, harnesses and other aids used

In many places maintenance of the implements and aids introduced along with draught animals, and in particular the provision of necessary spare parts, presents considerable problems, usually as a result of a shortage of trained local craftsmen. In this area, therefore, the individual farmers incur quite considerable costs which in practice fluctuate within a broad range, i.e. depending on the area cultivated and the type of implements used. Unless detailed information is available, however, at least 10% of the purchase price of an implement should in general be taken as representing annual expenditure on repair and maintenance (including spare parts).

(2) Costs of additional performance feed for draught animals

The following aspects are of significance when fodder costs are being determined:

- a) If the draught animals derive their feed only from the farm's available fallow land or bushland the fodder costs will be relatively low (they can often be disregarded altogether) and only the grazing costs (usually only labour costs) need be considered.
- b) If harvest residues (groundnut straw, rice straw etc.) form the major basic feedstuffs only the cost of recovering them (drying, transportation, storage etc.) is decisive, assuming there is no local market for these products. If there is a market, however, the corresponding opportunity costs¹⁾ for the products (determined by their relative purchase and sale values) must be determined and added to the recovery costs.
- c) If fodder has to be purchased (industrial residues such as brewer's grains, groundnut cake or palm kernel meal; or mineral licks etc.) the market prices actually paid (plus any transport costs) are to be taken as the fodder costs.

(3) Cost of tending draught animals

The importance of the costs incurred in tending the draught animals (usually only labour costs) may vary. On farms employing only family labour they are generally ignored in operational costing, while on farms employing hired labour they are one of the variable cost factors. On average, half an hour per animal per day can be regarded as necessary for looking after the animals, i.e. around 365 working hours per year for a team of two animals. The level of the wages to be paid is often a decisive factor as regards the profitability of animal traction in comparison with other forms of mechanization.

1) The principle of calculating opportunity cost is often of only theoretical significance in economic evaluation and has its origins in the practice of rigidly thinking in precisely measurable quantities. Opportunity costs can result from the lost profit from alternative production and application possibilities. If, for example, a shortage of land in general forces a reduction in the area devoted to a particular crop so that fodder for draught animals can be grown, the farmer is deprived of a "profit" amounting to the yield obtainable from the crop. Only the net sums are taken as opportunity costs.

(4) Interest on gross working capital

This is determined - if at all - by the usual interest rates for the respective location.

The introduction of animal traction generally causes a rise in the proportional special costs of the individual production methods used by a farm. When evaluating these costs the internal farm values (e.g. "relative purchase value" or "production cost value" of additional performance fodder etc.) should always be decisive.

In addition to the proportional special costs, however, the fixed costs incurred by a farm also rise (see Section 2.4.3). The resultant higher overall costs are economically justifiable only as long as potential capacity expansion and/or corresponding increases in yield lead to a drop in the (long-term) average costs.

As far as labour, land and capital requirements are concerned - these usually being designated in farm management terms as fixed production factors - the introduction of draught animals will result in the following changes:

(1) Labour

If draught animals are used all agricultural production processes in which they are involved will require less labour than if performed manually. As a result of this it becomes possible to intensify production and/or increase capacity (e.g. expansion of cropping area) while the farm's labour force complement remains the same.

Data on the time required for working on various crops with and without draught animals are subject to substantial variation as a result of numerous parameters (e.g. soil quality and moisture, natural vegetation, capacity of draught animals, condition of implements and tools, production level etc.). The figures given in the following table and diagram are therefore only rough guidelines (see also Section B/II/7).

Table B/IV/3: Time required for various types of work with and without draught animals (hours/hectare)¹⁾

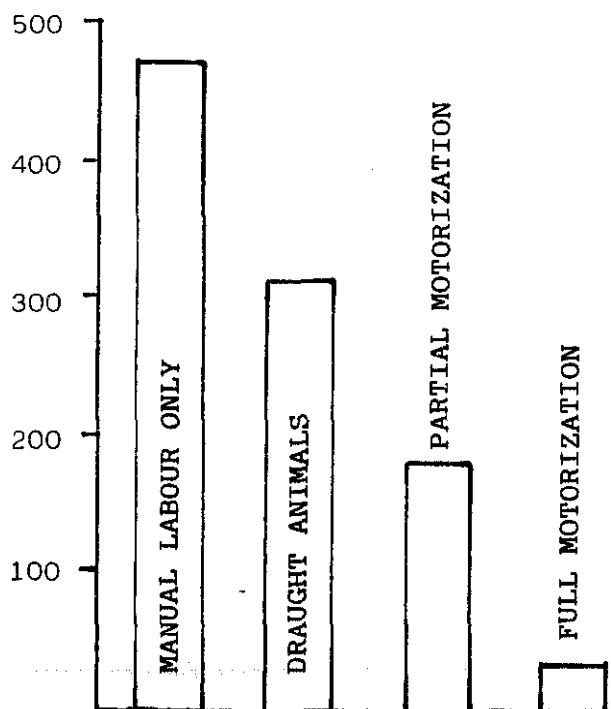
Type of work	Manual labour ²⁾ (1 worker)	Draught animals (+2 or 3 workers)	
		1 pair of draught oxen	1 donkey
Cultivating (dry soil)	30-35	12	25
Ridging (with plough)	120 (140)	12 (30)	-
Ridging (with ridger)	-	9	-
Ridging in ploughed field	-	7	-
Ploughing (with light plough)	200 (230)	-	60
Ploughing (with heavy plough)	-	25-30 (40)	-
Harrowing	-	5 (15)	5
Row seeding (1 seed drill)	64	12	7-10
Hoeing	160 (165)	15	12
Groundnut lifting	96	20	-

1) The figures in brackets apply to heavy soils

2) Figures only for using traditional hoes, no other implements.

Source: MINISTERE DE LA COOPERATION (1974)

Diagram B/IV/4: Average time requirements of various forms of mechanization (hours/hectare)



Source: FAO/C.E.E.M.A.T. (1972)

TRAVERSE,S. (1974) states that in swamp-rice growing in Senegal (BasseCassamance) work performed manually takes 25 times as long as that carried out using draught oxen.

Studies made by DIMA,S.A.J./AMANN,V.F. (1974) on time requirements in Uganda indicate that the use of draught animals can reduce time requirements by more than 50% on average.

As observed in Northern Cameroon or Mali, the time thus gained is not necessarily used for agriculture but is often devoted to earning additional income from non-agricultural sources.

It is generally agreed that more advanced forms of mechanization than animal traction are more efficient in terms of productivity per worker and/or per hectare. Comparative studies on the amount of time required when using tractors (both two- and four-wheeled models) and draught animals provide evidence of this in every case, no matter whether the work involved tillage, crop tending or transport work.

DEOMAMPO(1967/69), for example, established that for the ploughing work involved in rice growing in the Philippines a 6 HP (DIN) tractor with 2 days/hectare, required only a third of the time needed by a water buffalo (6 days/hectare).

Studies comparing so-called "simple tractors" (without sophisticated engineering) and draught oxen on cotton and groundnut farms in Mali produced similar results (see also Section 2.7.1). A pair of oxen took four times as long as a tractor to till one hectare and twice as long to sow the same area using simple sowing implements.

In many parts of Africa, where sex-specific division of labour is common, the introduction of animal traction may create problems. If, for example, typical men's work (e.g. tillage) is made easier by using draught animals and the farm area consequently expanded - on the basis of a decision taken by the men - a heavy burden is then placed on the women during the crop-tending and harvest work for which they are usually responsible. Although transport work (often also the women's responsibility) can be facilitated to a certain extent by the use of suitable carts, it should always be analysed before draught animals are actually introduced whether this makes the extra work justifiable. Appropriate measures (e.g. use of multi-purpose implements) have then to be considered for women.

(2) Land

The introduction of draught animals usually increases the demands placed on land as a production factor (i.e. in this case the

need for arable land as well as possible fallow and pasture), particularly if specific types of production are to be expanded because they are more competitive. The necessary land can be provided by:

- Restricting other types of production, for example, more cotton
 - as cash crop - instead of millet
- Shortening fallow periods
- Adding new crop areas (= expanding the farm's capacity).

(3) Capital

Among capital requirements for financing animal traction it is important to make a distinction between capital needed for

- investments such as draught animals and implements (= change in fixed assets) and
- use of the draught animals, i.e. fodder etc. (= change in current assets).

In general, a farm's capital requirements will increase if it goes over to using draught animals. This point is of relatively major importance for the majority of African smallholdings, since they mostly suffer from an acute shortage of capital, particularly in the case of farms with a high degree of subsistence production. Innovations such as draught animals must therefore be introduced with the aid of credits and/or subsidies (see also Section 2.5 - Excursion: Aspects of financing the use of draught animals).

2.4 Effects on the farm as a whole

All major effects which the use of draught animals has on the farm as a whole stem from or occasion the effects in the area of production methods. The following aspects are of primary importance:

- a) Expansion of the farm's capacity
- b) Change in area of farm-specialization
- c) Change in fixed costs
- d) Change in operating risk

2.4.1 Capacity expansion

Animal traction can essentially contribute at three levels to expanding a farm's capacity:

- 1) With a fixed labour force it becomes possible to cultivate a larger area and/or - if land is in short supply - to make more intensive use of the existing area (e.g. by achieving several harvests in each production period).
- 2) The inclusion (or expansion) of irrigation measures - e.g. using capstans or water wheels operated by animals - is facilitated; this also amounts to more intensive land use but can additionally lead to a change in the area of farm specialization.
- 3) The animals and implements available on the farm make it possible to perform work against payment (ploughing, transportation) for neighbouring farms, resulting in additional income.

At all three levels the outcome will be increased yields or increased net cash income, respectively. It is generally assumed that small-holdings cultivating around 2-3 hectares in the traditional manner can at least double their agricultural area using at least one pair of draught oxen and suitable implements and retaining a family labour force of the same size as previously. However, this often has serious consequences as regards the manual labour which still has to be performed during harvesting, a point which all in all should not be ignored.

Larger farms employing hired labour can often increase their agricultural area by well over 100%.

The major framework conditions which make it possible to achieve a relatively large increase in the cropping area using draught animals are the following:

- Availability of sufficient cultivable land with light to medium-heavy soils
- No problems in clearing natural vegetation
- High degree of motivation on the part of the farmers (possibly because work is made much easier and working-time saved)
- Availability of relatively inexpensive draught animals and implements
- Good opportunities for marketing those crops which can be easily mechanized with the aid of animal traction

Such conditions are to be found throughout much of West Africa, particularly south of the Sahel belt and north of the evergreen rain-forest zone, which is why it was possible to achieve considerable expansion of the area cultivated per farm when draught animals were introduced in this region.

Table B/IV/5: Average expansion of agricultural area (in %) achieved by introducing draught animals on West African small-holdings

SENEGAL		MALI	
Thiès region	100 %	Hte Vallée region	201 %
Siné Saloum region	128 %	Ségou region	156 %
Baoul region	159 %	Sikasso region	153 %

Source: CASSE, et.al. (1965)

A limited increase in agricultural area can be expected wherever the following conditions, for example, are to be found:

- Relatively heavy soils
- Dense natural vegetation, making clearance work difficult
- General shortage of land
- High degree of competitiveness on the part of those crops unsuitable for cultivation using draught animals (e.g. tea, coffee, oil palms etc.).

Under the above-mentioned framework conditions it is possible in some cases to make it easier for the farmers to go over to using draught animals by means of appropriate support measures (e.g. land clearance and initial tillage using tractors).

It is quite often the case that the transition from manual labour to animal traction not only increases the area cultivated but also results in shortening of the fallow periods due to a lack of cultivable land, leading in the long term to reduced yields. In many places this accompanies the transition from traditional shifting cultivation to permanent land use. The situation may be exacerbated still further by incorret tillage unless suitable countermeasures are taken (use of organic fertilizer, catch crop growing, crop rotation etc.).

The possibility of using draught animals to perform work against payment may present certain allocation problems in an economic farm analysis, because under African conditions, this problem is closely related to general difficulties involved in defining agricultural work. Contract ploughing and transportation of harvested crops against compensation (also in kind) etc. should be included in the agricultural sector since this work makes a direct contribution to the farm income. The introduction of draught animals, as well as other forms of mechanization, frequently does not lead immediately to expansion of farm capacity in one single step. The development is generally gradual and the accompanying production-increasing process continues for a certain amount of time. The resultant work and expenditure thus do not arise suddenly, remaining at the same specific level from then on; instead, their development is linked to the general changes taking place on the farm.

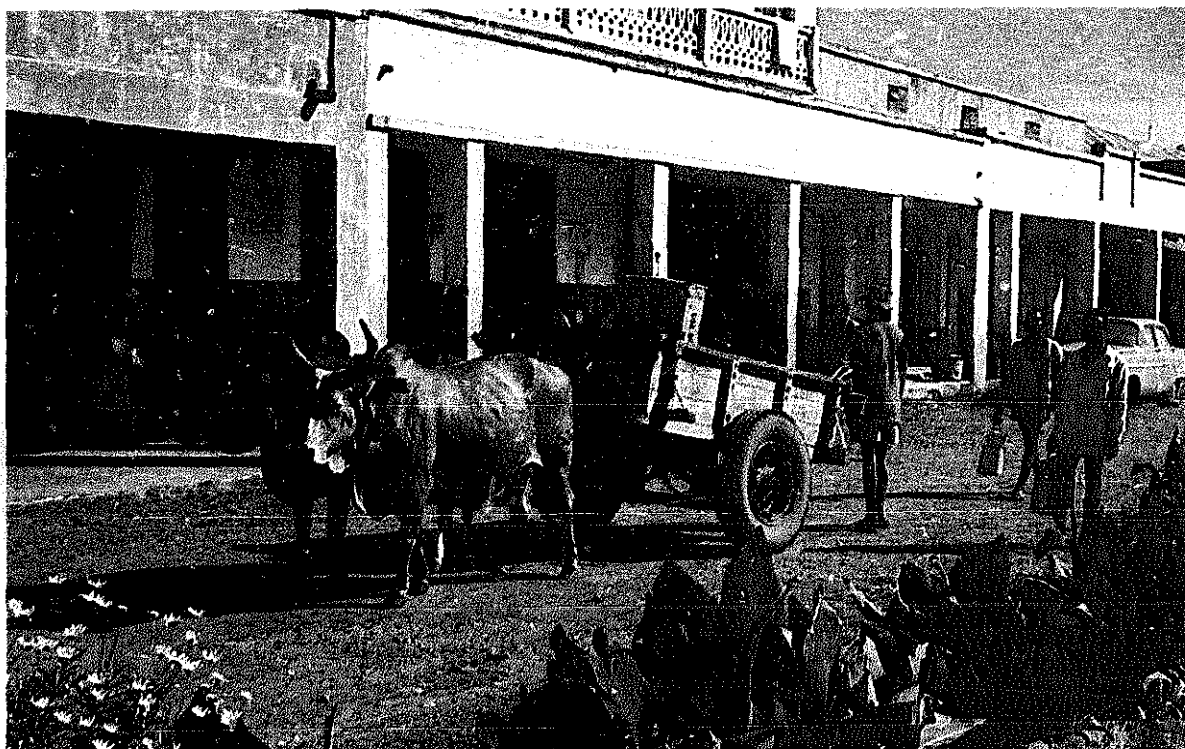


Fig. B/IV/2: Urban areas and regions near to towns offer particularly good opportunities for obtaining additional income, e.g. by transporting milk as shown here in Kenya. (Photo: Reh)

2.4.2 Change in area of farm-specialization

The changes in the competitiveness of individual methods of production, resulting from a farm's changeover to draught animals, lead to modifications in the organization of the farm, i.e. its area of specialization. The first step is often only increased cultivation of market crops, usually resulting in higher net cash income.

This positive effect of the use of animal traction is in some cases used directly as a kind of "economic lever" to encourage the promotion and spread of the technique. In parts of West Africa the C.F.D.T. (1968) and its subsidiary regional organizations were relatively successful in their sustained efforts to combine increased cotton growing with the use of draught oxen. In view of the fact that this crop is highly suitable for oxen-based mechanization, credits for the purchase of draught animals, implements, seed and mineral fertilizer were granted to smallholdings growing cotton with the aid of animal traction. The increased proportion of production accounted for by cash crops gave the individual farmers sufficient incentive to adopt the innovation.

The specific promotion of certain animal-drawn implements (e.g. groundnut lifters, seed spacing drills etc.) may foster a potential existing tendency to increase market-crop production. In the groundnut-growing areas of Senegal, for example, it was found that the introduction of animal-drawn seed drills on holdings cultivating up to 10 hectares not only meant that the use of draught oxen was adopted as a technique in itself but also at the same time led to more than doubling of the groundnut-growing area per farm (CASSE et.al., 1965/66).

In many parts of Africa arable farming is traditionally separated from the keeping of heavy livestock. If the general framework conditions so permit, the introduction of draught animals may in the long term lead to significant changes in farm organization, for example if livestock husbandry is increasingly integrated into the farm through the breeding of new draught animals. The female animals required for this purpose can be used both for draught work and - as in the case of draught cattle - for milk production.¹⁾

The use of draught cows, however, is not without its problems, since during the last months of pregnancy they can only be used to a limited extent and preferably not at all as from the seventh month.

Farms of this type - i.e. combining animal breeding and crop cultivation - are still comparatively rare in Africa, although details are available on the use of draught cows and animal reproduction on farms in Senegal, North-Cameroon and some other countries in North Africa.²⁾

The increasing shortage and rising cost of draught animals, particularly cattle, necessitate a stronger promotion of the breeding of additional draught animals on the farms.

1) This was formerly traditional, for example, on many farms in Central Europe. See also: DRAWER, K., 1959.

2) TRAVERSE, S., (1974), HENRY, A., (1972), SALLE, B. (1970), M'BODJ, M. (1973); HOLTkamp et.al. (1978), for example, describe the intensive use of draught cows in Egypt.

The following arguments favour such measures:

- 1) A farm's net cash income can be increased through the continual sale of young animals and/or milk.
- 2) Breeding of animals by the farms themselves to meet their own requirements, coupled with the additional proceeds from the sale of draught animals at the end of their working life, result in a type of "farm capital formation".
- 3) The fertility of the soil on the farm can be increased on a long-term basis by using dung.

Under African conditions it is difficult to give an economic assessment of the fertilizing value of dung. It has a certain value in that it can maintain or improve soil fertility and production of dung must therefore be classified under the output involved in the use of draught animals. According to FAO/CEEMAT (1972) one pair of oxen produce on average 6.4 tonnes of manure per year and the figure can be increased to around 20 tonnes provided that the animals are kept under suitable conditions within the farm-yard or compound. A horse with a live weight of 300 kg produces around 300 kg per month and a donkey approximately 100 kg. These figures must, however, be evaluated with caution.

- 4) The use of draught animals is accompanied by a diversification of agricultural production which permits
 - equalization of labour burdens,
 - improved subsistence production and food supply for the farm families (milk) and thus
 - a certain reduction of general risks.

In addition to the already-mentioned advantages of combining animal husbandry and crop cultivation in the above-mentioned manner, the costs and labour requirements accompanying a new area of farm specialization must be considered every time. In case of farm planning it must always be established, for example, whether it is in fact economical to buy the necessary draught animals or rear them on the farm itself.

The general framework conditions must not be overlooked when considering such points, for the increased fodder requirements of a breeding herd will, for instance, be coupled with the need for additional drinking water which cannot be met permanently in every part of Africa. Nomads and their herds are considerably more mobile and can move from one existing fodder area or watering place to another, whereas draught animals will sustain a substantial drop in performance if forced to go a long way to find drinking water. Under certain

climatic conditions, therefore, it may in future be more practical in many cases to have the necessary draught animals reared by nomads.

VALENTIN,P./SPITTLER,G. (1976) draw attention to the problems of using draught oxen within the framework of integrated animal husbandry on West African smallholdings. On account of the relatively large pasture area needed for a farm's own breeding herd, most farms in the region using draught oxen will continue to be dependent on purchased animals.

2.4.3 Change in fixed costs

The introduction of animal traction increases overall operating costs, particularly the fixed costs. It does, however, cut the average costs, mainly as a result of the increased efficiency of the production factors used.

The fixed costs incurred through the use of draught animals are:¹⁾

1) Depreciation on draught animals

The amount of depreciation depends on the period of use (oxen 4-6 years, horses 7-15 years, donkeys 8-10 years) and the difference between the purchase price and the animals' residual or slaughter value. The costs of training the draught animals must be added to the purchase value unless already-trained animals are bought.

In many places, e.g. Gambia (METTRICK, 1978), the value of old draught oxen (aged between around 8 and 10, slaughter weight approximately 500 kg) is considerably greater than the purchase price of young oxen (usually aged between 2 and 3 with a live weight of 250-300 kg).

2) Depreciation on implements and equipment

These costs also depend on the period of use and often vary from one implement to another. For costing purposes it is advisable to regard depreciation as fixed, since the periods for which the implements are used are generally unknown. No empirical data are available on the life of African animal-drawn implements and it would seem appropriate to take a maximum of 10 years as a guideline.

3) Cost of basic fodder for the draught animals

Under African conditions these costs are low and can be ignored if there is no actual fodder growing and existing fallow land and natural pastures are grazed instead or the animals fed with non-marketable harvest residues produced on the farm. Fixed costs

¹⁾ The cost factors listed subsequently are considered to be fixed costs since a farmer keeping draught animals will incur them every year irrespective of the degree to which he utilizes the capacity of his animals.

may occasionally be incurred if herdsmen are employed to look after the animals. If fodder is grown for the draught animals this form of production will result in separate fixed and variable costs which must be allocated accordingly.

4) Cost of keeping and caring for draught animals

This category includes depreciation on any livestock housing constructed (or shade-providing roofs, silos, fences etc.) as well as veterinary costs and the fixed costs of keeping the animals. Veterinary costs are among the most important costs entailed in the keeping of draught animals and are incurred as a result of regular inoculations, castration, care of the animals and certain continuous prophylactic measures. FAO/CEEMAT (1972) gives a figure of 8% of the purchase price of the draught animals as a guideline for use in farm cost accounting but this figure is in most cases seldom achieved in practice.

5) Cost of insuring draught animals

Draught-animal insurance is of immense importance to the farmer in that it serves to reduce his investment risk.

Insurance companies in the relevant countries - insofar as they exist at all - have to date been somewhat unwilling to insure draught animals, since proving the loss of an animal - it is usually necessary to submit a veterinary certificate - frequently involves numerous problems. The insurance premiums to be paid are accordingly high.

In Senegal the annual premium was 8% out of 80% of the purchase price of draught oxen, since the hide was valued at 20%. In many places, such as Mali, the inflation rate to which prices for draught oxen are subjected has risen so fast that the sum paid out in the event of a claim (corresponding to the original purchase price) is not sufficient to buy a replacement animal.

6) Interest on capital invested in fixed assets

This must be related to the average asset value in the case of all capital assets. The level of interest must be in line with the usual local conditions.

If there are opportunities for alternative use of capital - which is scarcely to be expected among African smallholders possessing little capital - the alternative interest rate should be taken as a basis for eventual farm-budget calculation.

7) Taxes and similar charges

Other fixed costs of importance for the farm as a whole may take the form of annual taxes on draught animals or carts, since this form of taxation is relatively easy for a state or a government to implement. It was frequently used in earlier times, whereas in Africa it has to date been largely unknown.

In view of the fact that most African farms - particularly smallholdings - have insufficient funds of their own, the introduction or promotion of draught animals often requires state support in the form of credits or direct subsidies on account of the relatively heavy investment involved. This applies above all to the initial

phase of corresponding development programmes and should be given special attention during project planning.

In many parts of West Africa the prices for draught oxen have risen tremendously during the last 20 years, an increase which can be attributed on the one hand to the disastrous droughts between 1973 and 1975 and on the other hand to the growing local demand for draught oxen. The prices for animal-drawn implements have risen to the same degree almost everywhere in Africa.

In general, it can be assumed that horses (and camels) are more expensive than draught cattle since they are more highly valued as animals for riding and are therefore used less for draught work in the countries where they are found. Donkeys, on the other hand, are less expensive in many places but on account of their smaller tractive effort are only suitable to a limited extent for draught work (on light soils and using suitable implements). The importance of mules is unfortunately declining, although they were formerly popular draught animals in Africa, particularly during colonial days.

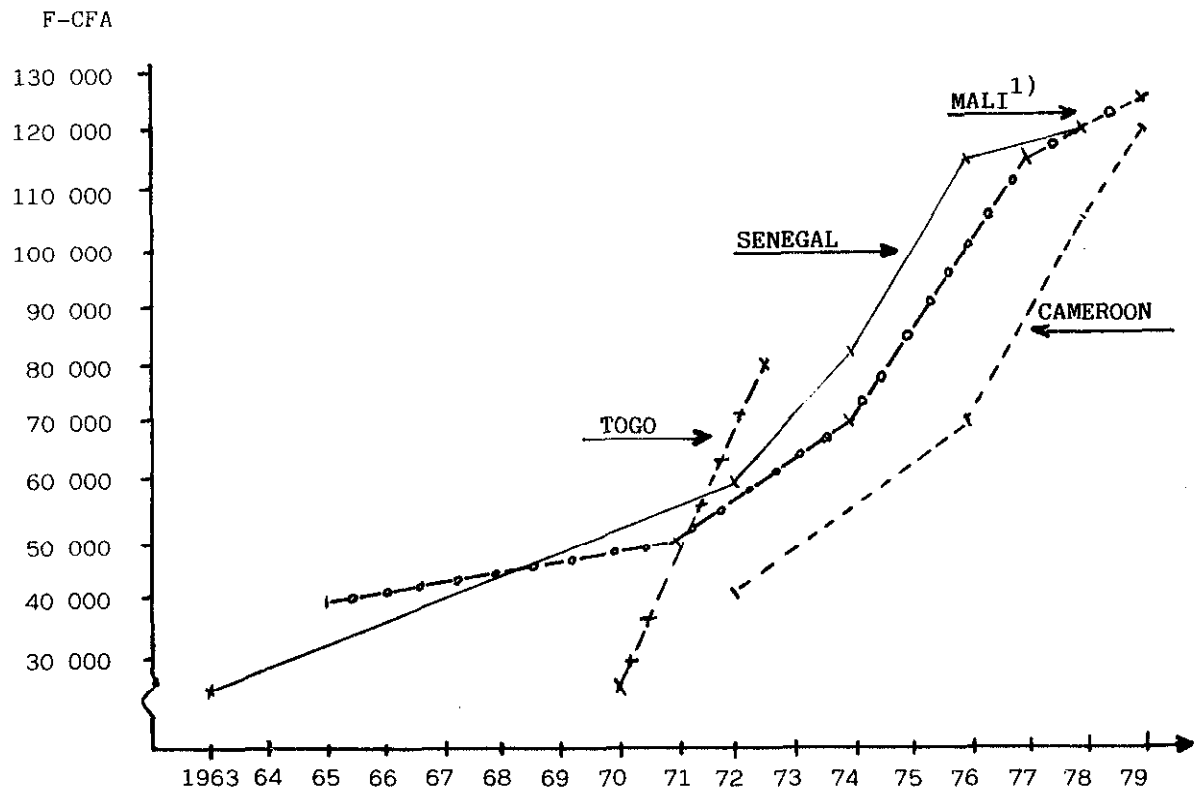


Fig. B/IV/3: Price trends for draught oxen in selected West African countries. (Sources: various)

1) Mali: Does not take into account the 1974 devaluation of the Malian franc.

2.4.4 Change in operating risks

The transition from manual labour to animal traction generally increases the operating risk. This is caused by the following factors:

- 1) The increased fixed costs and resultant recurring expenditure create a certain investment risk.
- 2) An increase in the proportion of market crops leads - depending on possible price fluctuations - to an increased market risk (dependence on government decisions and possible world market prices).
- 3) Expansion of the area cultivated may, coupled with simultaneous shortening of the fallow period and possibly in conjunction with climatic influences, result in yield fluctuations and consequently in increased production risk.
- 4) Any cut in subsistence production will increase the food-supply risk for farming families, particularly if it is made worse by yield fluctuations.

The readiness of African farmers to take risks is often insufficient - perhaps as a result of bad experiences - to permit direct adoption of innovations such as draught animals. There are a wide variety of reasons for this which cannot be discussed in detail here.

2.5 Aspects of financing the use of draught animals

The need for credits to aid the introduction and promotion of animal traction has already been brought up at various junctures. Experience has shown that development projects in this field must almost always comprise their own credit programme unless it is possible to call upon efficient existing institutions.

The need for credits on the part of the smallholdings results from the acute shortage of capital, which in Africa can be attributed to a variety of causes such as:

- A continued high degree of subsistence production with a low market volume and therefore low capital income
- Substantial yield fluctuations, possibly resulting from changing climatic influences
- Heavy traditional expenditure on non-agricultural items (e.g. weddings, burials, etc.)
- Little tendency to save (resulting in insufficient asset formation).

The real problems involved in awarding credits often arise not in determining the individual farms' credit requirements but rather in institutional areas (unsuitable credit organization or sponsor, insufficient liquidity, inefficient awarding and collection methods, etc.).

Terms of repayment and credit periods must be determined on a case-to-case basis and must be in line with the situation of the individual farms (see also Section 2.7.1). Inflationary trends, poor repayment rates and delays often mean that repaid credit amounts are not sufficient to benefit the same number of borrowers as before. This aspect must be given particular consideration on account of the heavy investments - which are still rising - for draught animals and implements.

The possible means of promoting animal traction via credits and subsidies comprise the following:

- 1) "Direct" credits, e.g. for purchasing draught animals and implements; these must be repaid within a specific period. The farmer is in most cases given not the capital but only the equipment (= credit in kind).
- 2) "Indirect" credits, e.g. through "free" distribution of improved seed for crops the cultivation of which is particularly suitable for mechanization using draught animals. This may be combined with the issuing of fertilizers and plant protection agents. Credit repayments are usually collected upon sale of the produce if the credit organization and the marketing company buying up the goods are one and the same institution.
- 3) Subsidies, e.g. by means of government grants for the purchase of expensive (possibly imported) animal-drawn implements and draught animals or for local production of implements and tools.

2.6 Effects in the non-agricultural sector

Many African smallholdings have only limited opportunities for increasing their agricultural income and are therefore increasingly dependent on additional income from non-agricultural sources. Draught animals can make a considerable contribution here, e.g. by performing

transport work outside the farm against payment (trips to the local market; transporting firewood, dung or harvested produce; services for local construction projects etc.), for in many parts of Africa, particularly around villages, transportation in rural areas is still based largely on human musclepower and it is usually the women and children who are forced to carry out the heavy and time-consuming work. Bearing this in mind, the reduction of physical exertion must be regarded as one particular advantage of animal traction. Additional income can also be obtained by hiring out animals and/or implements.

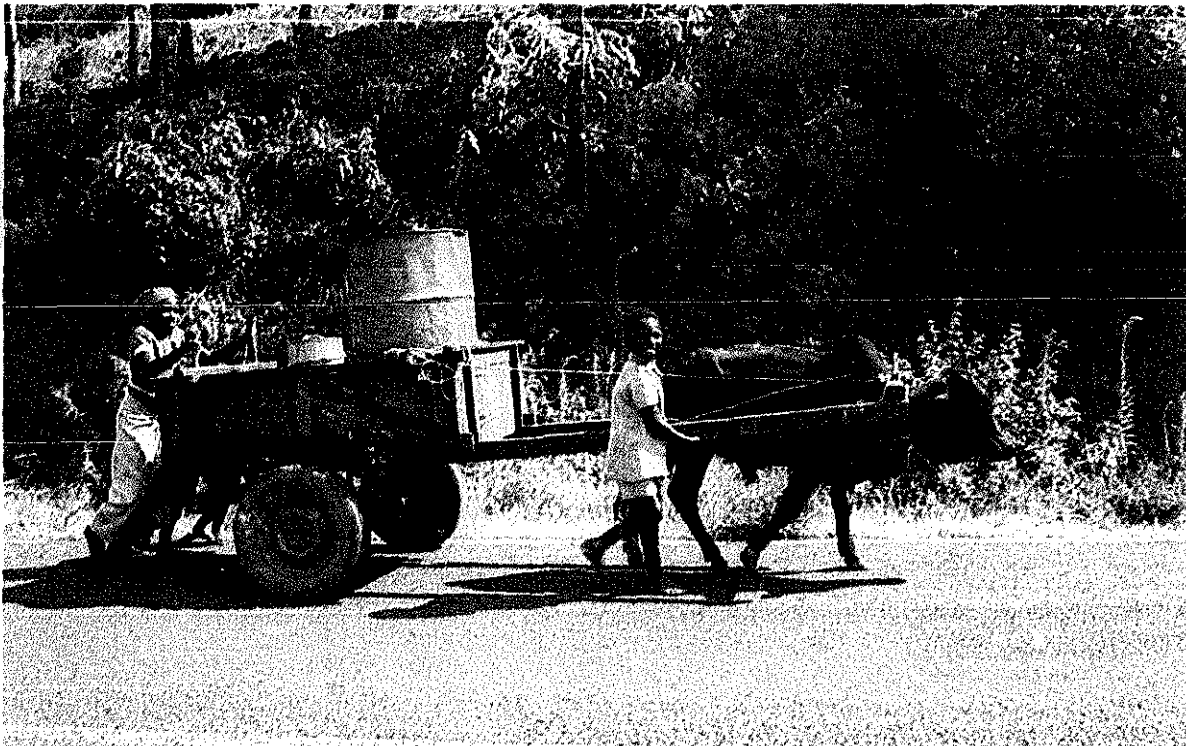


Fig. B/IV/4: The use of draught animals can substantially lighten the burden of work placed on many women and children in the rural areas of Africa. Old pneumatic-tired car axles are highly suitable for use in carts wherever roads and tracks are already in existence. Harnessing of single animals, as is common practice in some parts of Kenya, is an extremely suitable method for lighter transport work. (Photo: Munzinger)

It is reported from the Ivory Coast (RUTHENBERG, H., 1969) that owners of draught animals have achieved annual subsidiary earnings of 300-400 DM by means of ploughing or transport work away from their farm. Similar findings have been produced in Mali (LAGEMANN, J., 1977) and Kenya.¹⁾ The additional income of the draught-animal owners in areas of Mali near to towns was estimated at 50 000 FM (Malian francs) per year. Kenyan smallholders earn around 200 Kshs (Kenyan shillings) per day from contract work such as ploughing, harrowing and ridging.

¹⁾ Author's own investigation in 1980.

Attention has already been drawn to the importance of draught animals in conveying water. Further improvements will undoubtedly be possible in this area in the future with the aid of more modern capstans and water scoops but animals will still be required to provide the energy. The related yield increases, production expansion or cost savings must be examined systematically on a case-to-case basis and taken into account in farm cost accounting. For many smallholders, ownership of draught animals also involves a not inconsiderable gain in status, i.e. a higher social standing. The sociological factor must be borne in mind, particularly when evaluating the improved adoption of animal traction.

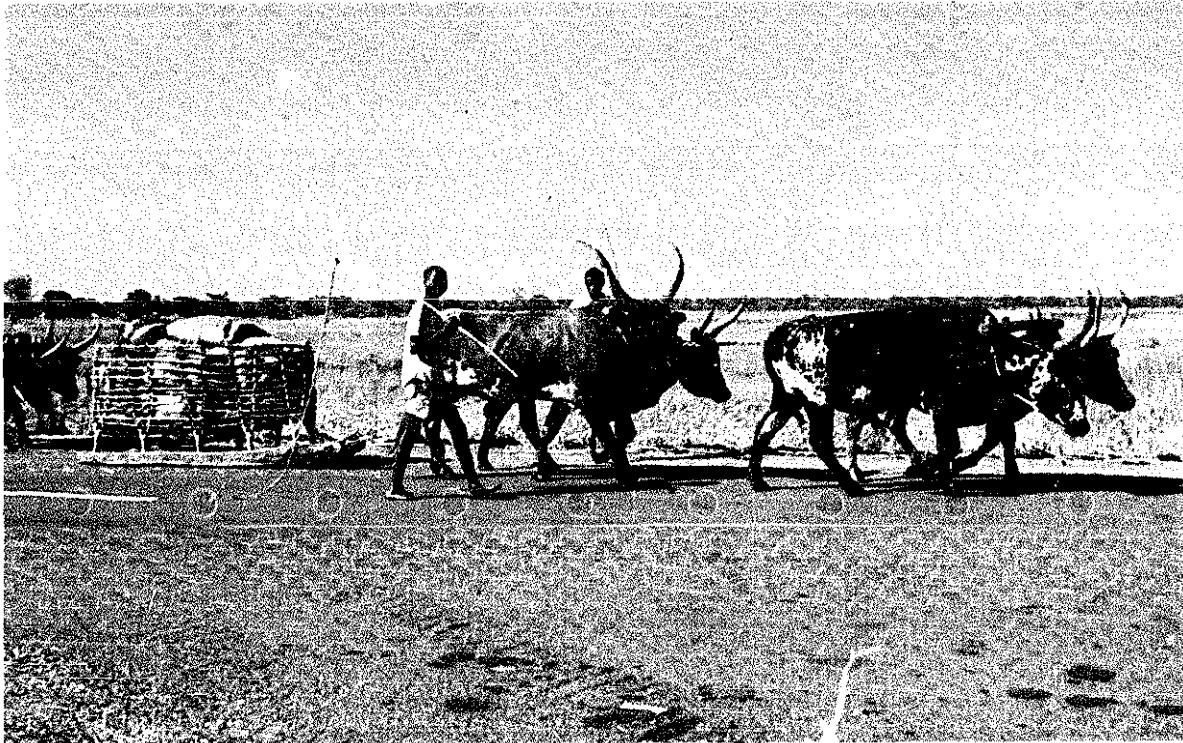


Fig. B/IV/5: Harnessing of several animals is common if sledges are to be used, the latter being more suitable for transportation in areas lacking good roads. In Zambia long distances to the markets are covered in this way. (Photo: Fernsebner)

2.7 Methods of assessing the microeconomic effects of animal traction

Microeconomic assessment as part of project planning essentially has the following aims:

- a) Recording and evaluation of the actual situation on farms (= ex-post analysis): This serves to ascertain the current economic situation and pinpoint weak spots and bottlenecks which can be overcome with the aid of suitable project measures.

b) On a basis of a situation analysis: Farm planning (= ex-ante analysis) taking into account possible changes on the farm, e.g. higher level of mechanization, alternative production methods, reduced labour input, increased land use etc.

A number of costing methods have been developed for farm assessment (e.g. STEINHAUSER et.al., 1978). Not all of them can be put to practical use under the conditions prevailing in developing countries, chiefly as a result of the shortage of data and its unreliability. The most important selection criterion for an evaluation method should therefore be the purpose for which the information and performance data to be ascertained are to be used. The methods set out and discussed here are considered to be sufficient for microeconomic assessment of the use of animal traction.

In addition to other distinguishing features, farm accounting systems are divided up into those calculations for specific parts of the farm (individual production areas or crops) and calculations for the farm as a whole. Valuation methods for specific parts of the farm are used principally to determine the profitability of individual crop-cultivation areas or methods of production with varying types of equipment and degrees of expenditure. Costing systems for the farm as a whole serve mainly to determine a farm's overall performance over a period of time, the figures for the production methods used in each case being added together. Such an analysis forms the basis of farm planning.

For one part of a farm the aspect under investigation may, for example, be the contribution to a change in yield within one area of a farm which can be achieved by using draught animals and/or mineral fertilizers. The profitability of using draught animals for a specific method of production is determined on the basis of the ratio of potential yield increase to necessary expenditure. Thus, a form of production may, for example, be characterized by relatively low yields and the use of manual labour for all operations or by comparatively high yields and the use of mineral fertilizer and draught animals.

2.7.1 Assessment of profitability

When assessing the profitability of a farm, a specific production method or a potential innovation it is generally assumed that the farmers' efforts are aimed primarily at earning a sufficient income and safeguarding the sources of this income.

The determination of profitability involves calculation methods for both individual areas of the farm and the farm as a whole.

2.7.1.1 Methods for individual areas of a farm

a) COST COMPARISONS

A direct cost comparison between two or more types of production relates the fixed and variable costs¹⁾ of the type in question to the area used for production or the units of working time required. When the various results are being described the performance level of the production methods in question is largely ignored and cost comparisons therefore have only a limited information value as a comparison of methods. In view of the fact that this procedure often requires only a minimal amount of data and calculation work it is most frequently used when a decision is to be taken for or against the promotion of a specific level of agricultural mechanization.²⁾

Cost comparisons are truly meaningful only if the subject at issue is the purchase or rental of a necessary machine or if the decision to be taken is of a similar and equally simple nature and has no particular effect on farm organization or profits, for example if the topic is "sowing by hand or with a seed drill" or "ploughing by a contractor or using the farm's own team of oxen". Cost comparisons are therefore unsuitable for comparing farms as a whole (e.g. "farm using manual labour" versus "farm using draught oxen"), although they may - in the form of complete cost accounting - contain all the cost factors involved in the relevant levels of mechanization.

The principle of cost comparison will now be illustrated by an example and the individual fixed and variable cost elements involved in the use of draught animals set out in brief in the form of a table.

The following table giving the overall costs involved in the use of draught animals (Table B/IV/6) can - in the form given here -

1) Costs (i.e. expenditure) are divided up into fixed (constant, planning-dependent) costs and variable costs. The former are incurred by the farm irrespective of the expansion or limitation of a production method (e.g. cost of purchasing draught oxen and fodder etc.), while the latter are directly dependent on the extent to which a production method is used.

2) Detailed instructions on grouping and calculation of costs and the profitability of agricultural mechanization are given by ADELHELM, R./STECK, K., 1974.

act as a basis for cost comparisons. A "pure" cost comparison is in no way sufficient if different levels of mechanization are to be compared; labour requirements and the respective crop-season capacities of the various levels of mechanization must also be taken into account. Different allocation of the cost components may also be advisable in certain cases.

Example I

Cost comparison between oxen and
simple tractors (Type TE, made by Bouyer)

The C.M.D.T. (= Compagnie Malienne pour le Développement des Textiles) tested simple tractors on selected cotton farms in the Koutiala region of Mali. The major criterion for selecting farms to be included in the study - in addition to a minimum size of 15 hectares - was the condition that the farms should have sufficient experience in the use of teams of oxen in order to guarantee a definite possibility of comparison. In addition to the costs involved in using the tractor or oxen the working hours required per hectare for the various essential operations (ploughing, hoeing, ridging) were also noted since the total costs per hectare were to be ascertained to act as a basis for comparison.

The calculation of the costs per hour of tractor use (including the necessary detachable implements) covered the individual costs specified in Table B/IV/7.

TABLE B/IV/6: PLAN FOR DETERMINATION OF TOTAL ANNUAL COSTS OF KEEPING DRAUGHT ANIMALS
WITH VARYING AMOUNTS OF USE (SITUATION IN MALI AS AN EXAMPLE)

LINE	COST FACTORS AND INDIVIDUAL COSTS	VALUES	AMOUNT OF USE (HOURS PER YEAR) ¹⁾			
			250	500	750	1000
1. FIXED COSTS OF KEEPING DRAUGHT ANIMALS						
1	PURCHASE PRICE (PER PAIR OF DRAUGHT OXEN)	178 000	-	-	-	-
2	COSTS OF TRAINING DRAUGHT ANIMALS	10 000	-	-	-	-
3	PURCHASE OF HARNESSSES (CHAINS, REINS ETC.) ²⁾	12 000	600	600	600	600
4	RESIDUAL VALUE (SLAUGHTER VALUE) OF 3) DRAUGHT ANIMALS	80 000	-	-	-	-
5	WORKING LIFE OF DRAUGHT ANIMALS	5 YEARS	-	-	-	-
6	DEPRECIATION ON DRAUGHT ANIMALS (1+2-4):5	-	21 600	21 600	21 600	21 600
7	INTEREST TO BE CALCULATED (6% ON 70% OF LINES 1+2+3)	-	8 400	8 400	8 400	8 400
8	FIXED FODDER COSTS A) PASTURE ⁴⁾	-	5 000	5 000	5 000	5 000
9	B) FOR FODDER GROWING	-	-	-	-	-
10	C) FOR FODDER RECOVERY	-	-	-	-	-
11	VETERINARY COSTS ⁵⁾	10 000	2 000	2 000	2 000	2 000
12	HOUSING OF DRAUGHT ANIMALS ⁶⁾	-	-	-	-	-
13	CARE AND OTHER COSTS OF KEEPING DRAUGHT ANIMALS	10 000	2 000	2 000	2 000	2 000
14	INSURANCE OF DRAUGHT ANIMALS ⁷⁾	12 000	2 400	2 400	2 400	2 400
15	TAXES AND OTHER CHARGES	-	800	800	800	800
16	MISCELLANEOUS FIXED COSTS	-	-	-	-	-
17	TOTAL FIXED COSTS OF KEEPING DRAUGHT ANIMALS	-	42 800	42 800	42 800	42 800
18	TOTAL FIXED COSTS EXCLUDING INTEREST TO BE CALCULATED	-	34 400	34 400	34 400	34 400
2. VARIABLE COSTS OF USING DRAUGHT ANIMALS						
19	PERFORMANCE FODDER, MINERALS ETC.	-	4 000	5 000	6 000	7 000
20	VARIABLE COSTS OF FODDER GROWING (OPPORTUNITY COSTS IF APPLICABLE) ⁴⁾	-	-	-	-	-
21	VARIABLE COSTS OF FODDER RECOVERY	-	-	-	-	-
22	LABOUR COSTS (FOR PEOPLE TO LOOK 8) AFTER ANIMALS)	-	2 500	5 000	7 500	10 000
23	MISCELLANEOUS VARIABLE COSTS	-	-	-	-	-
24	INTEREST ON CIRCULATING CAPITAL (3%)	-	120	150	180	210
25	TOTAL VARIABLE COSTS	-	6 620	10 150	13 680	17 210
26	TOTAL COSTS OF KEEPING DRAUGHT ANIMALS	-	49 420	52 950	56 480	60 010
27	TOTAL COSTS EXCLUDING INTEREST	-	40 900	44 400	47 900	51 400
28	TOTAL COSTS PER HOUR OF USE	-	198	106	75	60

SOURCE: MODEL CALCULATION BASED ON SURVEYS IN MALI BY LAGEMANN (1977) AND HAUG (1979)

NOTES: SEE NEXT PAGE.

NOTES ON TABLE B/IV/6:

- 1) ALL FIGURES GIVEN IN MALIAN FRANCS (AS OF 1979).
- 2) IT IS ASSUMED THAT THE HARNESSSES WILL LAST FOR 20 YEARS.
- 3) RESIDUAL VALUE OF DRAUGHT ANIMALS IS LOW BECAUSE LOCAL DEALERS FORCE DOWN THE PRICES. CAUTIOUS CALCULATION OF DEPRECIATION ALSO APPEARED ADVISABLE IN VIEW OF THE RISK FACTORS (LOSS RATE FOR DRAUGHT ANIMALS).
- 4) AS YET THERE IS NO FODDER GROWING AND THEREFORE NO CORRESPONDING COSTS. THE AMOUNT GIVEN FOR "CONTRACT GRAZING" IS PAID DURING THE DRY SEASON.
- 5) VETERINARY COSTS ARE HEAVILY SUBSIDIZED IN MALI. APPROX. 2 % OF THE PURCHASE PRICE OF THE DRAUGHT ANIMALS CAN NORMALLY BE CONSIDERED AS AN APPROXIMATE FIGURE FOR THE ANNUAL COSTS.
- 6) HOUSING THE ANIMALS LEADS TO NO SPECIAL COSTS IN THIS CASE.
- 7) THE COSTS OF INSURING ANIMALS VARIES WIDELY. IN MALI IT AMOUNTED TO 6000 FM PER ANIMAL INSURED (GROUP INSURANCE) IN THE FORM OF A SINGLE PAYMENT, RESULTING IN 2400 FM IF A TEAM IS USED FOR 5 YEARS.
- 8) 10 FM/HOUR ARE TAKEN AS A BASIS FOR THE LABOUR COSTS INVOLVED IN LOOKING AFTER THE ANIMALS SINCE SOME OF THESE COSTS ARE ALREADY INCLUDED IN THE COSTS FOR "CONTRACT GRAZING" (FIXED). A TOTAL OF HALF AN HOUR PER ANIMAL PER DAY SHOULD BE TAKEN AS A GUIDELINE.

Table B/IV/7: Costs of machinery for motorized farming in Mali

INDIVIDUAL COSTS	Tractor	2-furrow plough	Crop-tending implement	3-row sowing machine
Purchase price (FM)	2,457,000	247,500	270,000	174,000
Service life (years)	5	10	10	10
Cost of use (hours)	3 000	1 250	1 250	500
Repair costs as % of purchase price ¹⁾	50	50	50	50
<u>Fixed costs:</u>				
Depreciation/year	491,400	24,750	27,000	17,400
Accommodation, insurance ²⁾	-	-	-	-
Interest ³⁾	73,710	7.425	8,100	5,220
Total fixed costs/year	565,110	32,175	35,100	22,620
Total fixed costs/hour ⁴⁾	942	257	281	452
(hours of use/year) ⁴⁾	(600)	(125)	(125)	(50)
<u>Variable costs: ⁵⁾</u>				
Maintenance and repairs	410	99	108	87
Fuel, coolants and lubricants	318	-	-	-
Total variable costs/hour	728	99	108	87
Total costs/hour	1,670	356	389	539

Source: HAUG (1979); C.M.D.T. (1978)

- Notes: 1) The total repair costs differ substantially from the values given by the C.M.D.T. which took a figure of 150%. This seems to be too high on account of the short service life of the tractor.
- 2) Accommodation and insurance were ignored.
- 3) Interest rate: 6 % of half of original value.
- 4) Fixed costs vary depending on degree to which machine capacity is utilized (below depreciation threshold).
- 5) See C.M.D.T. report.

Table B/IV/8: Comparison of costs involved in performing various jobs using draught oxen or a tractor in Mali (in FM/hectare)

M O T O R I Z A T I O N		T E A M O F D R A U G H T O X E N	
1. Ploughing		1. Ploughing	
Tractor costs/hour	1 670	Team costs/hour	106
Plough costs/hour	376	Hours required/ hectare: 18	
	<u>2 046</u>	Team costs/hectare: 18 x 106 =	1 908
Hours required/ hectare: 6.2		Plough costs/hectare	<u>1 011</u>
Total costs per hectare	12 685	Total costs/hectare	2 919
2. Weeding		2. Weeding	
Tractor costs/hour	1 670	Team costs/hour	106
Hoe costs/hour	389	Hours required/ hectare: 9	
	<u>2 059</u>	Team costs/hectare: 9 x 106 =	954
Hours required/ hectare: 2		Costs for multi-purpose implement/hectare	<u>1 003</u>
Total costs per hectare	4 118	Total costs/hectare	1 957
3. Ridging		3. Ridging	
Tractor costs/hour	1 670	Team costs/hour	106
Hoe costs/hour	389	Hours required/ hectare: 9	
	<u>2 059</u>	Team costs/hectare: 9 x 106 =	954
Hours required/ hectare: 2.5		Costs for multi-purpose implement/hectare	<u>1 003</u>
Total costs per hectare	5 148	Total costs per hectare	1 957
Total costs of ploughing and tending 1 hectare (excluding labour costs) 21 951		Total cost of ploughing and tending 1 hectare (including labour costs) 6 833	

Source: Author's own calculations based on Tables B/IV/6 and B/IV/7.

Remarks: The data given above are based in part on studies performed by the Institut d'Economie Rurale du Mali. The daily working period of a pair of oxen is estimated at 6 hours of effective work, i.e. excluding travelling time to and from the field. There are no utilization costs for the fodder areas since the animals are grazed on fallow land and bushland.

The results of this comparative calculation simply show which form of mechanization is the more cost-effective for performing certain jobs under Malian conditions. Profitability calculations are necessary to determine in more detail to what extent the increase in production costs which mechanization entails is justified.

b) DETERMINATION OF COMPETITIVENESS

Productivity and profitability calculation methods which, in addition to costs, also take into account the performance (i.e. expenditure and earnings) of a certain area of production on a farm.

1) Productivity calculation¹⁾

This type of calculation investigates the productivity of using a specific production factor (partial productivity). The yield - expressed in kind or monetary units - produced during a specified period is divided by the production factor input required to obtain it. A distinction is therefore made between the following terms:

<u>Area productivity</u>	=	yield measured in kind (or monetary units)	per ha of agricultural area
<u>Labour productivity</u>	=	"	per worker
<u>Capital productivity</u>	=	"	per unit of capital used

Changes in productivity can be used as indicators of the profitability of using draught animals if the corresponding surveys and calculations are performed for methods with and without the use of animal traction.

However, productivity changes may occur as a result of changes in the input ratio and their information value as indicators of the profitability of using tractors is therefore limited. Productivity is generally expressed not in terms of absolute figures but rather as percentage changes.

2) Profitability calculation

In contrast to productivity calculations, this method is used to determine the profitability of the means of production used.

The fact that production and goods in this case are always evaluated in monetary terms means that it is relatively easy to apportion them provided that the market prices for the production inputs used and the resulting products are known. In the

1) In French-speaking areas productivity calculations are often used as macroeconomic planning calculations.

case of products with no market price (dung, non-marketable harvest residues etc.) it is necessary to use internal farm valuation criteria such as processing value, replacement value and relative sale or purchase value.¹⁾

Profitability calculations are divided up into income-expenditure calculations and output-input calculations, the former being used chiefly for assessing the farm as a whole. Whereas income-expenditure calculations record the expenditure and income during a specific period, output-input calculations lead to item-specific comparison of the value of products and the production inputs required to obtain them. Depending on the way in which costs and output are covered a further distinction is made between the following two methods:

- a) Complete costing = all costs are apportioned to a cost unit (i.e. a product or a production method)
- b) Partial costing = covers only part of the costs (e.g. the proportional special costs)

Complete costing is only partially suitable for individual areas of a farm since single production methods cannot be considered in total isolation from other areas of the farm. Partial costing methods, and in particular gross-margin calculation, permit this form of analysis.

3) Gross-margin calculation

Gross-margin calculation is the best method for making an economic comparison between various production methods, i.e. determining their competitiveness. It is not only an effective means of evaluating the actual situation on the farm but also at the same time forms the basis for overall farm planning calculations (see 2.7.2). The gross margin is formed by the marketable output of the production method minus the related proportional special costs.²⁾

If production methods at different levels of mechanization are to be assessed - e.g. "rice-growing using manual labour" and "rice-growing using draught animals" - the proportional

1) For detailed calculation procedures see the relevant literature, e.g. in STEINHAUSER et.al., 1978.

2) In contrast to the income-expenditure calculation for the farm as a whole it must be remembered here that

- byproducts (straw, fodder, dung) used on the farm are classified as output. If the items in question are significant they must be recorded and valued;
- production inputs, if generated on the farm (seed, fodder, dung), must be regarded as costs;
- payable interest must be calculated for the circulating capital.

special costs must in each case be increased by those of the level of mechanization to be examined. The gross margin ascertained then serves to cover the fixed costs and contains the farm income (profit) on a proportional basis.

For precise determination of competitive yardsticks the demands on the fixed production factors (e.g. labour, amount of arable land etc.) imposed by the production methods to be covered in the calculation must also be included, for as soon as a scarce production factor is being fully utilized (e.g. as a result of the farm's specific capacity) any further expansion of the production method in question will of necessity entail the restriction of another method.

Example II

The example in Table B/IV/9 illustrates the situation. When used in practice the calculation method should be modified to cater for requirements and the actual situation.

TABLE B/IV/9: COEFFICIENTS (IN MONETARY UNITS AND IN KIND) OF GROSS-MARGIN CALCULATION FOR VARIOUS PRODUCTION METHODS WITH AND WITHOUT USE OF DRAUGHT OXEN

LINE	UNIT	MANUAL LABOUR ⁴⁾			DRAUGHT OXEN ⁴⁾		
		SESAME	RICE	GROUND-NUTS	SESAME	RICE	GROUND-NUTS
1	CROP	1 HA					
2	YIELDS	KG/HA	400	600	1 200	600	1 400
3	PRICES	F/KG	60	50	30	60	50
4	MARKETABLE OUTPUT:	F/HA	24 000	30 000	36 000	36 000	60 000
5	OUTPUT FOR USE ON FARM ¹⁾	STRAW	STRAW/HUSKS	STRAW	STRAW	STRAW	STRAW/HUSKS
6	UTILIZATION: FERTILIZER	+	+	+	+	-	-
7	FODDER FOR OXEN	-	-	-	+	+	+
	PROPORTIONAL SPECIAL COSTS ²⁾						
8	SEED	F/HA	1 080	3 750	5 400	1 350	5 400
9	PLANT PROTECTION	F/HA	-	-	-	-	-
10	MINERAL FERTILIZER	F/HA	-	-	1 000	-	-
11	WAGES FOR HIRED LABOUR	F	-	-	-	-	-
12	SPECIAL COSTS FOR DRAUGHT OXEN	F/HA	-	-	-	2 000	2 000
13	OTHER SPECIAL COSTS	F/HA	175	175	250	175	350
14	INTEREST ON WORKING CAPITAL (5%)	F	63	196	333	176	380
15	TOTAL	F/HA	1 318	4 121	6 983	3 701	7 980
16	GROSS MARGIN/HECTARE	F	22 682	25 879	29 017	32 299	52 020
	FACTOR REQUIREMENTS ³⁾						
17	LABOUR IN MAN-DAYS, TOTAL	MAN-DAY	46.5	91	112	60.5	104
18	" " " " PERIOD I	" "	-	-	24	-	-
19	" " " " PERIOD II	" "	-	41	12	-	25
20	" " " " PERIOD III	" "	24.5	-	32	25	30
21	LAND: NORMAL ARABLE LAND	HA	1	-	1	1	-
22	SWAMPLAND	HA	-	1	-	-	1
23	GROSS MARGIN/HECTARE	F/MAN-DAY	488	284	259	534	500
	REQUIREMENTS IN TERMS OF INDIVIDUAL OPERATIONS (TOTAL IN LINE 17)	MAN-DAY					
24	LAND RECLAMATION/CLEARANCE		6	2	8	10	3
25	UPROOTING TREE STUMPS		-	-	-	-	3
26	HOEING/PLOUGHING		7	35	30	6	14
27	SOWING		2	6	14	2.5	8
28	FIRST WEEDING		7	8	12	7	10
29	FERTILIZING		-	-	1	-	-
30	SECOND WEEDING		-	5	-	-	6
31	RIDGING		-	-	8	-	-
32	THIRD WEEDING		-	-	6	-	-
33	CHEMICAL WEED CONTROL		-	-	-	-	-
34	HARVESTING		18	27	33	25	40
35	THRASHING		6.5	8	-	10	20

SOURCE: MODEL COMPILATION BASED ON GROSSER/PFEIFFER (1977/78), THE DATA ARE BASED ON SURVEYS MADE IN THE CENTRAL AFRICAN REPUBLIC.

- NOTES:
- 1) THE PART OF THE OUTPUT OF THE PRODUCTION METHODS SHOWN WHICH CAN BE USED ON THE FARM IS NOT QUANTIFIED HERE. THE UNRELIABILITY OF THE DATA MAKES VALUATION DIFFICULT SINCE SEPARATE CALCULATIONS, GEARED TO THE ACTUAL FORM OF USE (FERTILIZING VALUE OF STRAW, SALE OR PURCHASE PRICE OF HARVEST RESIDUES ETC.) WOULD BE NECESSARY.
 - 2) THE PROPORTIONAL SPECIAL COSTS GIVEN ARE CALCULATED USING THE PRODUCTION INPUTS USED AND THEIR CURRENT PRICES.
 - 3) REQUIREMENTS IN TERMS OF THE PRODUCTION FACTOR "LABOUR" ARE GIVEN BOTH FOR VARIOUS PERIODS OF TIME AND INDIVIDUAL OPERATIONS. THIS IS DONE ONLY TO ILLUSTRATE THE TWO POSSIBILITIES AS THE PROCESS CAN BE SIMPLIFIED IN PRACTICE. THE TABLE CLEARLY INDICATES THAT DRAUGHT OXEN REQUIRE LESS TIME FOR MOST OPERATIONS, EXCEPT LAND RECLAMATION, CLEARANCE AND UPROOTING OF TREE STUMPS, SINCE THE FIELDS MUST BE BETTER PREPARED IF DRAUGHT ANIMALS ARE USED.
 - 4) CORRESPONDS IN EACH CASE TO THE HIGHEST LEVEL FOUND IN THE REGION.

The example clearly shows that the gross margin is the vital criterion for the competitiveness of individual production methods and provides information on the advantageousness of the methods from the microeconomic point of view, as regards both the labour and land used.¹⁾ Under certain circumstances, however, incidental conditions such as

- utilization of the farm's own fodder;
- utilization of capacity of the farm's own labour force;
- use of available implements;
- minimization of operating risk etc.,

can also be used as yardsticks for competitiveness but cannot be easily quantified.

Although comparing the gross margins of various production methods at different levels of mechanization provides information on their profitability, the relative advantage of one production method over another may depend on additional factors which are not included in gross-margin calculation (e.g. capital expenditure on investment, together with the related risk). In order to carry out a comprehensive comparison of the profitability of various alternative forms of mechanization, therefore, more detailed farm analyses and planning are required. Gross-margin calculation can form the basis for this.

2.7.1.2 Methods for the farm as a whole

a) PROFIT AND LOSS ACCOUNTING

The output-input calculation for the farm as a whole is essentially based on "extrapolation", i.e. aggregating individual calculations from various areas of the farm.

The overall gross margin (= comparative gross margin) for the farm is established using the calculated gross margins of the individual production methods. Following deduction of the fixed operating costs (excluding interest, rent and wages) this yields

1) If corresponding information is available the gross margin can also be related to other factors, e.g. the number of "team working hours" required or the monetary unit invested.

the net farm income¹⁾ which can be used as the basis for determining further performance data. In farm management theory these factors essentially differ in that they take wage expenditure, interest and rents etc. into account in different ways (see Table B/IV/10).

The income-expenditure calculation is probably the most common method of evaluating the farm as a whole and compares all the farm's expenditure and income within a specific period (e.g. a production period or calendar year). Performance criteria are here again derived from the net farm income, which covers the cost of the production factors employed and can be individually related to these (net farm income per hectare or per worker). Extensive part-calculations are in some cases necessary to determine expenditure and income.

Calculation of the net farm income also has a certain degree of importance from the macroeconomic point of view, since it largely corresponds to the income in macroeconomic terms following addition of the taxes chargeable as expenses, other charges and state prepayments (subsidies) which do not constitute operating expenditure. From the point of view of animal traction this means that the resulting change in net farm income provides a rough indication of the overall net product derived from the use of draught animals (ABROMEIT, 1968).

1) Under African conditions the net farm income should be given preference over the gross income as a criterion for profitability, since ascertainment of the gross income is based on the "debt-free and rent-free farm", a term for micro-economic calculation methods only worthwhile under higher developed agriculture.

Table B/IV/10: Performance criteria for farms and how to determine them

Line	
1	<p><u>FARM INCOME</u></p> <p>derived from: a) Proceeds from the sale of products from arable farming and animal husbandry b) Value of changes in quantity of goods produced on the farm (incl. livestock) c) Value of wages paid in kind d) Value of withdrawals in kind e) Miscellaneous (farm) income</p>
2	<p>- <u>FARM EXPENDITURE</u></p> <p>derived from: a) Expenditure on materials, livestock and maintenance of durable goods b) Value of changes in quantity of materials c) Depreciation on durable goods d) Expenditure on machines and services e) Expenditure on taxes, rents etc. f) Miscellaneous (farm) expenditure</p>
3	<p>= <u>NET FARM INCOME</u></p> <p>- Expenditure on hired labour - Expenditure on payable interest</p>
4	<p>= <u>PROFIT</u></p> <p>+ Non-agricultural income + Miscellaneous family income</p>
5	<p>= <u>TOTAL INCOME</u></p>
6	<p><u>DOMESTIC WITHDRAWALS</u></p> <p>derived from: a) Value of withdrawals in kind b) Cash withdrawals for household expenses c) Recurring traditional obligations d) Expenditure on education and training e) Private asset formation f) Miscellaneous withdrawals g) Private taxes and charges</p>
7	<p>+ Expenditure on payable interest - <u>ALLOWANCE FOR RISKS</u> (or liquidity reserve)</p>
8	<p>= <u>CAPITAL SERVICE LIMIT</u> (permanent)</p> <p>- Depreciation (may be available) - Current service of capital (for repayment, interest payable etc.)</p>
9	<p>= <u>CAPITAL SERVICE LIMIT</u> (current)</p>
10	<p><u>TOTAL INCOME</u></p> <p>+ Depreciation (values used for calculation purposes) - Investments (financed by profit and depreciation) - Repayments - Personal taxes and charges</p>
11	<p><u>CONSUMABLE INCOME</u> (= net cash income)</p>

Source: Based on STRÖBEL, H./PFEIFFER, J.: Unpublished manuscript for DSE (German Foundation for Developing Countries) seminar "Agrarkredit und Betriebsplanung" (Agricultural credits and farm planning); FELDAFING, August 1979.

b) LIQUIDITY CALCULATIONS

Investigating the liquidity of a farm serves to estimate its solvency, a factor which is of particular importance if innovations in the area of production techniques are to be introduced with the aid of credits. A liquidity check on farms should therefore be made in particular as part of project planning (to act as a safeguard for the project executing agency).

Liquidity is generally calculated by comparing inpayments and outpayments and the process should take the form of a cash flow-analysis covering several years. In many cases it is helpful to draw up a farm financing schedule (DOPPLER, W., 1978).

The most important criterion for checking creditworthiness is the so-called capital service limit (an example of how to determine this is given in Table B/IV/10, lines 5-9). This expresses the maximum burden which can be imposed on a farm in terms of repayments and interest.

A distinction is made between the permanent and current capital service limits. The latter is often used as a basis for decision-making if a farm's short-term lack of capital resources can be compensated for by longer-term depreciation on capital goods (= "stretching" of the capital service limit for calculatory purposes).

An important factor in the calculation is formed by the reserves, which cover the risk of failed harvests, loss of draught animals etc. (see also Section 2.7). The various domestic withdrawals on the farm must also be taken into account; these are of particular importance if high traditional expenditure is anticipated (paying for brides, funeral costs etc.).

The poor repayment rates encountered in projects involving credits indicate that liquidity is apparently not one of the farmers' major aims. In view of the fact that the "kind" and "cash" areas are often still largely separated in developing countries with a high degree of subsistence production the cash income is considered more important. Calculation of consumable income (= net cash income) (see Table B/IV/10) must therefore be given priority in farm analysis and planning.

Withdrawals in kind are frequently difficult to record and value and it is often necessary to use estimates, which should be as accurate as possible.

2.7.2 Farm planning

The farm evaluation methods described so far are used primarily for analysing the actual situation on farms; in part, however, they also form the basis for farm planning (= calculation of optimum situation). The objective of this planning is to determine the type of farm organization which, with the given production capacities, results in the largest profit.

The most familiar types of planning calculations are budgeting, programme planning and linear programming.

2.7.2.1 Budgeting¹⁾

Budgeting is regarded as the simplest method and frequently involves only a rough estimate of data, situations and changes concerning the farm. This method is therefore used only if few data are available or rapid results required.

The basic concept of budgeting involves the following stages in drawing up a farm plan:

- Determination of the farm's capacities (land, labour, machines, buildings, rights etc.)
- Investigation and establishment of alternatives for land-based and animal-based production (i.e. how many hectares of land, how many animals etc.), taking into account future developments relevant to the farm (market sector, technical standard etc.)
- Production of the farm plan using various individual operating plans (part-budgets) for the relevant areas of the farm. Actual formulation of the farm plan (which in the long run will be near enough optimum) takes the form of a continuous "trial and error" process and calls for quite a lot of experience and intuition on the part of the planner.

1) Numerous work sheets and sets of forms are available for drawing up budgets and have been modified according to the situation and its requirements. Those given in the "Mémento de l'Agronome" (Ministère de la Coopération, France, 1974) are considered particularly suitable for West Africa.

2.7.2.2 Programme planning

As in the case of budgeting, the aim of using programme planning methods is to establish the optimum type of farm organization under given conditions and with methods still to be introduced (e.g. "increase in production capacities" or "use of draught animals"). The calculations are more extensive than those involved in budgeting and entail the following steps:¹⁾

- a) Ascertainment and preparation of data base, together with analysis of the actual situation on the farm.
- b) Ascertainment of the farm's capacities (land, labour, machines etc.) for the planning period.
- c) Establishment of the potential production methods and estimation of their gross margins and requirements in terms of labour, land, machines etc.
- d) Aggregation of production methods (e.g. "fodder growing" and "keeping of draught animals").
- e) Formulation of farm plans according to the criterion "utilization of the scarcest production factor".

Additional profitability criteria can be derived (on a model basis) using the gross margins of production methods already in use or still to be introduced. In developing countries programme planning is a more suitable farm planning method than linear programming since it

- does not require electronic data processing systems;
- is easier for the planner to understand, allows him a certain scope for discretion and makes it possible to follow and reconstruct the calculation procedure;

1) Based on DOPPLER, W. (1978), who illustrates the individual steps with the aid of a simple example of the use of draught animals, and no further examples will therefore be given here. In this connection DOPPLER also refers to further literature. The only investigations and farm planning concerning the use of animal traction which employ the programme planning method and which were available to the author are those by GROSSER, E./PFEIFFER, J. (1977/78) which deal with the Central African Republic. Following a detailed survey of selected farms in the PAQUA region they compared the profitability of farms using manual labour and farms using draught oxen. On the basis of the farms' capacities in terms of agricultural land, labour and capital (need for credit) they determined, at various levels of intensity, the types of farm to be regarded as near enough optimum and at the same time performed profitability calculations.

- permits the correction of errors during calculation;
- on the whole requires relatively little expenditure.

The linear programming method represents the farm as a series of linear equation systems, giving the opportunity for simultaneous planning approaches. In contrast to programme planning the production methods are not competing consecutively but rather simultaneously for scarce production factors, i.e. all intra-farm relationships are included simultaneously in the calculation. Linear programming will not be discussed in detail here; the reader is referred to further literature on the subject.¹⁾

2.7.2.3 Consideration of risk and uncertainty aspects

The related operating risks and uncertainty factors must be taken into account when farms are being planned and innovations introduced. Increased risks may, for example, result from the following factors:

- Yield fluctuation as a result of climate
- Major changes in the price of the goods produced and production inputs used
- Comparatively heavy investment in production inputs and/or capital assets (including the purchase of draught animals, implements etc.)
- Other causes attributable to framework conditions (e.g. high mortality rate among working animals, insufficient fodder basis etc.).

Farm planning methods can take risk factors into account in a variety of ways:

- a) One extremely pragmatic method provides for comprehensive additions or deductions (cf. Table B/IV/10).
- b) Provided that sufficient data are available a substantially more accurate method involves calculations containing yield and/or price variations; either the mean of the actual variations is included in the calculation or several calculations are performed using a range of different prices and yields. The effect of the variations on the competitiveness of the production methods should be determined in the case of both procedures.
- c) If the risks are already reduced by means of corresponding insurance (e.g. covering the death of draught animals) the related costs should be directly included in the planning.²⁾

1) e.g. STEINHAUSER et.al., 1972, and the literature referred to there.

2) The risk of premature loss of draught animals can also be included under depreciation in farm costing if no insurance policy has been taken out.

d) Linear programming can take price and yield variations into account within the model and special formulations have been developed for this purpose but must be practically disregarded since it is almost impossible to apply them under African conditions.

2.8. Conclusions derived from the microeconomic effects

From the microeconomic point of view there are essentially two problem areas involved in the introduction or promotion of animal traction:

- a) What form of technical progress - biological or mechanical - should be given priority in development measures?
- b) What level of mechanization, i.e. manual labour, animal traction or tractors (up to full motorization), is economical and appropriate to the situation on hand? With what degree of intensity is this mechanization to be employed, i.e. only for individual operations/production methods or for the entire farm?

The examples given and the discussion of the productive capacity of animal traction under African conditions permit only a few overall conclusions. Actual planning requires more detailed analyses and it is important to make distinctions on the basis of the following factors (see also checklist in Part A/Section 4.4):

- Production factors (labour, land and capital) available on the farms
- Size of farms (large, medium-sized or small)
- Production geared to subsistence or market crops
- Labour structure of farms (family labour or predominantly hired labour)
- Availability of credits, agricultural extension services etc.
- Natural (i.e. particularly climatic and ecological) framework conditions.

As regards the general possibilities for using animal traction in Africa the effects discussed - above all in comparison with other levels of mechanization - permit the following conclusions:

- 1) In regions where relatively cheap labour, sufficient arable land and suitable animals for draught work are available simultaneously animal traction is often more economical in the long term than "more advanced" forms of mechanization. In most cases the main interest is expansion of a farm's capacity rather than intensification of production. Comparatively high labour costs (resulting from the scarcity of labour), financially sound farms with a pronounced degree of market production, a good supply of agricultural production inputs and sufficiently large farms, on the other hand, favour tractor-based mechanization since under such conditions this is often more economical and has a greater impact.

The advantage of tractors over draught animals is often founded only in the opportunity which they offer for more rapid tillage of the soil and is less marked in the case of crop tending and harvesting. An increase in agricultural production by means of measures aimed primarily at improving yields (irrigation, improved varieties, suitable cultivation techniques, use of fertilizers, several harvests per year etc.) should be encouraged above all in areas where land is scarce but labour in abundant supply. The keeping of draught animals can only become significant if fodder areas which cannot be used for any other purpose are available or if sufficient quantities of harvest residues are produced which can be used to feed draught animals.

- 2) In general, animal traction is primarily suitable for smallholdings, since on medium-scale and large farms - even under African conditions - efficiency criteria often point to tractor-based mechanization, provided that the necessary framework conditions (spare part supply, repair workshops etc.) are met. If these conditions are not fulfilled draught animals may also become an attractive prospect for medium-scale farms (around 5-50 hectares) depending on the competitiveness of the crops grown.
- 3) Pure subsistence production is in most cases economically reasonable only at the manual-labour level. Aspects of mechanization become increasingly important if there is a changeover to increased cultivation of market crops unless permanent crops providing a high income and requiring considerable manual labour are more competitive and thereby stabilize the manual-labour level. Experience in West Africa has proved that given selective promotion of market-crop cultivation, animal traction is the best form



Fig. B/IV/6: Use of draught animals above single-farm level - as practised in some parts of Kenya - can become important wherever the holding structure is characterized by smallholdings with a high proportion of permanent crops (e.g. coffee, tea, bananas). The animals in a team are in most cases privately owned. (Photo: Munzinger)

of mechanization on smallholdings and it was quickly adopted because the increase in the farms' market income justified the outlay.

Similar promotional approaches are also economically practical for other parts of Africa.

- 4) The use of draught animals is relatively independent of the labour structure of a farm. Its labour-saving advantages - over manual labour - are smaller than those of tractor-based mechanization. A variety of additional jobs concerned with looking after the animals must be carried out and on smallholdings these are usually performed by members of the family labour force. As a whole, therefore, the use of draught animals tends more to reduce the need for outside or hired labour. Another reason why animal traction should be promoted is the fact that the cut in labour requirements means that the women can be relieved of the burden of having to perform the heavy work and that child labour can be reduced (e.g.

in transport work etc.), although this is not possible everywhere to the same extent, experience having shown that the increase in farm capacity accompanying the introduction of draught animals results in additional burdens for the women who often have to carry out harvest work. Tillage, however, is frequently the responsibility of the men, which is why draught animals are used only for this purpose.

If possible, therefore, draught animals should be used for all agricultural work and not just for parts of the farmwork.

- 5) For most African farmers easy access to adequate credits provided on favourable terms is a prerequisite for the adoption of innovations such as animal traction. This should also involve an agricultural extension service, which should be as efficient and comprehensive as possible, for only then will the farmers be able to make profitable use of new techniques.
- 6) One important microeconomic advantage of animal traction which should under no circumstances be ignored is that it provides the opportunity to earn additional non-agricultural income relatively easily and for many draught-animal owners it is only this which makes animal traction profitable at all.
- 7) As far as the natural framework conditions are concerned, experience to date has revealed that
 - it has been considerably easier to introduce draught animals in semi-arid regions, where land clearance is less problematic on account of the natural vegetation and fairly light soils are often found, than in rain forest areas with lush vegetation;
 - although the problems of infectious diseases affecting both man and animals (e.g. trypanosomiasis) have an inhibiting effect on the use of draught animals, they can be solved through appropriate and specifically directed development measures;
 - it is only under extreme ecological conditions that animal traction cannot be introduced in any form.
- 8) In some parts of Africa today the local prices of animal-drawn implements and draught animals - in comparison with tractors and tractor-drawn machines as well as with regard to follow-up costs - suggest, from the microeconomic point of view, that animal trac-

tion should be used to a greater extent. As a result of the rising energy prices this applies in particular to those African countries possessing few suitable raw materials or none at all. The need to obtain more natural fertilizer - an area where the keeping of draught animals can make a major contribution through the production of dung - additionally confirms these facts.

3. Macroeconomic assessment

In contrast to the assessment from the point of view of individual farm management, the macroeconomic aspects of animal traction will be discussed only in brief. Attention will be focused on the discussion of the potential macroeconomic effects of the use of draught animals and these will be assessed from the point of view of the contribution they can make to achieving the national economic targets of developing African countries and the nature of the macroeconomic expenditure they cause (see also Diagram B/IV/1).

The most important macroeconomic assessment methods will be discussed only briefly with regard to their applicability for agricultural mechanization projects.

3.1 Macroeconomic targets concerning agricultural mechanization

It is well known that despite a high degree of correspondence, the national economic targets of the developing countries and the development policy objectives of the so-called "donor countries" exhibit a number of differences which repeatedly arise on account of the rigid attitudes adopted by political decision-makers on both sides. As far as agricultural mechanization is concerned these differences have a substantial influence on the decisions taken by local politicians and help to explain certain misdirected developments in the mechanization field. The private economic interests of the industrialized nations are a factor which should not be ignored in this context.

The following list gives a number of macroeconomic targets specific to developing countries and related to agricultural mechanization. No distinction is made between economic and social targets or direct and indirect ones:

a) Paramount aims

- Independence in matters of foreign policy, i.e. largely in the economic field (e.g. no dependence on machine imports)
- Continuous economic growth accompanied by social adjustment and an increase in self-sufficiency

b) Subsidiary aims

- Increase in the income of the farming population (e.g. with the aid of efficient and appropriate agricultural mechanization)
- Increase in net value added (i.e. national income)
- Production increase in the agricultural sector to improve self-sufficiency (possibly import substitution and/or expansion of exports)
- Maintaining of employment opportunities and creation of new jobs in rural areas
- Squaring the balance of payments
- Improvement of income distribution among individuals and regions as well as capital accumulation

These objectives listed by way of example may be opposed by the intentions of the donor countries (or private investors), such as

- opening-up and maintaining of markets for (agricultural) machines and implements or
- general expansion of export possibilities etc.

which may cause or reinforce the above-mentioned differences in objectives.

The essential task for planners of agricultural mechanization projects is therefore to carry out a situation analysis and determine to what extent the national economic aims of the developing country in question are identical with

- a) the interest of the donor countries (or private organizations) in terms of development policy and private economic concerns
- b) the aims of the rural population or other target groups (interest groups), in which case regional distinctions must be drawn.

Only when fairly clear and unambiguous results are available on this area which support one or more forms of agricultural mechanization, on the basis of the identified framework conditions, is it practical to plan suitable (and necessary) project measures.

3.2 Macroeconomic effects of the use of draught animals

In the course of actual project planning a study of macroeconomic effects of a form of agricultural mechanization is often possible only as a comparison with other mechanization levels, i.e. the "with/without principle" must be used. This involves analysing the macroeconomic effects which will occur with the form of mechanization under investigation and which effects will not occur without this mechanization.

This often involves highly complex and interdependent relationships. In order to make the situation clearer the effects of animal traction will therefore be discussed in terms of the degree to which they achieve macroeconomic targets, as given above.

In some places the effects of animal traction and those of tractor-based technology will be compared.

3.2.1 National product (net value added)

The most important contributions made by agricultural mechanization to the national product results from the increases in individual farm incomes which themselves stem from increased yields, expansion of farm capacity (including land reclamation) and additional off-farm income etc. The value is reduced above all by costs which must be paid in advance (see Section 3.2.3) by the state (or the project executing agency) to permit the introduction of this technology.

Methods for determining the contribution to the national product (net value added) are described in Section 3.3. It is important that when using the "extrapolation" method described there for microeconomic cost and income data, items such as interest, subsidies, compensation payments and taxes are deducted from the total farm income as "adjustment items".

A distinction can be made between net value added and gross value added depending on the way in which prepayments, depreciation, indirect taxes and subsidies are treated.

Numerous local parameters determine the position occupied by animal traction - on the basis of the national-product criterion - as regards achievement of macroeconomic targets.¹⁾ Experience gained to date in this area has indicated that under the smallholding-based

1) See also Part A: "Framework conditions concerning the introduction and promotion of the use of draught animals". On the basis of the "national-product criterion" the most advisable mechanization level from the economic point of view is that which - in absolute terms - makes the greatest contribution to increasing the national income.

conditions in Africa animal traction often

- clearly results in a higher national income (e.g. in Senegal, Mali, Upper Volta) than is the case with manual labour unless the majority of the crops grown require a great deal of manual labour and simultaneously have a high degree of competitiveness (= high opportunity costs, e.g. in parts of Kenya)
- also has advantages over tractors since the introduction of tractor-based technology causes substantially higher overall economic costs, particularly long-term follow-up costs.

If, however, certain resources (e.g. arable land, labour in rural areas, suitable animals for draught work) are in relatively short supply, the situation is considerably less favourable for animal traction. Other agricultural technologies (e.g. use of small or two-wheeled tractors) then often provide better opportunities for increasing the national income on account of their advantages for the individual farms.

Taking into account the sometimes very strained financial situation of many African countries, therefore, it must be determined whether income growth rates like those achieved through the use of animal traction could be attained by means of other project measures in a way which is better for the overall economy, for as far as increases in agricultural production are concerned "biological/technical progress" (based on improved seed, use of mineral fertilizer etc.) is known to be more effective than "mechanical/technical progress". The necessary expenditure on extension and training services (time, costs etc.) for draught animal owners is, in relation to the desired increase in income, in part substantially greater than that required for comparable extension services dealing with more efficient use of biological/technical innovations for farmers not owning draught animals.

It must therefore be examined whether, from the macroeconomic point of view, the use of animal traction represents the most economical way of increasing the national product, and in particular whether it guarantees optimum use of resources which may be in short supply. It is impossible to give a generally valid answer to this question and the topic must always be covered in the course of project assessment.

3.2.2 Balance of payments

Macroeconomic assessment of a development project or promotion measure must involve the examination of its short-, medium- and long-term

effects on a country's balance of payments. This applies in particular if the country's balance of payments has been in the red for some time.

If the effects of animal traction in this sphere are compared with those of other levels of mechanization the related foreign-exchange expenditure must be ascertained and set against the potential (or anticipated) foreign-exchange earnings. The former are caused for the most part by the import of necessary machines, implements, spare parts, fuel, coolants and lubricants etc., while the latter may result either from

- increase in exports of appropriate crops (minus any transport or utilization costs) or from
- import substitution (= foreign-exchange savings: if there is fairly intense use of draught animals this applies in particular to tractors and the related implements).

It can generally be assumed that in the medium and long term animal traction will be less of a burden on a country's balance of payments than tractor-based technology. The latter has the largest foreign-exchange requirements of all levels of agricultural mechanization and not only causes high import costs at the time of investment but also leads to relatively high follow-up costs and a high degree of dependence as a result of the continuous need for spare parts, fuel, coolants and lubricants, advanced technical knowledge and so on. The countries which will be particularly hit in the future are those which do not have the necessary resources at their disposal.

Whether the form of mechanization chosen or to be introduced in an actual case can ease the balance of payments depends in the long term not only on the necessary foreign-exchange expenditure but above all on the increases in the yields of export crops which can be achieved with its introduction. As long as the country has sufficient foreign exchange to import tractors and the related technology or if it can obtain foreign exchange by means of corresponding exports (or possibly by borrowing) the utilization and spread of animal traction may be regarded as uneconomical. In view of the fact, however, that most African countries are not in this happy position, draught animals may become still more important for them in future. Agricultural mechanization based on animal traction also considerably reduces dependence in matters of foreign policy.



Fig. B/IV/7: In Tanzania the government is also promoting use of draught oxen (National Oxenisation Programme) for the "Ujamaa villages" which, with their communal cultivation of the land, are in some cases comparable with large-scale farms. The decision to introduce draught animals was based on the desire to ease the balance of payments. (Photo: GTZ Archives)

The examination and quantitative recording of the effects of mechanization on a country's balance of payments frequently involves problems which may stem from a variety of causes and the information value of such an assessment is therefore often somewhat limited.

When different levels of mechanization are being compared the net foreign-exchange balances determined can be related either to the individual farm (e.g. in US\$ per cotton farm) or, in aggregated form, to the project region or the entire country.

Inpayment and outpayment flows should if possible be estimated in the form of a "cash-flow analysis" for a lengthy period (around 10 years) in order to record long-term trends.

3.2.3 National budget

Experience gained to date with development projects aimed at introducing or promoting animal traction have shown that such schemes usually have a detrimental rather than a positive effect on the budget of the country in question.

One way in which the use of animal traction eases the budget may be found, for example, in additional tax revenue which can be skimmed

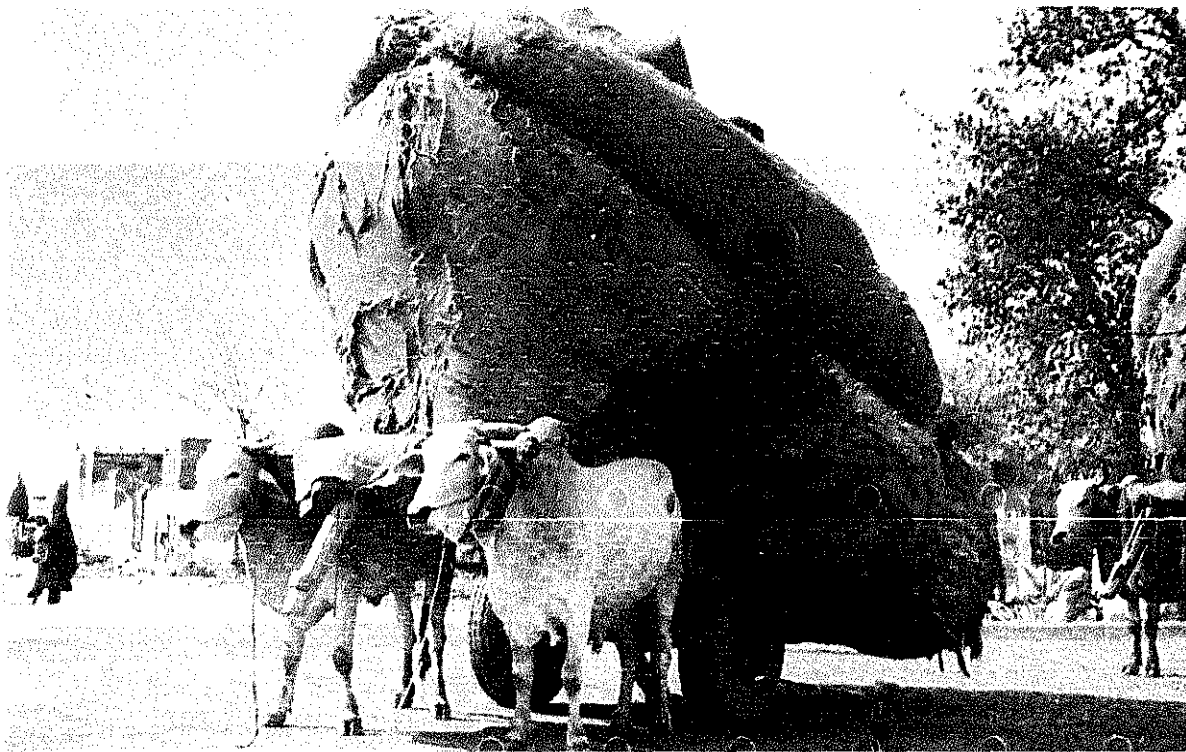


Fig. B/IV/8: If draught animals are used for commercial transport work - as shown here in the case of cotton marketing - it may certainly be practical to impose a tax on the animals in order to provide the state with additional revenue. (Photo: GTZ Archives)

off from the increased product earnings in the sectors preceding and following agriculture. This aspect must not be overestimated, however, since the effects cannot always be clearly attributed to the use of draught animals.

Far more important than the benefits for the national budget in this context are the strains imposed on it, i.e. costs resulting from measures to promote the use of draught animals. These comprise in particular the additional back-up or framework measures which are necessary in order to realize the projects and can often be financed only with government (or external) aid.

Examples of such framework or preliminary contributions are given below.¹⁾ When a project is actually being planned they must be examined and evaluated separately:

1) Establishment or expansion of an agricultural extension service

The additional training and permanent support of the extension personnel (who may already be available) in matters concerning the keeping and use of draught animals result in substantial costs (salaries, accommodation, means of transport, teaching materials etc.).

1) The points mentioned do not claim to be exhaustive and are not given in order of importance.

2) Credits and/or subsidy programmes

This type of financial burden, usually intended to provide draught animals and implements for the farmers to be assisted, frequently exceeds the available government finances. Moreover, credit repayments are often incomplete and - in many cases as a result of inflationary trends - do not cover the new requirements. Additional subsidies from government agencies are then necessary to compensate for unfavourable price/cost ratios.

3) Expansion or establishment of veterinary services

In conjunction with any necessary epidemic control or inoculation measures this area results in heavy expenditure for the state, which may be increased still further by the need for special schemes (e.g. to repel the tsetse-fly).

4) Promotion of local craft industries

Particular importance must in general be attached to this area. Extensive financial assistance from the state is also necessary in conjunction with the development of small-scale local industries for producing animal-drawn implements (and the relevant spare parts).

5) Training centres

The necessary training centres require government support, whether they are intended for the target group of the farmers themselves or for extension workers and the like. It must be examined in each case whether the training is to take place on a centralized basis at one or more permanent training institutions or whether "mobile training centres" should be set up.

6) Support of the local marketing and procurement system

This measure is particularly necessary if sale of the additional produce is to be guaranteed in order to provide the farmers with a sufficient income and give them an incentive. Closely linked to this is the opportunity for on-schedule credit repayments.

This also applies to the provision of agricultural production inputs (fertilizers, chemicals, implements, spare parts etc.).

7) Improvement of the infrastructure

Animal traction in general does not place such heavy demands on the infrastructure as tractor-based technology. In some cases government support provides an incentive for self-help through the construction of roads by the local labour force.

Special infrastructure measures necessary for promoting animal traction - in addition to those already described above - may include the following:

- Sinking of wells to provide drinking water
- Drainage or irrigation measures
- Mechanical land clearance using tractors, followed by development of a system of roads and paths
- Erosion control measures.

In order to keep the national-budget expenditure entailed in the use of draught animals at a comparatively low level it has proved advisable during promotion work to date to make animal traction one element of an overall extension programme for the farmers. It is thereby possible at the same time to instruct them on improved cultivation techniques, the use of mineral fertilizers and plant protection agents and other subjects.¹⁾ The measures which agricultural extension theory refers to as "package programmes" appear to be the best and least expensive way of convincing African smallholders of the advantages of draught animals.

When planning an actual project it is of course also necessary to weigh up all the above-mentioned preliminary and framework measures from the point of view of cost and returns in comparison with other potentially alternative forms of agricultural mechanization, for from the macroeconomic angle, and particularly as regards burdening or easing of the national budget, it is only rarely practical to give one single level of mechanization priority for every possible size of farm or system of farm organization.

3.2.4 Employment²⁾

A comparative assessment of the employment effects of agricultural mechanization projects at various levels must consider the climatic framework conditions and the existing population density as the most important basic factors and these two elements are in most cases closely interrelated.

If the employment effect of animal traction and that of tractor-based technology is analysed - in comparison with manual labour each time - with relatively little differentiation, it simply becomes apparent that tractor-based technology usually releases far more labour than the use of draught animals. However, this is not always the case and when an actual project is being considered its indirect effects on the job situation should be given particular consideration alongside its effects on the preceding and subsequent sectors.

1) As is done, for example, in Tanzania as part of the National Oxenisation Programme or in Senegal, Mali, Cameroon and the Central African Republic, where the C.F.D.T. (a French cotton production agency) in particular has developed and promoted this type of extension work (cf. also the country-by-country tables in Part A).

2) In a macroeconomic assessment the "employment criterion" relates to the project's effect in terms of the creation (or reduction) of jobs. The total number of additional jobs created or the amount of investment per job can thereby be used as competition criteria in a comparison with other projects.

YUDELMANN et.al. (1971) use a number of case studies to demonstrate that the introduction of tractor-based technology has led to a dramatic reduction of labour requirements in agriculture in some developing countries. However, they do not reject this type of mechanization on a general basis but instead propose "selective mechanization", which in particular can overcome seasonal labour peaks without releasing workers. "Selective mechanization" is regarded as being the "optimum" form which fully takes into account the economic, technical, climatic and social framework conditions.

CARILLON/LE MOIGNE (1975) report that in Senegal, Mali, Cameroon and Madagascar the use of draught oxen creates a relatively large number of jobs, and not just in the agricultural sector. In these countries the factor preventing still more marked employment effects was usually the lack of suitable draught animals.

According to CLAYTON (1972) the use of draught oxen can also have considerable detrimental effects on the employment situation as was the case, for example, in Uganda, where animal traction was for a time promoted as a form of mechanization requiring particularly little capital. In the same article he cites examples of the successful promotion of tractor-based technology which created additional jobs, mostly in the non-agricultural sector.

The numerous factors influencing the employment effects of agricultural mechanization make it impossible to select individual aspects and consider them in isolation. A usable analysis must therefore always include the related areas as well (cf. also e.g. FAO, 1975).

In relatively arid regions, which on account of their climate generally have a low population density and can often be used only for extensive grazing (permanent arable farming being in most cases impossible), agricultural mechanization is of little importance. In cases of need, however, tractor-based technology has advantages over draught animals in such areas on account of its greater impact and efficiency in so-called "dryland farming". The employment effects are nevertheless marginal in both cases.

If any irrigation measures are implemented animal traction may achieve a certain degree of importance, particularly for smallholders (operating water wheels, tillage etc.), although this applies only if irrigated land already in short supply is not required for fodder production. Motorization (i.e. in this case the use of motor-driven pumps, small tractors etc.), which under these conditions is often the only way of permitting agriculture at all, has more positive employment effects than the use of draught animals.

In semi-arid regions of Africa, on the other hand, animal traction can become still more important, particularly if in addition to good arable land (with fairly light soils) sufficient pastureland is available together with a supply of drinking water throughout the year. Factors other than climate and population density, such as shortage of capital, lack of technical knowledge and an inadequate infrastructure, have a far more inhibiting effect on animal traction in these areas.

Experience in semi-arid regions of West Africa has demonstrated that the use of draught animals clearly has a positive effect on the degree of employment of the rural population. The need to look after the animals (feeding, care etc.) and maintain the implements (work for the local craft industries) not only safeguards jobs but in some cases also creates new ones. This effect is reinforced by the opportunities for earning income outside agriculture.

In the more humid grass and tree savannah regions the population density in relation to the available arable land (including potential arable land) - and thus the possible competition between man and draught animals - is a more important criterion in agricultural mechanization strategies. As long as sufficient arable land is available to cope with the expansion of agricultural area which results from mechanization all levels of mechanization above the manual-labour stage will to a certain extent have positive employment effects. Differences arise primarily as a result of the economic and political framework conditions.

In tropical rain forest areas motorization has clear-cut advantages over animal traction in terms of the safeguarding or creation of jobs. In many cases animal traction is not sufficient for performing the necessary land clearance work or tilling the predominantly heavy soils found in such areas.

However, the two forms of mechanization can complement each other in a practical manner if land clearance and initial tillage are performed using tractors and sowing, crop tending and harvesting with the aid of draught animals.

The relative wage level and the general wage trend are usually taken as pointers for increased use of labour-saving agricultural technologies. This means that wherever wages are relatively high or are

rising, hired labour is being replaced (in societies organized on a private-enterprise basis) by capital, i.e. for the most part machines and implements. This has only limited significance for the mechanization level constituted by animal traction, since it is used above all on family farms and in many cases employs labour which could still be replaced by "higher" levels of mechanization.

When a project is actually being planned the anticipated employment effects of alternative forms of mechanization must be subjected to an "ex-ante" examination in as much detail as possible. Consideration of the individual farms, on the basis of the labour peaks actually occurring, may often be an additional aid. In most cases, however, it is extremely difficult to quantify employment effects, particularly in the sectors preceding and following agriculture.

3.2.5 Other macroeconomic effects of animal traction

In addition to those already discussed other important macroeconomic effects may result from the use of draught animals. These, however, are of a marginal nature and it may be a long time before they materialize. For the most part they can only be roughly estimated rather than quantified:

1) Improvement of regional and sectoral income distribution

Changes in regional and sectoral income distribution result from the effects in preceding and subsequent sectors, already referred to several times (causes: increase in range of products, market intensification, involvement of local craft industries etc.). Certain problems may arise as regards income distribution, since often it is only a few farmers who will benefit from this at the start of a promotion scheme. These are mostly the wealthier or better trained farmers, which means that there may be substantial income variations to start with.

The greater the number of farmers assisted, the more positive the effects on general income distribution which can be expected.

2) Increase in capital accumulation by the rural and farming population

The contribution to capital and asset formation on assisted farms chiefly takes the form of acquisition of draught animals and implements. Although in most cases this effect can be achieved only by means of appropriate support (credit, subsidies etc.) it should under no circumstances be ignored since it forms the basis for independent further development of the work started by the promotion scheme.

3) Improvement of the level of education

Specific training and advising of farmers on matters concerning the keeping and use of draught animals, possibly combined with general extension work, produces a certain improvement in the general level of education.

4) Improvement of the food situation

Improved nutrition (and thus health improvement as well) is based on the higher yield level which can be attained using animal traction and on the potential for diversifying farm production (various crops, integration of livestock husbandry etc.).

3.3 Methods of assessing the macroeconomic effects of a project

The methods available for assessment of project approaches and effects - in terms of the overall or regional economy - essentially comprise three procedures which are also suitable for evaluating development projects aimed at promoting agricultural mechanization (see also RUTHENBERG, H., 1976 and GITTINGER, 1973).

- 1) The "cost-effectiveness analysis" is mostly used wherever only the costs of a project (or measure) are to be ascertained in monetary terms with little or no consideration of output or benefits. This is often the case when dealing with effects in the social sphere, e.g. if the employment effects of a project measure and/or indirect effects of extension work are to be set against the costs which they cause. In "ex-ante" project planning using possible project alternatives the "degree of target achievement" is used as an assessment criterion. The alternative which entails the lowest macroeconomic costs in achieving the desired targets is regarded as the best.

This method is only partially suitable for planning and evaluating projects to promote animal traction; it can often be used only for certain aspects of an overall scheme.

- 2) In a macroeconomic "cost-benefit analysis" the results achieved on individual farms and the project's planning data (cost and benefits) are determined - or in some cases estimated - over a period of time and taken as a basis for the assessment. The difference between the payment flows, i.e. the macroeconomic costs and benefits determined, yields the project's contribution to the national income (net value added) as the most important yardstick of success.

The evaluation criteria used in the cost-benefit analysis in the

narrower sense are the internal rate of return (on the funds used), the capital value and/or the cost-benefit ratio. In addition to the internal effects of the project external ones can also be considered depending on the extent of the evaluation (RUTHENBERG, 1976).

The internal effects of a project are based on the impact of the actual project measures, e.g. the desired improvement of farm incomes with the aid of appropriate mechanization and/or the establishment and operation of project institutions. External effects, on the other hand, are to be found outside the project, e.g. in the sectors preceding and following agriculture. It may be relatively difficult to make this distinction.

Working on the basis of profitability calculations for individual farms, this evaluation method is used to determine macroeconomic costs and benefits through "extrapolation" of the figures from the microeconomic sector (see Table B/IV/11).¹⁾ Problems may, however, arise through the need to include

- several production periods (or years) or
- various mechanization and yield levels, as well as in
- pricing.

Extensive preliminary calculations are usually necessary in practice, i.e. they must be substantially more differentiated and comprehensive than those in the example given here.

In order to permit ascertainment of all costs entailed in setting up and implementing the project these costs must be systematically assigned to the areas of the project giving rise to them. Only when this has been done in as much detail as possible can they be set against the macroeconomic benefits resulting from the "extrapolation" and the external effects of the project.

A value can be placed on the costs and benefits involved in the following ways:

- According to LITTLE, I.M.D. and MIRRLEES, J.A., on the basis of world market prices.
- Using the UNIDO method, based on current domestic prices.
- Using the WORLD BANK method, on a combined basis of world market prices and domestic prices.

1) This area cannot be discussed here in greater detail. Descriptive instructions on use of this method are given, for example, by DOPPLER, E., (1978) and the authors to whom he refers.

The opportunities for using a macroeconomic cost-benefit analysis are largely limited to the examination of the economic effects of a project. This type of analysis makes it possible - depending on the quantifiability of the criteria for determining relative advantages - to evaluate alternative forms of a project; if agricultural mechanization is to be promoted, therefore, this means examining which form of mechanization is the best in economic terms under the given conditions from the national point of view.

Despite the large amount of calculation work involved, based on as broad a range of data as possible, the cost-benefit analysis is the most suitable and informative method for macroeconomic assessment.

- 3) A "utility-value analysis" also investigates the degree to which the targets of planned and/or realized projects are achieved. An attempt is made to include and evaluate (weight) all possible targets and a utility-value matrix is formulated for this purpose.

This method is suitable for assessing agricultural mechanization projects, particularly if the task is to investigate which form of agricultural technology best achieves a wide variety of macroeconomic, regional and target group-specific objectives. The importance of the utility-value analysis is increased by the opportunities it offers for including targets in the social sphere and those which cannot be quantified in monetary terms.¹⁾

1) For a more detailed methodological description see GITTINGER, DOPPLER and RUTHENBERG.

TABLE B/IV/11: THE PRINCIPLE OF "EXTRAPOLATION" FROM THE MICROECONOMIC TO THE MACROECONOMIC LEVEL ON THE BASIS OF A THEORETICAL COMPARISON BETWEEN THREE LEVELS OF MECHANIZATION (IMAGINARY FIGURES GIVEN IN MONETARY UNITS)¹⁾

LEVEL/PROJECT YEAR MECHANIZATION LEVEL ^{A)}	1980			1981			1982			1983			1984		
	ML	AT	T	ML	AT	T	ML	AT	T	ML	AT	T	ML	AT	T
MICROECONOMIC LEVEL															
1) YIELDS FROM MAIN MARKET CROPS (100 KG/HA) ^{B)}	6	6.6	6.3	6	7.25	6.6	6	8	7	6	8.8	7.4	6	9.7	7.8
2) PRODUCT PRICE (MU/100 KG)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
3) CROP AREA IN HA ^{C)}	10,000	14,000	15,000	10,000	18,000	20,000	10,000	22,000	25,000	10,000	26,000	30,000	10,000	30,000	35,000
4) INCOME: (1)x(2)x(3) IN 1000 MU	600	924	945	600	1,305	1,320	600	1,760	1,750	600	2,288	2,220	600	2,910	2,730
5) EXPENDITURE IN 1000 MU ^{D)}	200	700	900	200	900	1,200	200	1,100	1,500	200	1,300	1,800	200	1,500	2,100
6) SURPLUS INCOME (4)-(5) IN 1000 MU	400	224	45	400	405	120	400	660	250	400	988	420	400	1,410	630
ADJUSTMENT 2)															
7) TRANSFER PAYMENTS FOR SINGLE-FARM INCOME IN 1000 MU ^{E)}	-60	-92.4	-94.5	-60	-130.5	-132	-60	-176	-175	-60	-228.8	-222	-60	-291	-210
8) TRANSFER PAYMENTS FOR SINGLE-FARM EXPENDITURE IN 1000 MU ^{F)}	--	-70	-30	--	-90	-40	--	-110	-50	--	-130	-60	--	-150	-70
MACROECONOMIC LEVEL															
9) SURPLUS INCOME (6)-(7)-(8) IN 1000 MU ^{G)}	340	61.6	-79.5	340	184.5	-52	340	374	25	340	629.2	138	340	969	350

1) BASED ON DOPPLER, W. (1978), "EINFÜHRUNG IN DIE PROJEKTPLANUNG UND PROJEKTBEURTEILUNG".

2) NUMEROUS INDIVIDUAL ITEMS MAY BE REQUIRED AS ADJUSTMENT FACTORS IN ACTUAL PRACTICE BUT ONLY TWO ARE GIVEN HERE IN THE INTEREST OF SIMPLIFICATION. ALL DATA AND ASSUMPTIONS GIVEN MUST BE DETERMINED OR CALCULATED IN DETAIL WHEN USING THIS SYSTEM.

A) ML = MANUAL LABOUR; AT = ANIMAL TRACTION; T = TRACTORS; MU = MONETARY UNITS.

B) TO SIMPLIFY MATTERS ONLY ONE MARKET CROP IS CONSIDERED, ALTHOUGH SEVERAL CAN BE INCLUDED IN PRACTICE. IT IS ASSUMED THAT YIELDS ACHIEVED WITH MANUAL LABOUR REMAIN CONSTANT, THAT THOSE ATTAINED USING ANIMAL TRACTION RISE BY APPROX. 10% PER YEAR WITHIN 5 YEARS (EFFECT OF DUNG) AND THOSE ACHIEVED USING TRACTORS BY ONLY AROUND 5% (NO ORGANIC FERTILIZER).

C) WITH MANUAL LABOUR THE CROP AREA REMAINS CONSTANT SINCE CAPACITY IS FULLY UTILIZED, WHILE WITH ANIMAL TRACTION IT INCREASES BY 200% WITHIN 5 YEARS (150% RESULTING FROM EXPANSION OF THE AREA CULTIVATED PER FARM AND 50% RESULTING FROM AN INCREASE IN THE NUMBER OF FARMS USING DRAUGHT ANIMALS).

D) THE FOLLOWING PER-HECTARE OPERATING EXPENDITURE IS ASSUMED: MANUAL LABOUR: 20 MU (CHIEFLY LABOUR COSTS); ANIMAL TRACTION: 50 MU (ALL COSTS OF USING DRAUGHT ANIMALS); TRACTORS: 60 MU (COST OF HIRING TRACTORS AND IMPLEMENTS).

E) E.G. NATIONAL-ECONOMY EXPENDITURE ON EXTENSION SERVICES AND MARKETING (TRANSPORT) ETC., GIVEN HERE AS 1 MU/100KG OF MARKET CROP.

F) E.G. SUBSIDIES FOR PRODUCTION INPUTS, GIVEN HERE AS 2 MU/HECTARE OF CROP AREA (FOR MACHINE STATIONS) IN THE CASE OF TRACTOR USE AND 5 MU/HECTARE IN THE CASE OF ANIMAL TRACTION, SINCE IT IS ASSUMED THAT THE LATTER TECHNOLOGY IS GIVEN PARTICULAR SUPPORT ON ACCOUNT OF ITS MICROECONOMIC ADVANTAGES FOR INDIVIDUAL FARMS.

G) ON THE BASIS OF THE ASSUMPTION MADE HERE ANIMAL TRACTION PRODUCES A HIGHER MACROECONOMIC INCOME THAN MANUAL LABOUR AS EARLY AS THE THIRD YEAR, WHEREAS THIS DOES NOT OCCUR UNTIL THE FIFTH YEAR IF TRACTORS ARE USED.

H) THE SURPLUS INCOME GIVEN IN LINE 9, SUPPLEMENTED BY ANY INCOME RESULTING FROM THE INDIRECT OR EXTERNAL EFFECTS OF THE PROJECT, CAN NOW BE SET AGAINST THE MODEL TOTAL OF THE (PROJECT) COSTS FOR EACH MECHANIZATION LEVEL IN THE COURSE OF A MACROECONOMIC COST-BENEFIT ANALYSIS.

4. Conclusions

Smallholdings will in the long term continue to be the predominant type of farm in the majority of developing African nations. The problems - which have already been repeatedly referred to - of providing sufficient energy sources for tractor-based agricultural mechanization, coupled with the related logistic problems, mean that there is a certain need to give increased promotion to animal traction as the more appropriate form of mechanization. The examples given show that the use of draught animals is a suitable means for increasing agricultural production from both the microeconomic and macroeconomic points of view. Besides this contribution to the overall economic objectives of most African countries it can provide substantial help in achieving other macroeconomic targets, as has been briefly described under the individual assessment criteria.

However, the current shortage of empirical data (research findings, studies etc.), particularly on the macroeconomic classification of animal traction in comparison with other forms of mechanization - may as a result of the latest energy price developments, lead to certain incorrect estimations. The majority of the findings available so far are already outdated as a result of the changed situation; new research in this area - if possible of a highly empirical nature - is therefore necessary and will undoubtedly call for different assessment criteria from those used previously.

Appropriate forms of agricultural mechanization - and animal traction must be placed in this category for much of Africa - must take into account all the technical, economic and social conditions of the situation in which they are to be used. When the opportunities for using draught animals are being investigated, therefore, all important parameters and framework conditions (see Part A) should be analysed and considered during project planning, despite the highly complex and interdependent relationships among them.¹⁾

Appropriate promotion measures should not be initiated until this work is largely completed and the results obtained permit decisions to be taken in favour of one form of mechanization or another.

1) The "checklist" given in Part A, Section 4.4 of this handbook can be used as a basis.

The introduction or promotion of animal traction should be started only in regions where

- the specific framework conditions favour this;
- competitive advantages over other forms of mechanization can be determined at individual-farm level and it is likely that the farmers will be prepared to adopt the technique on account of the social and economic conditions;
- the macroeconomic assessment criteria speak more strongly in favour of animal traction than other forms of mechanization.

With regard to the last-mentioned aspect it is essential above all that there should be complete agreement among all the political decision-makers involved in the country in question. In this connection it would be desirable if all the donor countries' activities in the area of agricultural mechanization could be coordinated to a very large extent in order to permit the introduction of a mechanization strategy which is as uniform and appropriate as possible.

B/V

Sociology and social anthropology

B/V SOCIOLOGICAL ASPECTS OF THE USE OF DRAUGHT ANIMALS ON AFRICAN
SMALLHOLDINGS

(D. Kalb)

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1. Preliminary remarks

The aim of this section is to supplement the technical aspects of animal traction described in Part B and give a survey of the most important sociological factors involved in the promotion of animal traction on African smallholdings.

This intention is confronted with the basic problem that there are very few systematically collected and examined empirical data on the numerous social aspects of the use of draught animals in an African context. This can be attributed to the fact that animal-traction projects have frequently been dominated by factual knowledge in the fields of agricultural engineering and agricultural economics, with the result that under these circumstances systematic recording of social factors and analysis of their influence on animal-traction projects was possible only in rudimentary form. In feasibility studies, project evaluations and the like, therefore, sociological data on the use of draught animals often only take the form of marginal notes and in most cases cannot be generalized beyond their immediate local or regional context.

Moreover, it is noticeable that even in the academic field of social research there has to date been little interest in agricultural mechanization schemes in general and animal-traction projects in particular, so that these circles have also failed so far to make much effort to remedy the existing shortage of information.

In view of the lack of data the following approach was chosen for this section:

The first part describes the essential sociological features of African smallholders in terms of their relevance to the use of draught animals. This will be illustrated by examples as far as the available data permit.

Following this description of the general characteristics of the social environment in which animal-traction projects are required to operate, the second part of this section formulates criteria for the implementation of projects aimed at promoting the use of draught animals. It is implied that the greater the extent to which these criteria can be met in the course of project implementation, the more likely it is that the innovation will be adopted by target groups to which the features described in the first part apply.

The most important findings of this section were finally compiled to form the "checklist" set out and briefly discussed in Part A of this handbook (see Section A/4.4).

2. Social characteristics of African smallholders

2.1 Social division of labour and cultural identity

One of the most prominent features of traditional African agriculture is its often very rigid separation of arable farming and livestock husbandry. Mixed farming of the type familiar in Europe is only widespread in places where it was introduced or forced onto the African continent from outside as a result of European colonialism. The traditional form of social division of labour between the subsistence farmers earning a living from crop growing and the nomads with a livelihood based on stock breeding must be regarded as an optimum method - developed over the course of time - for using available resources under given ecological conditions. It is therefore determined to only a small extent by market conditions, being influenced more by natural factors such as climatic conditions, particularly amount of rainfall and guarantee of precipitation, together with the amount of family labour available and - for the nomads - the fertility of the herds.

The fact that the two types of production are seldom or never found in an integrated form can be initially ascribed to environmental conditions such as climate, vegetation and amount of rainfall, which often mean that only one of the two forms is practicable at all in the long run. In parts of Africa where both forms would be possible from the point of view of ecological conditions, the separation can be explained by the fact that, on the one hand, clearly defined rainy and dry seasons, together with the plants' correlated growth and stagnation period, mean that stock breeding is possible only on an extensive nomadic basis. On the other hand, the seasonal nature of crop growth leads to marked seasonal labour peaks in arable farming which, given the predominantly low standard of agricultural means of production, require the entire family labour capacity, so that there is not enough time left for the keeping of heavy livestock and the resulting lengthy treks to pastures and waterholes. The ownership of livestock, particularly cattle, is therefore limited for the most part to farmers possessing a high status who have at their disposal a potential labour supply greater than that required for direct reproduction.

Under certain conditions, therefore, it is above all the limited nature of the "labour" factor which forces the population living

under traditional conditions to devote more or less exclusive attention to one of the two sectors of production. The remarkable rigid form taken by traditional social division of labour is thus attributable in the long run to the fact that it represents a reaction to natural production conditions which are almost impossible to influence using conventional means.

The rigidity of the social division of labour resulting from the dependence of agricultural production on natural conditions is increased still further by the fact that in the African context different basic forms of production usually correspond to ethnic differences and thus to varying languages, myths, rituals, ideologies and lifestyles:

"L'agriculture et l'élevage des bovins ne sont pas deux professions agricoles, mais deux modes de vie de l'homme africain."
(CASSE et al., 1965)

The different types of production and lifestyles correspond at the psychological level to different sociocultural identities. The change-over from one area of production to the other is therefore not only determined by access to specific resources (land, livestock etc.) but also simultaneously necessitates giving up a specific sociocultural identity in favour of a different one.

HAALAND (1972) has described this phenomenon, taking as his example the interaction in the western Sudan between the crop-growing Fur and the nomadic Baggara.

Like most African smallholders the Fur use any surplus agricultural income to invest in livestock, particularly cattle. Due to environmental conditions, the cattle must be entrusted to the Baggara nomads during the dry season, who take them on their treks together with their own herds. The specific contract conditions, however, result in reducing the utility value of the animals for the Fur, while increasing the risk of loss at the same time, since the Baggara keep the milk produced by the cows as a kind of wage for looking after the animals but assume no responsibility for losses. One way of solving this dilemma would be for the Fur farmers to migrate themselves once their herds reach a certain size (around 7-10 cows), initially only during the dry season, and, after the herd increased, to change over completely to the nomadic mode of production and lifestyle.

This occurs once the herd comprises around 20-25 cows and the change-over simultaneously involves a change of identity:

"The style of life associated with cultivation is categorized as Fur, the pastoral way of life as Baggara. By practising nomadism, persons perform an activity that identifies them as Baggara. A Fur is thus categorized as a Baggara the day he

leaves the village and migrates with his cattle. (...) In other words, he is ascribed Baggara identity the day he goes to camp." (HAALAND, 1972:164)

The important feature here is that the change of identity is not simply an individual psychological process but rather that the Fur farmer is ascribed a different identity as soon as he adopts a different production strategy; or, in other words, he maintains his old sociocultural identity precisely because he does not adopt certain production strategies, no matter how practical these might seem from the technical or economic angle. This can be illustrated by two of HAALAND'S examples:

The Fur regard milking cows as women's work and it is considered shameful for men to perform it. Once Fur start to migrate, however, the cows are milked by both men and women, as is the case with the Baggara, without this being regarded as a disgrace.

"A Fur from the village does not consider it shameful for a nomadized Fur to milk because the nomad is considered to be in a category to which Fur standards are not applied." (HAALAND, 1972:164)

Once a Fur returns and resettles in the village, however, his identity changes again: Fur men no longer milk the cows, for this would be regarded as shameful and would be sanctioned accordingly.

The second example directly concerns the subject of this study. The Baggara, as one of the nomadic cattle-owning tribes in Africa, use oxen for riding and for transport purposes. The possibility of using oxen as beasts of burden and for riding, together with the resulting advantages in the form of facilitation of work and time savings on necessary transportation jobs, is also familiar to many other ethnic groups far beyond the direct migration area of the Baggara. This method is nevertheless employed only by the Baggara since the use of oxen for transport purposes is a major feature of the Baggara identity. A Fur will therefore use oxen for transport work only when he starts to migrate with his herd and is thus ascribed Baggara identity. Once he returns to the village and resumes arable farming he will no longer use his oxen as beasts of burden, even though he did so previously and thereby experienced at first hand the practical benefits of this method.

These examples demonstrate that in the African context production methods - or, in more general terms, technologies - are not neutral with respect to existing cultures and values, but are perceived as features of a specific ethnic or sociocultural identity. Adoption of such "new" methods, as it were, therefore requires not only a decision motivated by considerations relating to economics or production strategy but also a change of identity which often entails a change in social relations and lifestyle. It also becomes apparent

that the system described can have a substantial inhibiting effect on the flow of innovations between various ethnic groups. HAALAND assumes that the mechanisms described do not just represent a local phenomenon in the western Sudan but that his observations are also valid for other parts of Africa with similar ecological conditions.

I observed a similar phenomenon in a Zigua village in Handeni district, Tanzania, in early 1980. During our visit a number of Zigua farmers complained that the village's only watering place was several kilometres away and that substantial time and effort were required to fetch water each day. This village is located on the edge of the Masai Steppe and there is therefore frequent contact with the Masai. The Masai use donkeys for transport work such as fetching water and everyone in the village is familiar with the advantages of this method from first-hand observation. Although the majority of the Zigua farmers would certainly be able to keep a donkey, all those questioned replied that they could not use donkeys to fetch water since only the Masai did this. Use of donkeys for transport purposes is indeed an important and well-known feature of the Masai identity and the only solution to the dilemma which the Zigua farmers could visualize was that the government should lay a water pipe to the village or sink a well there (LINK/KALB, 1980).

This example shows that the above-mentioned association of apparently neutral production methods with a specific ethnic or cultural identity can also relate to animal traction, because the use of draught animals is not just an innovation in the sense of the introduction of more productive agricultural implements, but also involves a change in the use of traditional resources in the form of livestock. It is therefore likely that certain aspects concerning the animals, such as the above-mentioned use for transport purposes, or specific forms of livestock-keeping (kraals), care, feeding etc. are simultaneously identity features of a specific ethnic group. There is always a risk that this will hinder adoption of the technique if the group in question is not identical with the target group.

The possibility of this constraint to adoption of the techniques must be investigated during the planning phase of a project aimed at promoting or introducing the use of draught animals, and this is often time-consuming and expensive. The most prominent identity features can often be established by means of simple surveys, since they are known far beyond the immediate area populated by an ethnic group.

In the Sudan, for example, I discovered that the "oxen used for transport = Baggara" identity link is made even by North Sudanese tribes, some of whom live over a thousand kilometres away. The same applies to the above-mentioned identity link "donkeys used for transport = Masai" in Tanzania.

This rough clarification of the situation can never preclude the

possibility, however, that a constraint to adoption of technique - as described above - may occur during specific phases of project implementation. A more detailed sociological and/or ethnological analysis will become necessary then at the very latest.

2.2 Social stratification

Originally, social stratification in the traditional isolated subsistence sector was not very marked, the predominance of subsistence farming permitting only a limited agricultural surplus. The differences in the amount of surplus production available per production unit are attributed chiefly to the varying effects of natural factors in individual cases, e.g. growth of the family, disease, failed or particularly good harvests. Moreover, differences in terms of access to land were for the most part evened out by shifting cultivation and the effects of ecological factors (e.g. soil fertility) thus ironed out in the course of time for the individual producers. Social redistribution mechanisms were also still in existence which, for instance, imposed on the wealthier members of a society the obligation to be particularly hospitable, to look after the poor, to organize festivities etc. All these factors counteracted the development of marked social stratification under traditional production conditions.

During colonial days, however, the traditional system was integrated into a new market-oriented economic system. The increase in market production and the creation of earning opportunities outside the farm sector (colonial administration, commerce, crafts etc.) gave rise to previously unknown possibilities for increasing individual accumulation potential. In many cases the colonial governments also created differences in terms of access to these new resources - and often to traditional ones as well - by making this access conditional upon certain requirements such as education, religion or political beliefs. The social distinctions in the subsistence sector therefore increased as the sector was integrated into the colonial system. This trend continued even after decolonization, often as a result of both national and international economic and development policy. Nowadays, therefore, even in the subsistence sector with its apparently uniform social structure, one is likely to find more or less marked social stratification, except perhaps in extremely remote areas where the original form of shifting cultivation is still practised.

Differences in socioeconomic status in the African smallholding sector are largely characterized by the uneven distribution of the following factors:

- 1) Ownership of livestock, particularly cattle: Under traditional conditions livestock and above all cattle are one of the main targets for the investment of surpluses. Possession of a number of cattle therefore always indicates that a farmer produces regular surpluses. The fact that ownership of cattle is often unevenly distributed, i.e. often only a minority in a village will own cattle, means that this is usually a good indicator of socioeconomic status.
- 2) Above-average labour supply per production cell: This means that the production unit with higher status (e.g. the family) has a larger labour force available than the average. This advantage stems from two causes. Firstly, there may be more family labour available because the farmer has two or more wives. In view of the fact that in Africa a price must be paid for a wife, e.g. in the form of cattle, every marriage requires the accumulation of surplus beforehand.

Another way of increasing the potential labour force is to employ hired labourers, usually on a seasonal basis. This also calls for surplus production on the part of the employer and today this must be available - at least in part - in the form of cash. On smallholdings, therefore, continuous hiring of labour is also an effective indicator of a high socioeconomic status.

- 3) Cultivation of more land than the average: With the given standard of the production inputs (and even with partial mechanization) cultivation of a larger area than the average always requires that a larger labour force than the average should also be available, be it in the form of increased family labour, hired labour or a combination of the two.
- 4) Access to non-agricultural sources of income: Access to additional non-agricultural sources of income (e.g. trade, crafts, paid administrative functions etc.) leads to a regular cash income which can be wholly or partially invested in agriculture, e.g. for hiring labourers or purchasing additional cattle. Access to such sources of income is also subject to certain prerequisites: trade requires prior accumulation of a certain minimum amount of capital;

craft calls for special qualifications and surplus income for the purchase of tools, raw materials and so on; execution of paid administrative work necessitates a certain standard of education and often also the right contacts.

The four types of resources described here are mutually transformable, i.e. having one of them available facilitates access to another, thereby speeding up the accumulation process. A farmer possessing a high socioeconomic status in the sense of having one or more of these resources at his disposal is therefore in a better position than the average, from the point of view of production strategy, and this has a particular effect in times of crisis. SUMRA (1975:152) illustrates this by taking the ownership of cattle as an example:

"People with fewer cattle may find themselves with no cattle after food shortages, but people with more cattle may even be in a position to buy more cattle. The process continues whereby a person with more cattle grows richer while at the same time a peasant with no other source of income but his land finds he has no alternative but to sell his labour."

Social stratification thus occurs as the result of a process during which one group of individuals within a social unit succeeds in accumulating the strategical advantages of the use of a variety of resources, while the majority of individuals are not permitted access to these resources.

Analysis of the degree of social stratification in a specific social unit and identification of the various status groups are important when agricultural innovations are to be introduced because the economic gap between high and low status groups also takes the form of a social gap which, according to SCHÖNHERR (1975:246 ff.), prevents the spread of innovations if these are introduced via the higher status group.

A social gap expresses itself in the form of a lack of communication between wealthier farmers and those with an average or low status. So-called "elite" farmers are seldom motivated to tell average farmers about new techniques, while the latter are seldom able to overcome this gap through their own initiative. The fact that agricultural innovations like the animal traction under discussion here are usually complex means that they cannot simply be adopted on the basis of observation. The existence of a communication gap may thus hamper the spread of a technique if the innovation is introduced via "elite" farmers.

A social gap also means that the average farmer has considerable difficulty in identifying with the "elite" farmers. Average farmers usually know that their wealthier colleagues have a sound financial basis and can therefore experiment. Moreover, better-off farmers mostly have the contacts necessary to enable them to obtain inputs, credits and advice, while the situation of the average farmers is precisely the opposite.

"The activities of the elite in the area of agriculture are often of no interest to the non-progressive farmers, who find it impossible to identify with this elite". (SCHÖNHERR, 1975:247)

Experience with draught-oxen projects in Africa has proved that such projects do indeed have little broad-based effect if they are initiated via the high-status group.¹⁾ The likelihood of achieving optimum spreading of an innovation therefore increases if it is introduced via the average farmers. The conditions for this type of approach in animal-traction projects are described elsewhere in this section of the handbook.

2.3 Family division of labour

In African subsistence farming the family forms the direct unit of production and reproduction. The main criteria used to distribute the necessary work among the members of the production cell are age and sex. In a large family a third criterion may be specialization on the basis of individual skills. The actual way in which family labour is distributed among the various productive and reproductive processes varies considerably according to ethnic, cultural, ecological and geographical factors. For the majority of African countries, however, particularly south of the Sahara, the following model is probably valid:²⁾

1) cf. in particular METTRICK, 1977, for Gambia and GROSSER/PFEIFFER et.al., 1977/78, for the then Central African Empire.

2) This does not apply, for example, to a number of societies in North and East Africa like that in the Sudan. Here, married women do not work in the fields but simply do housework as well as handicrafts producing goods for sale (embroidery, basket-weaving etc.). The field work is solely the concern of the men. In the case of northern Sudan this situation is based on the Islamic norm that marriageable women must remain excluded from public life, i.e. from production as well insofar as it has to take place outside the boundaries of the home (for details cf. O'BRIEN, 1978). However, the Islamic religion is not a sufficient criterion for explaining this rigid sex-specific division of domestic production and other types, for there are numerous Islamic societies, particularly in the Sahel zone, where such a system is unknown.

All the housework is done by the woman or women and the girls from a certain age upwards. This covers jobs such as preparing food, fetching water, collecting wood etc. The women are also directly involved in arable farming, being particularly responsible for the field crops which are to be directly consumed by the family. Wherever this is ecologically possible this always includes the cultivation of vegetables and spices and in many cases a large proportion of the family's staple foodstuffs.

The men and boys, on the other hand, normally do no housework, concentrating on the field work. In addition to growing basic foodstuffs this includes cultivation of one or more cash crops which are necessary in order to meet the family's consumer-goods requirements (salt, fabrics, working implements, domestic appliances etc.) and earn surplus income to cover special occurrences such as marriages, illness, deaths etc. A characteristic feature of many societies, therefore, is the division into "men's crops" and "women's crops". This distinction refers primarily to use of the product, the labour expended to create it being of only secondary importance. This is attributable to the fact that the men frequently call upon the women to help cultivate cash crops, while the women can only expect the men to help them with certain jobs such as land clearance which usually require heavy physical work. At the same time it is often only the men who can then make use of the product and the resulting cash income.

It can be generally assumed that African women play a more productive role in agriculture than men, particularly if the necessary housework is added on to the field work. Even in the area of pure crop-growing, women often work more than men. According to a study by the Economic Commission for Africa (ECA), the West Lake Region in Tanzania is typical of this situation: on average men perform 1800 hours of field work per year and women 2600 hours (quoted according to LELE 1976:16).

JIGGINS (1978:13) is therefore justified in his criticism that the productive role of African women has frequently been ignored or underestimated by development planners:

"... mechanization programmes have been directed almost always towards men, often leaving women with a greater physical burden in the maintenance of the family, and the benefits of labour-saving accruing only to the men".

The effects of this type of mechanization scheme, geared solely to the male producers, are still more negative if an agricultural exten-

sion service - as is the case in Gambia, for example - is closely linked to a mechanization project. METTRICK regards this as one reason explaining why a draught-oxen project achieved only small increases in productivity:

"Because extension has been so closely geared to the oxenisation programme, women have been largely left out. Half the agricultural labour force responsible for a large part of the food supply is ignored by the extension service". (METTRICK 1977:35).

The examples given and experience gained in other African countries¹⁾ make it clear that as a result of the traditional form of family division of labour it cannot be expected that an animal-traction project introduced via the male producers in the target group will also affect the women and thus the entire agricultural production sector. In order to prevent the unnecessary productivity drop resulting from this type of bad planning it is first of all necessary to analyse the family division of labour and thus determine the productive role of the woman under the given conditions. Should this analysis confirm the above description of the women's productive role it is essential that the women be directly included in the project. This relates both to training in controlling draught animals and using implements as well as to more detailed extension work, for example on plant protection and fertilizing.

2.4 Land law

Despite variations in detail between ethnic groups, e.g. as regards the law of inheritance the following four features are common to traditional African land law:

- 1) All land is the joint property of a social unit, which is bound together by kinship and which, in addition to the living, also includes ancestors and unborn generations. There is no individual or private land ownership. The land is a tool but not a marketable commodity. It has no exchange value and therefore cannot be sold either.
- 2) An individual's right to arable land or pastureland in an area claimed and settled by a community is a result of his position as a member of this community. This does not preclude the possibility that under certain conditions outsiders may also be allo-

1) cf. in particular GROSSER/PFEIFFER et.al., 1977/78 and the literature referred to there.

cated land; this however, usually accompanies assimilation into the community, e.g. through marriage or adoption. The right of a member of the community to have land nevertheless does not imply a direct right to a specific piece of land, but initially only to the amount of land which he requires for reproduction purposes.

- 3) The right enjoyed by an individual as regards community land is therefore merely a right of utilization taking the form of cultivation of the land assigned to him. This right lapses as soon as the land is no longer cultivated or used for other productive purposes. The land then automatically reverts to the community and can be reallocated.
- 4) Each community contains one person or group of persons bearing responsibility for distributing and taking back land and thereby representing the rights of the community against the individual. The person or group of persons is at the same time responsible to the ancestors for ensuring that traditional laws are upheld. The person in question, usually the eldest - in the case of a family group there may be more than one - is often directly related to the ancestor who first settled on the community land and made it cultivable.

However, this form of traditional land law no longer provides an adequate description of the current land-right situation in present-day Africa. In colonial days European systems of private and state land ownership alien to African tradition were introduced, frequently entailing the use of military force. Private land ownership is thereby simultaneously the legal expression of a modified farming system which was also imported (market production) and an accompanying change in the economic function of the land.

In many countries decolonization was followed by another change in land law. The independent territorial state now became the nominal owner of all the land and the individual relationships among the landowners or between the landowners and the state were regularized by national law. The individual national land law systems vary between large-scale modern-style private ownership (e.g. Kenya) and the restoration of traditional communal ownership accompanied by the mere right of use (e.g. Tanzania). These examples, however, tend rather to represent extreme cases in present-day Africa; in most

cases both modern forms of land ownership and traditional rights will be found in a country. The varied nature of the ownership and legal situations is a reflection of the varying production conditions on which they are based; these conditions are characterized on the one hand by capitalistic agricultural production on the basis of hired labour and the beginnings of mechanization and on the other hand by traditional subsistence farming, with a variety of intermediate forms and transitional levels between the two extremes.

The higher the degree of commercialization of agricultural production in a specific region, the more private land ownership there will be. It is often concluded from this phenomenon that commercialization - i.e. the spread of "commodity-cash relationships" - breaks down traditional production conditions and legal relationships. Commercialization on its own, however, is not a sufficient explanation of the increasing changes in the traditional situation. The fact that in subsistence farming most of the produce is directly consumed and only a few needs have to be met via the market means that such societies are largely immune to commercialization.

Under such conditions private land ownership and its economic basis - land as a commodity - can only result through the additional influence of non-economic factors, the most important of which are:

- state intervention
- population growth
- ecological changes.

These factors are often in reciprocal relation to one another, i.e. they reinforce their common effect, an increasing scarcity of land. During colonial days the best land in the most favourable zones, ecologically speaking, in the majority of African countries was generally concentrated - supported by direct intervention of safeguarding by the colonial governments - in the hands of a few settlers, often Europeans. In many cases this situation did not change after independence; on the contrary, the structure of concentration was perpetuated in that the farms formerly owned by the whites were taken over by a native elite or run as state farms. The concentration movement continued after decolonization in a governmental or private form, frequently promoted and safeguarded by national or international agricultural development programmes.

Population growth also leads to a relative scarcity of land, the effect being all the greater the more ecological and legal obstacles hinder the natural migration of the population groups involved. Ecological changes such as decreasing soil fertility or a disastrous increase in desertification also reduce the availability of land.

The interrelationship between different factors, e.g. population growth plus ecologically unsuitable forms of land use resulting from misguided agricultural policy, becomes particularly clear in the case of the desertification problem. The effect of the factors described only in brief here, i.e. an absolute and relative scarcity of land, often places the people living in traditional circumstances in a marginal situation and makes these circumstances themselves more unstable.

However, projects promoting the use of draught animals which aim to improve the situation of the target groups presuppose that the direct producers will have steady and guaranteed access to the land which they require for reproduction, including land for planned expansion. The type of land law is of only secondary importance as far as this prerogative is concerned, insofar as traditional land law also guarantees lasting access to land. This is not provided via the institution of private land ownership but rather via the traditional recognition of an individual's ownership of the products of his own work which, in addition to harvested produce, include working aids and domestic articles, livestock, houses, kraals etc. Although modern land ownership cannot therefore be regarded as a prerequisite for animal-traction projects it is often advisable, in view of the specific national land law systems, to obtain formal land ownership titles for target groups living under primarily traditional circumstances.

More decisive elements in guaranteeing long-term access to land, however, are factors such as population trends, land concentration, private and state economic programmes and ecological trends in the region concerned. Analysis of these points is of major importance in the planning phase.

2.5 Features of production strategies on smallholdings

The production situation of African subsistence farmers is characterized on the one hand by limited resources and on the other hand by imponderable natural factors which cannot be influenced. Existing under conditions of which the main features are scarcity and uncertainty, the smallholder is forced to adopt production strategies which permit him to reach his paramount production target, namely guaranteeing a basic food supply for his family, with a minimum amount of risk. The rationality underlying the production strategies and forms of land use found on smallholdings is therefore aimed not so much at maximizing yields but rather at reducing risks.

"Within that objective, various strategies are adopted to spread risk and safeguard the food supply, such as (i) fragmentation of holdings and rotating cultivation rights; (ii) intercropping, staggered planting, saving of famine crops which can be stored unharvested; (iii) adjustment in management as the season progresses, e.g. by maintaining a smaller area than originally sown, concentrating on moisture-tolerant crops; (iv) reciprocal arrangements between households." (JIGGINS 1978:11)

These safeguarding strategies are often outstandingly suited to the ecological production conditions and have frequently been used successfully for centuries. On the basis of traditionally reliable methods of reducing risks, each production unit, i.e. the members of a household who are able to work, cultivates a specific area, the size of which is determined by the household's consumption needs. These needs can be roughly divided up into:

- staple foodstuffs, the need which can generally be met by growing one or two food crops, e.g. millet, maize, cassava etc.
- necessary consumer goods such as clothing, implements, salt, lamps etc. In view of the fact that these needs can in general be met only via the market they necessitate the additional cultivation of one or more cash crops, e.g. groundnuts, sesame, cotton etc.

Priority is given to safeguarding the production of basic foodstuffs rather than to cash crops.

O'BRIEN has illustrated the link between consumption needs and size of area cultivated, taking as an example the production decisions of Sudanese smallholders:

"For the larger majority of farmers in Um Fila production decisions are made on the basis of calculations of consumption needs. It is the function of the head to assess these needs,

even within certain limits to decide what they are, and then to organize the land and labour power of the unit to meet them. The first and most basic need is dura (Sorghum D.K.), the staple of the diet, to feed the members of the unit. (...) The aim of each unit head is to meet his household's dura needs directly from crops produced in his fields, while striving to meet all the various cash needs through the sale of simsim (Sesame D.K.). His calculations of household needs for each generally determine how much land is cultivated by the unit. Not surprisingly, heads of units have a very clear idea of the physical productivity of their fields. Their basic strategy is to plant about half again as much land as is required to produce enough crops to meet unit needs given a normal rainy season. Thus, if a head calculates that his unit needs 10 ardeb of dura for a year, he will want to plant for 15 ardeb. In this way his yields in relatively poor years will be sufficient to meet minimum needs. This strategy helps to cope with "normal" fluctuations in rainfall from year to year. No production strategy within the resources of the people of Um Fila can prevent the drastic consequences for current production of a catastrophic bad rainy season, but surpluses from "normal" years can be stored or saved to substitute for failed current production in subsequent bad years". (O'BRIEN 1978:12)

This example, which can be generalized beyond the scope of the case study, shows how the size of the area cultivated is determined by the household's consumption needs and a certain safety margin based on experience. It is important that the production decision be taken on the basis of a subjective evaluation of the needs to be met and not on criteria such as the maximum yield physically possible under given conditions. Subjective evaluation of expected benefit in comparison with the additional work required also tends to control expansion of the cultivated areas beyond the extent necessary for safeguarding existence:

"The peasant producer would make an increased effort only if he had reasons to believe it would yield a greater output which could be devoted to enlarged investment or consumption, but he does not push the drudgery beyond the point where the possible increase in output is outweighed by the irksomeness of the extra work". (KERBLAY 1971:153)

Projects aimed at spreading the use of draught animals essentially derive their economic justification from the possibilities they offer for expanding farm area in comparison with the area which can be cultivated using traditional production technologies (see also Section B/IV). They are therefore often confronted with the structural problem that the criteria used by advisors and target group for evaluating the benefit of such a measure may differ considerably. Whereas project planners often aim for the maximum increase possible

from the objective point of view (which under the given conditions is considered to be limited mainly by the physical capacity of the draught animals) when calculating desirable expansions of area, the farmers frequently apply different criteria and may be satisfied with an increase which is only small in comparison with that which is technically possible because, for example, they rate the innovation's ability to facilitate work and save time higher than full exploitation of economic potential. Experience gained with animal-traction projects in Africa proves that actual increases in the size of farms are therefore often far smaller than those projected by the planners.

REMY, for example, refers to an animal-traction project in Upper Volta where increases in area of 60% in the first year and 100% in the second year were planned. In actual fact, however, the farmers expanded their farms by only 33% on average over four years. According to REMY these only small increases prove that the Mossi farmers favoured a strategy which guaranteed the food supply rather than a production strategy aiming for maximum yields:

"Prudents, les exploitants ont hésité à adopter d'emblée la houe sur la totalité des surfaces cultivées, à "jouer" avec leur récolte. Et surtout ils ont réservé en priorité l'usage de la houe à la production vivrière, le surplus de récolte éventuellement obtenue étant consacré en premier lieu à mieux manger et à faire des réserves." (REMY, 1972:515)

METTRICK (1977:27) also mentions an animal-traction project in Gambia where farms were expanded by only 20-25% on average.

The problem involved in realistic planning of farm expansion is that the subjective evaluation criteria used by the farmers in the target group are very difficult to assess a priori. In actual practice they also vary greatly from group to group and do not usually become obvious until the project is being implemented. It is probably possible in general to give the planning a more realistic foundation if the basis used for calculating farm expansion is not the maximum increase which is technically or physically possible but the average number of hours worked by the farmer before introduction of the innovation. This of course requires that the figure be determined beforehand.

Another aspect which should be considered during planning is the overriding importance - for the farmer - of the minimization of production risks as against the realization of increased yields. Here again the assessment criteria used by experts and smallholders may differ substantially, e.g. as regards mixed cropping versus single

cropping or parcelled-out, scattered fields versus land consolidation. Animal-traction projects should therefore in general be designed and implemented such that they identify, reinforce and optimize the characteristic rationality of the production strategies used by smallholders instead of trying to "transplant" farm models developed on the basis of European-oriented economic rationality into a socio-economic system operating according to different structural criteria.

2.6 Taboos

Taboos can generally be regarded as means of regulating social existence "... which are provided by society in order to protect interpersonal relationships against dangerous, aggressive, fear-arousing or libidinous tensions". (PARIN et.al., 1978:103). According to a classification scheme devised by FREUD (1956:30f.), the prohibitions imposed by taboos may - permanently or temporarily - cover the following:

- Humans (forbidden to touch the chief, to work on specific days, to have sexual intercourse with menstruating women; incest taboo, etc.)
- Animals (forbidden to keep, kill or eat certain animals)
- Miscellaneous objects such as plants, trees, specific localities etc.

In terms of function the prohibitions imposed by taboos are similar to norms laid down by law. However, the difference is that infringement of a legal norm initially results in a trial and subsequently in sanctions imposed and implemented by humans, while breaking a taboo automatically brings its own punishment, so to speak. The method by which taboos operate therefore presupposes a certain mental attitude which FREUD referred to in his classic work as "taboo anxiety". This is based on the belief that conscious or unconscious infringement of a taboo would disturb the rest of ancestors, spirits or demons who would then take their revenge by bringing misfortune and death upon the offender or the entire community. The ancestors, spirits and demons incensed by the breaking of a taboo can and must be appeased by means of propitiation ceremonies.

In psychological terms the observance of taboo rules is founded in the mechanism for avoiding socially defined situations triggering extreme fear. The fear aroused by the breaking of a taboo in some

cases can be so great that it automatically leads to the death of the person involved.

"There are reliable reports that unknowing violation of such a prohibition does in fact automatically produce its own punishment. The innocent offender who has, for example, eaten an animal forbidden to him, becomes severely depressed, anticipates his death and then actually does die." (FREUD, 1956:29)

In addition to regulating social relationships, e.g. protecting chiefs or other local dignitaries from the envy of their subjects, protecting women and children against interference, maintaining the exogamy rule through the incest taboo or providing protection against dangers connected with touching corpses or eating certain foods, the observance of taboo rules also has the important function of identity formation.

"There is almost no better way of feeling solidarity with a group of people and distinguishing oneself from other groups than by sharing the same objects of avoidance. The individual's feeling of identity is dependent on social features, i.e. easily perceptible signs of affiliation on the part of the other members of the group. (...) It is not just any traditional taboos which are observed but precisely those which impart the uniting feeling of identity wherever it is wanting." (PARIN et.al., 1978:105f.)

The function of identity formation through the division from other groups by means of submission to certain common prohibitions is particularly evident in totemism, a special form of taboo. The essential feature of totemism is that it is forbidden to kill and eat the totem animal of one's own clan; sometimes sexual intercourse with members of the opposite sex subject to the same totem is also forbidden.

I shall now use the above-mentioned classification system devised by FREUD to describe in simpler form the potential effects of taboos on the spread of animal traction.

a) Animal taboos

The most serious problem would probably be a case where the draught animal was the subject of a taboo or was the totem animal of the target group; this would represent an obstacle to acceptance which would be practically impossible to influence. This, however, would probably be a rare occurrence. For obvious reasons animal taboos do not usually relate to domestic or productive animals and totem animals are usually wild creatures. This possibility should nevertheless be considered.

Moreover, there are cases, particularly among tribes or races engaging in traditional cattle-keeping, where it is forbidden to kill and eat cattle even though they are not totem animals in the stricter sense. Certain Dinka tribes in the southern Sudan, for example, refuse to slaughter their animals for anything other than ceremonial purposes because they believe that the other cattle in the herd could take offence and fall sick, die or run away out of revenge.

Lastly, it may be forbidden to keep certain animals or allow them to remain within a village. In this case it should be determined whether this is a genuine taboo based on taboo anxiety or whether it is simply an agreement among the village people, for example in order to protect the crops. In the latter case it might be possible to change the situation, whereas a genuine taboo can almost never be modified in the course of a development project.

b) Taboos relating to humans or human behaviour

Within this category it is probably only work taboos which are of direct significance. Such taboos forbid work, for example, on specific days of the week or on the occasion of certain events such as births and deaths. The taboo forbidding women to work during menstruation is widespread in Africa. In view of the fact that a certain minimum working period is required for reproduction, work taboos are always of a limited duration and it therefore should not be assumed that they represent a serious obstacle to the introduction of draught animals.

c) Object taboos

Taboos in this category concern objects such as plants, houses, trees and implements or specific locations. It can be assumed that most crop plants are not the subject of taboos. Object taboos may be attached permanently or temporarily to specific localities or areas: burial places, places where serious crimes were committed or areas where "spirits" who could threaten anyone entering the place reside permanently or temporarily. PARIN et.al. (1978: 104), for example, refer to a taboo observed by the Agni in the Ivory Coast prohibiting them from going into the forest on Thursdays, because on this day the forest is the domain of the spirits who would kill any trespasser. However, areas or locations to which taboos are attached are generally limited in size or subject

to the taboo for a specified period only, so that they do not represent a serious obstacle to the introduction of draught animals.

Lastly, reference should be made to an object taboo widespread in certain parts of Ethiopia which forbids women to touch ox-drawn ploughs. However, the use of draught oxen has been traditional for centuries in Ethiopia, from which it must be concluded that this taboo was probably not created until after the technique had been introduced and spread and therefore did not seriously hinder it.

3. Sociological aspects of the implementation of animal-traction projects

3.1 General criteria concerning the process of innovation adoption

In the first part of this section it has been repeatedly pointed out that the ideas held by the expert advisors and the target group as regards the usefulness of an innovation or project measure may differ considerably. Although technical and economic suitability of an innovation for achieving a given target are necessary prerequisites, they are not sufficient to ensure that the innovation is accepted and becomes widespread. Instead, the degree of suitability (feasibility) of an innovation as determined by experts must be regarded as such by the target group as well. In the long run, therefore, it is not just the objective economic and technical features of an innovation which decide whether it will be accepted, but also the perception of these attributes by the target group.

"It is the attributes of a new project, not as seen by experts, but as perceived by the potential adopters, that really matters." (ROGERS/SHOEMAKER, 1971:137)

ROGERS and SHOEMAKER have developed a classification system comprising five criteria which describe in universally applicable terms the perceived attributes of innovations. They thereby hold the view that the more the following criteria are fulfilled (or, in one case, not fulfilled) the likelier it is that an innovation will be accepted and the higher its adoption rate will be. The five criteria constituted by observability, trialability, complexity, relative advantage

and compatibility will now therefore be described in brief in the light of their relevance to animal traction as an innovation.

3.1.1 Observability

This criterion is fulfilled if the results of an innovation are visible to the members of the target group, this being all the more important if the innovation is totally new to them. Particularly in places where animal traction is totally unknown, therefore, projects promoting it should attach paramount importance to correct, continuous demonstration of the technique in order to illustrate clearly its benefit, i.e. tillage of a given area in less time and with less labour than is possible under conventional conditions. It is important that use of the technique be demonstrated under circumstances typical of the production conditions for the target group and it may therefore be insufficient simply to set up a central demonstration farm.

The link between observability and adoption rate is substantiated by the results of animal-traction projects in Africa. For example, METTRICK (1977:6) points out with regard to Gambia that the proximity of the project area to Senegal and the resulting contacts between the target-group farmers and Senegalese ox-farmers had a positive effect on adoption of the innovation by the Gambian target group. GROSSER/PFEIFFER et.al. (1977/78:196) report similar findings in the Central African Republic.

LINK/KALB (1980:43f.) pinpointed insufficient observability for the actual target group as one factor contributing to the failure of a draught-oxen programme in Tanzania.

3.1.2 Trialability

This criterion is fulfilled if the members of the target group can try out the innovation on a small scale and can experiment with it. Whereas one function of observability is to arouse the target group's interest in the innovation, trialability should enable the farmers to gain practical experience in using it. It is often vital for a smallholder to examine in detail the effects of an innovation in comparison with the techniques used previously, since in view of his limited resources uncritical and untested adoption of an inappropriate innovation would directly endanger the basis of his existence. The frequently observed cautious approach to the use of draught

animals adopted by smallholders - with only small increases in area during the initial period - can without a doubt also be ascribed to the fact that many farmers, adopting a strategy founded on experience and aiming to safeguard their livelihood, prefer first to try out the innovation and gain practical experience with it on a limited scale before using it for their production as a whole.

Trialability, like observability, is thus more important for "early innovators" than for those coming after them, provided that the production conditions for both groups are similar and that there is little or no social distance between them. It is these conditions which will make the experience of the "early innovators" of use to those following them in that this reduces the risk entailed in adopting an innovation.

3.1.3 Complexity

This criterion relates to the perception of an innovation as being difficult to understand and use. Complexibility has a negative effect on the adoption rate, i.e. the more complex an innovation is regarded as being, the less likely it is that it will be adopted and will spread. Use of draught animals is more complex than hoe agriculture insofar as the farmer is required to master not only the use of a new tool, e.g. an ox-drawn plough, but also the method of controlling the draught animals. Moreover, the use of draught animals normally requires cooperation between two people, which may increase the impression of complexity for farmers previously used to working solely on their own.

From the point of view of the project complexity of an innovation always necessitates intensive training, followed by continuous extension work. It is extremely important that the instructor and extension workers themselves are fully conversant with the technique and can skilfully impart it to others. On some well-known animal-traction projects, e.g. in Tanzania, this has not been the case, with the result that the target group regarded the innovation as over-complex (cf. LINK/KALB, 1980:45).

The complexity angle should also be borne in mind when selecting implements. A simple design should always be given preference over a more complex one; this applies in the initial phase particularly for multi-purpose implements.

In this connection METTRICK (1977:9) points out that one reason why introduction of a multiple tool frame in Gambia was a failure was that a spanner was required to fit the attachments.

Lastly, the complexity angle should also be discussed with regard to so-called "innovation packages", i.e. several coordinated individual innovations (e.g. draught oxen plus inorganic fertilizer plus hybrid maize). The danger here is always that only the simpler elements of the package will be adopted and the more complex ones discarded. This was obviously the case in Upper Volta, where the use of draught donkeys was offered as a package together with inorganic fertilizers and row seeding but only the two last-mentioned - and less complex - innovations were adopted by the farmers (REMY, 1972: 516). In general it is advisable not to design animal-traction projects as packages but rather to refrain from offering relevant additional or complementary innovations until animal traction has really become established among the target group.

3.1.4 Relative advantage

Relative advantage refers to the perception of an innovation as being better, more useful or more advantageous than the traditional techniques which it is to supersede. Whether an innovation is perceived as advantageous or disadvantageous thus depends on the dimension used to evaluate it. However, the relative advantage of an innovation can be assessed on the basis of a number of dimensions, e.g. economic profitability, reduction of risks, facilitation of work and so on. It is sociocultural factors which determine to a large extent which of these dimensions will be used by a target group to assess the relative advantage of an innovation. The likelihood of varying assessments is great if they are made by groups with differing socio-cultural environments. In practical terms this means that development planners and experts tend to assess the benefit of an innovation in primarily technical and economic terms, while for the target group constituted by the smallholders other aspects are often more important. ROGERS and SHOEMAKER (1971:142) make the following comments:

"Economic profitability might be expected to be less crucial in explaining the rate of adoption of innovations among respondents who are peasants oriented largely to subsistence living. For them, other non-economic dimensions of relative advantage, such as social prestige and social approval, are expected to explain rate of adoption as would such other attributes of innovations as compatibility with socio-cultural values."

With regard to animal traction as an innovation there are also numerous indications that for smallholders the economic dimension is of secondary importance in comparison with the innovation's ability to facilitate work and save time. BAESSEM, for example, made the following observation concerning farmers in the then Central African Empire:

"... c'est plus l'économie de peine physique que la volonté d'augmentation de rendement qui a conduit les paysans au développement de la culture attelée". (quoted according to GROSSER/PFEIFFER et.al., 1977/78:197)

A French study on animal-traction projects in seven West African countries (CASSE et.al., 1965:56) comes to the conclusion that economic motives played only a minor role in adoption of the innovation, except in areas where commercialization had reached an advanced level and the farmers were heavily in debt.

The hypothesis that the economic dimension is of only secondary importance in assessing the relative advantage of animal traction as an innovation is also confirmed by RUTHENBERG (1964:24) for smallholders in Tanzania.

It must be concluded from the above that in animal-traction projects the rate of adoption is clearly related closely to perception of the innovation's ability to facilitate work. This point should be kept in mind during project planning for two reasons:

- a) Firstly, the rate of adoption can probably be influenced in the positive sense if the innovation's ability to facilitate work is particularly stressed and promoted in the course of the project, e.g. through the selection of appropriate implements.
- b) Secondly, the high value which the target group attaches to the innovation's ability to facilitate work may run contrary to the project's target of optimum exploitation of the innovation's economic potential, i.e. higher yields through an increase in area, particularly if this aim involves an increase in working hours.

3.1.5 Compatibility

An innovation is regarded as compatible if the target group considers it to be consistent with its socio-cultural values, past experience and existing needs.

It has already been pointed out in the section on socio-cultural identity that innovations are likely to be rejected if they are in-

consistent with the essential features of a social system. In this context it can be predicted, for example, that an attempt to introduce the use of oxen for transport purposes among the Fur would encounter considerable resistance (cf. 2.1).

ROGERS and SHOEMAKER (1971:146) mention a case in which an innovation was incompatible with the target group's previous habits. In an Asian country steel ploughs were distributed to a target group who had previously used wooden hook ploughs.

"The peasants accepted the new implements with polite gratitude but used them for ornaments rather than ploughing. Why? Because the steel ploughs require two hands to use; the peasants were accustomed to using only one hand (and driving their bullocks with the other)."

An innovation must not only be compatible with the socio-cultural values and previous experience of the target group but must also meet the felt needs of this group. Correct assessment of these needs by outsiders and persons unfamiliar with the culture involved is difficult and calls for a high degree of intuition on the part of project planners and experts, which means that the risk of mistakes is high.

As far as projects aiming to promote animal traction are concerned, however, it can be anticipated that an innovation's capacity to facilitate work will in most cases meet the direct needs of the target group.

3.2 Extension services

The fact that the use of draught animals is more complex than hoe agriculture necessitates the existence of an extension service, particularly in regions where innovations of this type or similar were previously unknown. It is the task of the extension service to create good preconditions for the adoption and spread of the innovation, particularly in the following fields:

- advising the target group i.e. imparting knowlege on how to actually use the innovation
- procurement and distribution of necessary production inputs
- marketing of surpluses and market produce
- arranging credits if no other institution exists.

However, few of the existing extension services in Africa have so far been able to meet these responsibilities in an adequate fashion, since they are usually faced with one or more of the following obstacles:

- Lack of finances
- Lack of personnel
- Inadequately qualified personnel
- Unsuitable form of organization
- Inadequate transport facilities and infrastructure
- Social gap between extension service and target group

Most development projects which aim to promote animal traction are therefore faced with the need to either set up an extension and training system themselves or reorganize any existing service to meet the needs of the project. This firstly makes it necessary to train or upgrade instructors, who should subsequently be able to initiate and support the spread of the innovation by imparting knowledge on how to use it. In most cases the appropriate forms of organization also have to be created at the same time.

Two aspects are of paramount importance as regards the efficiency of an extension service:

- 1) It has already been pointed out that an efficient extension service can increase the rate and speed at which innovations are adopted if it succeeds in introducing them via "average" farmers. This does not mean, however, that farmers with a high status should be excluded from the service's activities; on the contrary, the inclusion of individuals with a high status and traditional authority is often necessary in order to give the innovation a degree of traditional legitimation in the eyes of the whole target group. Introducing innovations via "average" farmers therefore means primarily that the activities of the extension service are designed to match the production conditions and lifestyle of these

farmers and not those of an elite. This of course requires prior ascertainment of average production conditions, a process which is often costly and time-consuming, particularly if it is carried out in the form of a basic socioeconomic study.

A simpler method of selecting "average" farmers has been developed, for example, by the Institute for Development Studies in Nairobi (cf. SCHÖNHERR, 1975:250f.). This involves having the village people themselves select groups of neighbouring farmers who are then approached via the group method. This procedure not only guarantees relatively reliable selection of "average" farmers, but also permits a simplified - and thus less personnel- and cost-intensive - form of assistance by means of the group method.

- 2) Another aspect involves the need to guarantee continuous extension work even after the actual project activities have ended. There is often a risk here that once the project is over the adoption process may slow down or come to a complete standstill, particularly if the project has provided considerable services in terms of organization, finance and personnel, which cannot be adequately replaced afterwards by services provided by the country itself. Animal-traction projects should therefore be designed from the outset such that they can be continued using local resources even after withdrawal of external specialists and the cessation of external services in terms of finance and equipment.

The most reliable way of ensuring that the diffusion process is self-supporting is to guarantee active participation by the target group as early as possible. Examples from the Sukuma regions in Tanzania show that this is possible above all as regards training the animals and imparting knowledge on how to use the innovation (cf. LINK/KALB, 1980:Annex 2). Farmers using draught animals should therefore be enabled from the very start not only to use the innovation correctly themselves but also pass it on to other interested smallholders.

Another prerequisite for ensuring that an innovation can spread of its own accord is the creation of a local craft industry structure, i.e. training and/or equipping of craftsmen who are able to repair implements and manufacture simple animal-drawn equipment (e.g. harrows). The development and testing of a technology geared to local conditions as well as the creation of the prerequisites - in terms of infrastructure and qualifications - for its continuous production must not be underestimated as regards their importance in ensuring the sustained spread of an innovation.

3.3 Credits

Wherever subsistence farming predominates it must be assumed that an average farm lacks sufficient capital to permit the acquisition of draught animals and the most necessary implements.

If the spread of an innovation is thus not to remain limited from the outset to high-status groups, it is in most cases essential to arrange credits for the acquisition of production inputs. The initial problem here is that most African countries have only the rudiments of an efficient agricultural credit system accessible for all interested parties. This applies in particular to smallholder credits (cf. LELE, 1976:81f.). Moreover, traditional credit institutions are designed only for granting consumer credits, e.g. to tide over the borrower in an emergency or in a special situation such as getting married. In addition, a "modern" credit, i.e. a specific sum of money at a specific interest rate, repayable within a fixed period, would be too great a burden for most subsistence farmers, since this would involve a changeover from the previous type of production planning, based on the meeting of food requirements, to market production. The likely result would be problems in repaying the credit which are often incorrectly interpreted as unreliability.

One approach which makes it largely possible to avoid the problems outlined here is the practice, used in northern Cameroon, for example, of linking an equipment credit to the limited cultivation of a cash crop and purchase of the latter by the lender (cf. NEUNHÄUSER et.al., 1977:192f.).

Here, the project provides the credit. The farmers are given draught animals and implements - no interest being charged - and undertake to grow a specific quantity of a cash crop which is then bought by the project and offset against the borrower's obligations. The advantage of this approach is that it is not only easy to understand (the credit takes the form of a simple exchange of products with a certain time lag) but also helps to avoid potential problems on the part of the farmers as regards storage, transportation and marketing.

When such an approach is being planned, however, it must be ensured that the farmers can meet their obligations without having to change their existing production priorities. The quantity of cash crops to be grown in order to repay a credit must therefore be calculated such that a farmer needs to expend little or no additional labour to grow his usual amount of foodstuffs and the cash crops necessary

for meeting additional needs. Planning of such an approach therefore makes it necessary to obtain reliable data on the production system used previously (see also Part B/IV, section on aspects of the granting of credits).

PART C

Case studies

Case Study C/I

INTRODUCTION OF DRAUGHT ANIMALS IN NORTH-WEST CAMEROON

BY THE "WUM AREA DEVELOPMENT AUTHORITY"

(C.M. Wagner/P. Munzinger)

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1. Conditions for the use of draught oxen

1.1 Natural locational conditions

The project region is located in north-west Cameroon and covers an area of 4 424 km². The topography is characterized by mountain chains rising to a height of 2 000 m and by the deep river valleys running between them. The centre of the project region is formed by an approximately 1 000 m high hilly plateau.

The soils are of volcanic origin and vary in colour from deep black in the river plains to red and light yellow on the mountainsides.

The climate is characterized by a long rainy season with substantial precipitation and a relatively short dry season. The rainy season generally begins with light rain in March and lasts until the end of October.

The meteorological data for the past 10 years produce the following average figures:

Temperature (C°)		Relative humidity (%)		Rainfall mm Days		Sunshine Hours
Max.	Min.	Max.	Min.			
26.5	15.1	81.2	47.2	3016	196	1825

The ecology of the region includes rain forests in the lower-lying areas along the river courses, changes to hilly tree-covered and bush savannahs and finally to grass savannahs. The greater part of the region is characterized by the thick grass on the mountain and hill chains and the region as a whole is therefore also described as "grassland" in cultural and historical terms.

1.2 Socio-economic and historical framework conditions

The population density in the region is approx. 17/km² with an average growth rate of 2.3%. Around 96% of the female population and 29% of the male population are involved in the agricultural sector; the proportion of the total population engaged in agriculture amounts to 80%.

The ethnic structure is of a heterogeneous nature and two main groups can be distinguished:

- a) The resident farming population (Bantu groups)
- b) The seminomadic Fulbe herdsmen (Fulani)

The local farming population is of varying ethnic origin but essentially exhibits few variations. The population contains various linguistic groups and exhibits a degree of tribal division which is gradually being reduced as a result of modern means of communication, marketing and trade. Pidgin English is used as the language of communication between the various ethnic groups. The traditional land utilization system in the region is extensive shifting hoe-based agriculture and is typical for the entire project region beyond ethnic boundaries. Small areas (0.3-0.5 of a hectare) are cultivated for around 4 years and then allowed to lie fallow for up to 14 years.

The pressure of an increasing population led to shortening of the fallow periods and thus to a change in the land utilization system. However, the exceptionally high degree of migration stabilizes the traditional system to some extent so that it has not yet collapsed. Land law is to a large extent still on a traditional basis i.e. involving the right to use communally owned land. The widespread division of labour allocates to the women the subsistence farming, which accounts for the major proportion of agricultural production. The work of the men is confined to small-scale cultivation of a few perennial cash crops, in particular - and to an increasing extent - coffee.

The seminomadic Fulbe herdsmen, the Bororo and the Aku (the two groups form the nomadic branch of the Fulbe and are known as the Fulani or Peulh) are to date the only cattle-keepers, since the local farming population have not so far owned cattle. However, cattle-keeping on a contract basis is increasing. This is purely a capital investment on the part of wealthy people and cannot be regarded as an agricultural activity in the true sense of the term since the animals are kept by Fulani herdsmen entrusted to carry out this work.

The Bororos have in the meantime become settled but still engage in extensive pasture farming. The breed of cattle which they keep is named after them; it is a very large, powerful and broad-framed type of zebu, coloured black to reddish-brown.

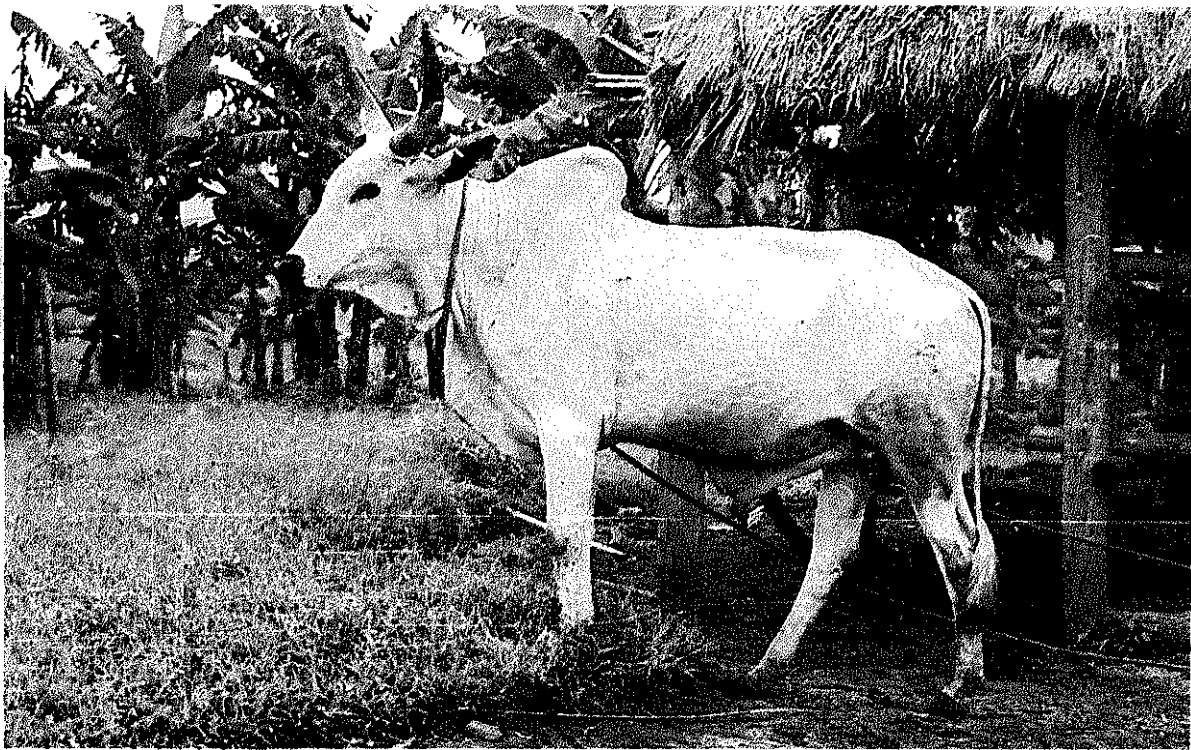


Fig. C/I/1: Named after the Aku tribe the Aku cattle are like the Bororo cattle a type of zebu but differ in colour and are not as powerful. Both are excellent draught animals and are already being used as such in the north of Cameroon and in the Central African Republic. (Photo: Munzinger)

The Aku have been immigrating from the Bauchi Plateau (Northern Nigeria) for around 20 years and are continuing to do so.

The extensive pasture utilization of the Fulani and the hoe agriculture of the local farming population form the basis for an ethnic balance which is becoming unstable as the amount of available land decreases. In common with all rural development regions in the country the project region is therefore already exhibiting a high degree of migration. Around 41% of the local male population is now in other parts of the country. The migration pattern is characterized by a high degree of migration to the plantations in the coastal regions. The age group between 21 and 30 is most affected; 64% of this group have already migrated to the plantation zones.

Infrastructure

The infrastructure of the Mechum Division is marginal. The major traffic artery is a laterite track which forms a ring road, starting and ending in the provincial capital, Bamenda. This road connects the individual Divisions and links them to the other provinces. Throughout the year it is passable only in one direction and only with great difficulty. There are also connecting roads to all towns

and villages of any size which are passable for vehicles for at least the major part of the year.

The local markets - held daily in the larger towns and villages - usually offer a limited range of the most common imported consumer goods and none of them sells local agricultural products to any great extent.

There are no traditional craft industries of any importance. The larger towns and villages usually have very simple vehicle repair workshops where simple animal-drawn equipment could possibly be maintained.

The government administration system is based on the centralistic French model and is present in full at divisional level (préfecture). There are usually considerable bottlenecks in the supply of materials and equipment (vehicles, petrol etc.). This has a particularly detrimental effect on the government veterinary service and the agricultural extension service, both of which comprise a relatively dense network in terms of organization and personnel.

The cooperative system in Cameroon has developed furthest in the two English-speaking provinces (which include the North-West Province). In each Division a Cooperative Union acts as an umbrella organization for the individual farmers' associations (primary cooperatives). Marketing (mainly coffee and rice), supply of fertilizer and seeds as well as allocation of credits to the farmers are carried out at union level. The Cooperative Union responsible for the project region is one of the most important in the province. The major organization in the field of agricultural credits is the "State Agricultural Development Fund (FONADER)"¹⁾ which is based in the capital, Yaoundé, and grants individual and group credits. The latter are as a rule distributed and administered via the cooperatives.

In addition to these bodies there is the Credit Union League (American model) which is, however, of lesser importance for agricultural credits.

The traditional credit institutions are the local savings societies; these are associations organized at village level which to date, however, have been of little commercial significance in the project region.

1) FOND NATIONALE DE DEVELOPPEMENT RURALE

2. Promotional approach via the WADA

2.1 History and development of the project

In 1965, the German Development Organization (GAWI), started attempts to increase agricultural production in the project region by means of a training and settlement project. In the course of the project, the use of tractors, until then the only form of agricultural mechanization to be promoted, was found to be comparatively uneconomical under given conditions (relatively poor infrastructure, inadequate number of workshops, small farms, enormous costs imposed by the tractors etc.). Modification of the original project approach therefore became necessary and eventually led to establishing the Wum Area Development Authority in 1972.

In addition to other non-agricultural promotion measures, the main emphasis of the modified project was to be placed in particular on the agricultural extension service. Three programmes were introduced one after another for this purpose:

The Block Extension Programme initially continued to assist farmers by subsidizing the use of tractors. Rice, maize and coffee were grown on the adjacent 2.5 hectare blocks of land cultivated by the farmers involved in the project. Despite subsidizing tractors, however, the project did not prove successful in the long term.

The Group Farming Programme offered short-term credits and advice aimed at promoting rice cultivation (upland and swamp rice) to farmers who set up production groups. This programme proved relatively successful within a short time since comparatively little capital expenditure and extension work were required, and the farmers were able through their activities in the programme to maintain an alternative source of work and income in addition to their other activities.

The Draught Animal Programme did not start until 1975, when a training centre was set up. The first 10 farmers were trained and settled in 1976, and since 1977 20 farmers per year have attended one-year courses; they are subsequently settled on selected areas of land.

Additional short courses for a total of 60 farmers (4 courses a year, each for 15 farmers) have been held since 1978. Expansion of farmers' training would allow regions outside the immediate project area to be also included.

Preparations are at present being made within a pilot project for further expansion of the Draught Animal Programme to the whole of the North-West Province, especially by increasing the number of short courses.

The major project targets and measures are given in Table C/I/1.

The structure of the training and extension organization is shown in Table C/I/2.



Fig. C/I/2: The training centre near Wum where the one-year courses are held for young farmers. The houses for the trainees' families are on the left side, to the right are the stables for the draught oxen. The manure collected there is always directly applied to neighbouring fields of the compound. (Photo: Munzinger)

Table C/I/1: Targets and measures of WADA

Development policy target	Project target	Programme measures
1. Changeover from shifting cultivation to permanent land utilization	Introduction of fallow periods and crop rotation	Practical training at the training centre in cultivation of rice, maize and groundnuts as permanent crops
2. Increase in food production	Enlargement of cropping area	Use of animal traction
3. Improvement of cash income	Introduction of cash crops Marketing of smallholders' produce	Training and extension services dealing with rice-growing Provision of equipment and funds for processing, storage and transportation
4. End of the rural exodus	Involvement of the men in agriculture Involvement of young people in the innovation process	Training and extension services relating to draught animals Creation of training and job opportunities in the agricultural sector
5. Development of self-reliance	Promotion of self-help organizations	Support of cooperation between smallholders, aid in setting-up and organization of primary cooperatives

The WADA extension service has an exceptionally dense network with around 1 extension worker to every 60 farmers. This advantage is aided still further by the fact that the participants in the Group Farming Programme at the same time also use draught animals and the land of the "group farmers" is usually near the farms using animal traction.

The increasing extent of the overall programme and the necessarily long extension period (at least 3 years) will, however, lead to a change in this distribution. Integration of the government extension service in the project programme is therefore extremely important. Equally vital in this context is integration of the trained farmers into the existing cooperative system so that the marketing opportunities and the supply of production requisites can also be guaranteed in the long term independently of the project.

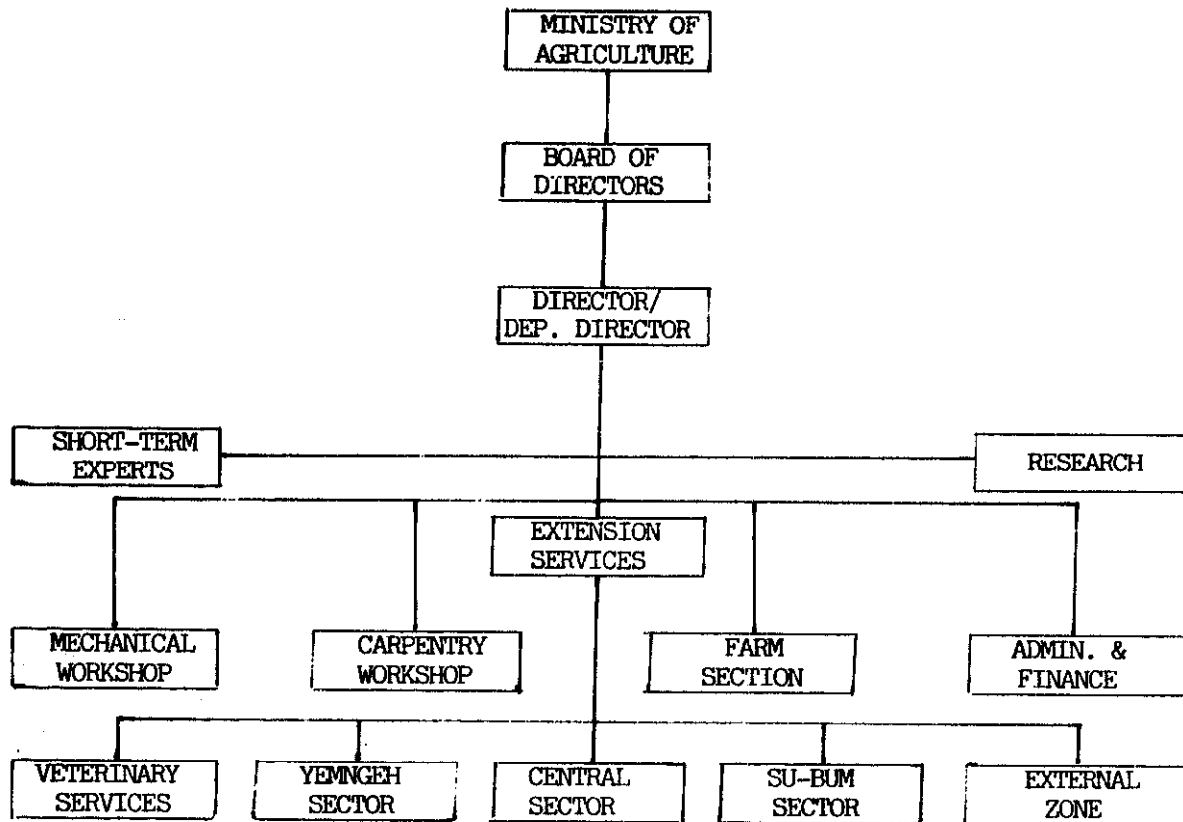


Table C/I/2: Organization Chart of WADA (revised 1981)

2.2 Training programmes for draught animal farmers

Since 1978, WADA has been running two different training courses dealing with the use of draught animals:

- a) 1-year training courses at the training centre
- b) Short courses in specific regions in the participants' villages.

a) Long courses

Duration:

1 year, covering the cultivation periods for maize, groundnuts and rice (January to December).

Capacity:

20 farmers, including their families.

Facilities and services provided:

- Accommodation at the training centre, meals, health care
- A garden plot of 0.16 of a hectare for growing vegetables to meet the farmer's own requirements
- Training in handicrafts and child care for the women
- Collecting from and transportation back to home village free of charge

Training:

- Use of a pair of oxen for ploughing, harrowing, weeding and transportation,
- Cultivation techniques for rice, maize and groundnuts in flat beds with row sowing and use of fertilizer,
- Instruction in cattle-keeping (setting-up of a simple cattle shed, manure pit and maize silo),
- Use and maintenance of agricultural appliances and equipment.

Theoretical instruction to back up and reinforce the basic practical skills has been prepared.

b) Short courses

The short courses generally last 2 months and provide instruction only in the use of oxen for ploughing and harrowing. The courses are held in the farmers' home villages so that no costs for board and lodging are incurred. The farmers can start maize cultivation as soon as the course ends, so that no losses result on account of the training.

The remaining necessary knowledge of production techniques involving draught animal use for maize, groundnuts and rice is to be imparted during intensive extension work and follow-up supervision after the courses.

Before the course starts, the group of farmers communally build a pen for treatment of the animals. Grazing of the animals is also carried out on a communal basis.

The farmers attending the short courses are granted the same credits at similar conditions as those attending the long courses; they also receive subsidies and can have their fields initially ploughed free of charge by tractor.

c) Ratio of long to short courses

As a result of comprehensive training, the participants in the long courses should be able to work independently and require relatively little extension work on the part of the project. It is intended that advice and support should mainly be given to farmers who were only able to attend a short course but who settle in the region, in order to gradually relieve the project of the burden of follow-up supervision within the constantly expanding

Draught Animal Programme. With this end in view it was in the beginning aimed to achieve a ratio of 1 : 3 of long-course participants to short-course participants on a regional basis. In the meantime, the tendency is going towards increasing the number of short courses due to the large number of farmers interested in the Draught Animal Programme and to the fact that the majority of the farmers cannot leave their farms for a whole year.



Fig. C/1/3: To accustom draught oxen to the work a simple tree trunk is used in the first phase. Simultaneously the young trainees learn to train oxen so that they will be able to act as demonstrators in their home villages. (Photo: GTZ Archives)

2.3 Credit component within the programme

In order to enable a farmer to obtain a pair of oxen and the necessary equipment, the pair of animals which he uses during training and the equipment become his property on a credit basis.

In detail, this comprises (1978 prices):

1 trained pair of oxen	100 000 FCFA
1 multipurpose plough (with ridger and weeder)	43 000 FCFA
1 harrow	20 000 FCFA
1 single-wheel hand-weeder ("Tropic" model)	15 000 FCFA
2 different markers for sowing	5 500 FCFA
1 double yoke with accessories (chains etc.)	8 000 FCFA
Tools and material	14 500 FCFA
	<u>206 000 FCFA</u>
	=====

This somewhat large total is reduced by a 20% subsidy, leaving 165 000 FCFA, which can be repaid in annual instalments over a period of 4 years and at 7.5% interest with a 1-year period of grace.

Each draught animal owner also receives a subsidy of 20 000 FCFA for material needed to construct a cattle shed and pasture fence. Initial ploughing of the new land to be cultivated by the farmer is carried out free of charge using tractors from the project.

3. Experience gained to date with the Draught Animal Programme

3.1 Target group

In contrast to similar project approaches in Cameroon the small-holders participating in the Wum project region had no previous experience with draught oxen. The innovation work was thus started from scratch with no knowledge of the possible effects or prospects for success. Although some experience in the use of animal traction had been gained in other parts of Cameroon it could be applied only in part to the project region.

In accordance with the project objectives it is intended that the male population - the target group - should be more strongly integrated into the agricultural system, particularly in order to include this potential labour force in agricultural production. An analysis of the farmers trained to date in the WADA Draught Animal Programme shows that this criterion has been fulfilled. The farmers recruited to date are in the age group between 18 and 40, with an average of around 31 for the long-course participants and around 28.5 for the short-course participants.

The aim of greater integration of younger farmers, i.e. potential migrants, into the programme and thus into the agricultural sector is being increasingly achieved. In 1979, farmers aged under 30 accounted for approximately 65% of short-course participants.

A random sample taken from participants of a long course revealed that 8 out of 20 farmers had previously left the region already once for an average time of 1 to 7 years, and had then returned. This proves that reintegration into the agricultural sector is possible

even in the peripheral regions. The general structure of the innovative group can be described as "modernized". This means that this group is characterized less by traditional values and attitudes and more by the trends towards breakdown of these traditional structures, through:

- a relatively high age at marriage
- monogamy and a small number of children
- primary education
- migration experience
- readiness to assist their wives in the field work.

However, confining project activities to this innovatively-minded group is not without problems. For example, it is clearly not possible to use this group as "change agents", so to speak, for transforming the traditional shifting cultivation into permanent land utilization since traditional agriculture (as subsistence farming) is in the hands of the women. Introduction of innovations via this target group therefore has no effect on traditional land utilization. On the other hand, the relative shortage of land becomes worse as this new group establishes itself in agricultural production.

3.2 Land reserves

The region's land use system has to date been characterized to a certain extent by a symbiotic relationship between extensive stock-keeping by the Fulani and extensive arable farming by the local population. The population pressure on the land - which is growing despite migration - and the increasing overstocking of the traditional mountain pastures are already leading to a relative shortage of land.

On the basis of the criteria for the use of draught animals in terms of production techniques, the overwhelming majority of the areas cultivated in the traditional manner would be suitable for the Draught Animal Programme. However, the sex-based division of labour in the traditional land use system has so far meant that animal traction could not be employed to utilize this land. The areas under traditional cultivation would only be available if the women were directly included in the promotion measures as a target group.

Implementation of the Draught Animal Programme in Wum is therefore closely linked with land development measures (= land settlement).

Remote, unused land reserves should be developed for the project activities, i.e. settlement of young trained farmers, by means of further infrastructural measures such as:

- improvement of access roads
- construction of simple bridges
- reclamation of hitherto uncultivated land by means of clearance (initial ploughing by tractor) etc.

Although such measures are extremely important for the development of remote rural areas, the resulting cost burden for the project must not be forgotten and - not least as a result of this - consideration is at present being given to diversification of the target groups and increased influencing of the traditional cultivation methods.

3.3 Experience with crop farming

The three main crops on the farms using draught animals are maize (mainly as a staple food), groundnuts (in part as a cash crop) and rice (as main market crop). They are grown as single crops with row sowing so that they can be tended using a team of oxen. Local varieties of maize and groundnuts are preferred on account of consumption habits, while for upland rice the imported "63-83" variety is used.

In view of the fact that the incidence of disease is still low there is no need to use plant protection products. The region's substantial precipitation stimulates the growth of weeds and a great deal of work is needed to remove them. Weed control can therefore lead to labour bottlenecks in rice cultivation, particularly during the maize and groundnut harvest (cf. cultivation schedule).

In addition to problems in weed control (weeding is carried out too late and only to an inadequate extent) various farmers do not observe the sowing and fertilizing times or the exact quantities of seed and fertilizer. In many cases there is also no correct crop rotation such as recommended during training and extension.

These inadequacies can only be gradually reduced as the farmers gain more experience. However, it is also being considered whether partial adaptation to traditional production methods (ridge farming, mixed

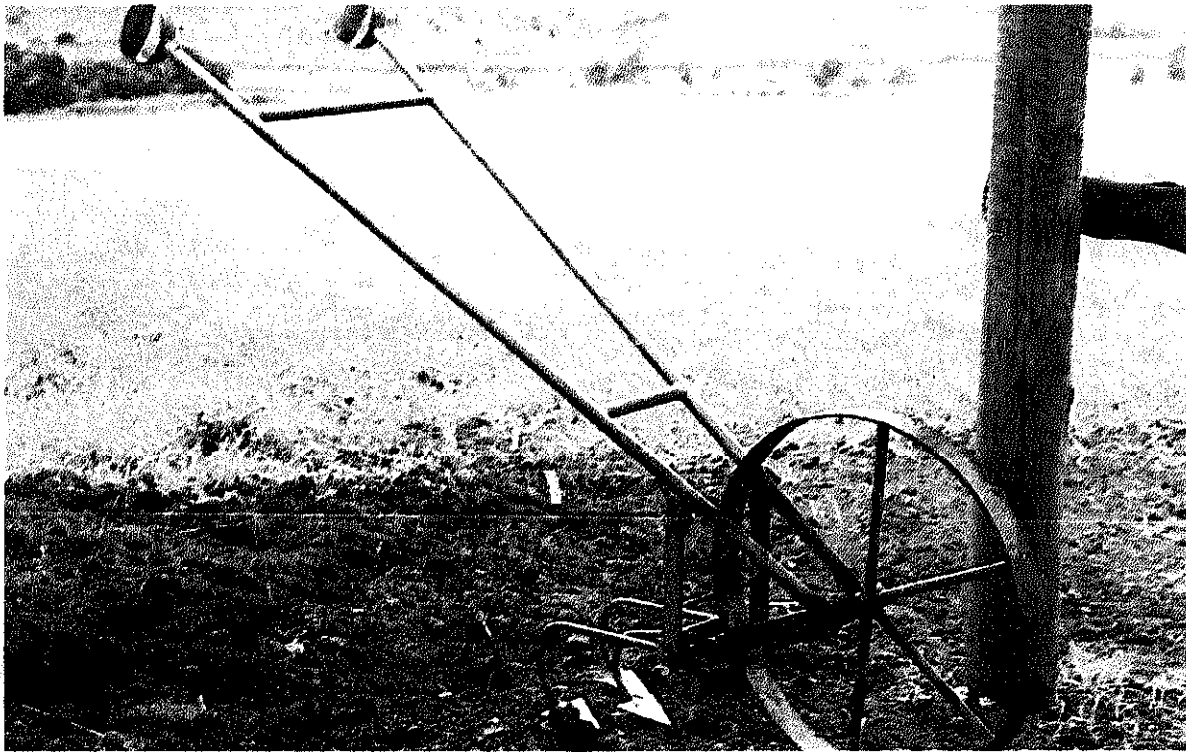


Fig. C/1/4: Initial weeding is carried out by hand, using as a rule the single-wheel weeder of TROPIC. Although this weeder is very much appreciated by the farmers, subsequent weed control should increasingly be done using a team of oxen. Sowing in proper lines is a precondition for both.

cultivation) could make the changeover to draught animals easier.

This type of simplification could help to reduce more quickly the farmers' still somewhat high degree of dependence on the extension services and supplies (particularly mineral fertilizers) provided by the WADA and thus increase the chances of wider and sustained diffusion of the innovation.

The cropping areas of each farm using draught animals are on average not expanded until the second or third year of cultivation. The average size of the farms is in the beginning between 1,5 and 3 hectares (not including pastures and areas lying fallow). In the long run economically viable farm sizes should be around 5 hectares. Whether this target can be achieved depends only partly on how the young farmers learn how to handle their oxen. More important limiting factors have to be seen in the shortage of arable land, heavy soils and to some extent, steep hills.

Table C/I/3: Cultivation schedule for farms using draught animals

	Maize	Groundnuts	Rice	Miscellaneous (cultivated by the women)
January				Yams Ground preparation
February				Yams, planting
March	Soil preparation Ploughing/harrowing Sowing	Soil preparation		
April	Fertilizing (20:10:10) Weeding (by hand)	Ploughing/harrowing Sowing		Yams, fertilizing, Setting
May	Top dressing Weed control (draught animals)	Weeding (by hand)	Soil preparation	
June	Weed control (draught animals)	Weed control (draught animals)	Ploughing/harrowing Seeding	Plantains Weeding
July		Weed control (draught animals)	Fertilizing Weeding (by hand)	Silo preparation for maize
August	Harvest	Harvest	Top dressing. Weed control (draught animals)	
September	Field clearance. Soil preparation (beans)	Drying	Weed control (draught animals)	Beans
October		Shelling	Guarding fields against birds	Planting Weeding
November			Harvest	Yams Harvest
December			Transportation of paddy for hulling	Beans Harvest



Fig. C/1/5: Tests of simple self-constructed tool carriers have been carried out in order to find a multi-purpose animal-drawn implement for all cultivation work. The frame for this tool carrier is the front axle of an old car. If farmers can afford the relatively high investment, these implements are especially useful for ridging and inter-row weeding. (Photo: Rauch)

3.4 Training and keeping of draught animals

Although local farmers - the target group for the Draught Animal Programme - do not engage in stockkeeping, sufficient numbers of the necessary animals, kept by the Fulani, are available in the region. The project buys young bulls aged between 1 1/2 and 2 1/2 years since they are less expensive than fully-grown animals.

The project has sufficient pastureland at its disposal and a fairly large number of young animals up to a suitable age of 3 years can therefore be kept. Both Bororo and Aku cattle are bought. The former is more suitable as a working animal because it is more powerful; fully-grown males weigh between approximately 350 and 450 kg and reach a height of 140 cm at the withers. The relatively quiet Aku cattle, which have a more slender frame, are not available locally in sufficient quantities. The males attain a weight of only 300 - 400 kg and a height of 130 cm at the withers.

Before training pairs are formed in which the animals should match as far as possible as regards size, breed and temperament; the two

animals are then tied together in the pen. Once they have become used to each other they are then introduced to the yoke for several days. As soon as they are able to walk together in the yoke without problems, the actual training as draught animals can start.

During this phase the farmers to be trained are involved in the work. The preceding taming of the animals must be carried out by permanently employed workers since the farmers themselves have little experience in handling cattle and tend to mistreat them out of fear of the still wild animals.

Training of the animals until they can pull ploughs and carts lasts a total of around 4-6 weeks. Some of the animals (around one-third) prove to be unsuitable during training and must be separated from the rest for subsequent sale. The bulls are castrated before they are handed over to the farmers to prevent them from following the cows in the Fulani herds. In general it can be said that uncastrated animals also appear to be suitable for draught work.

Experience has shown that the more lively temperament of cows makes them more difficult to handle and means that they can only be used as draught animals by experienced farmers.

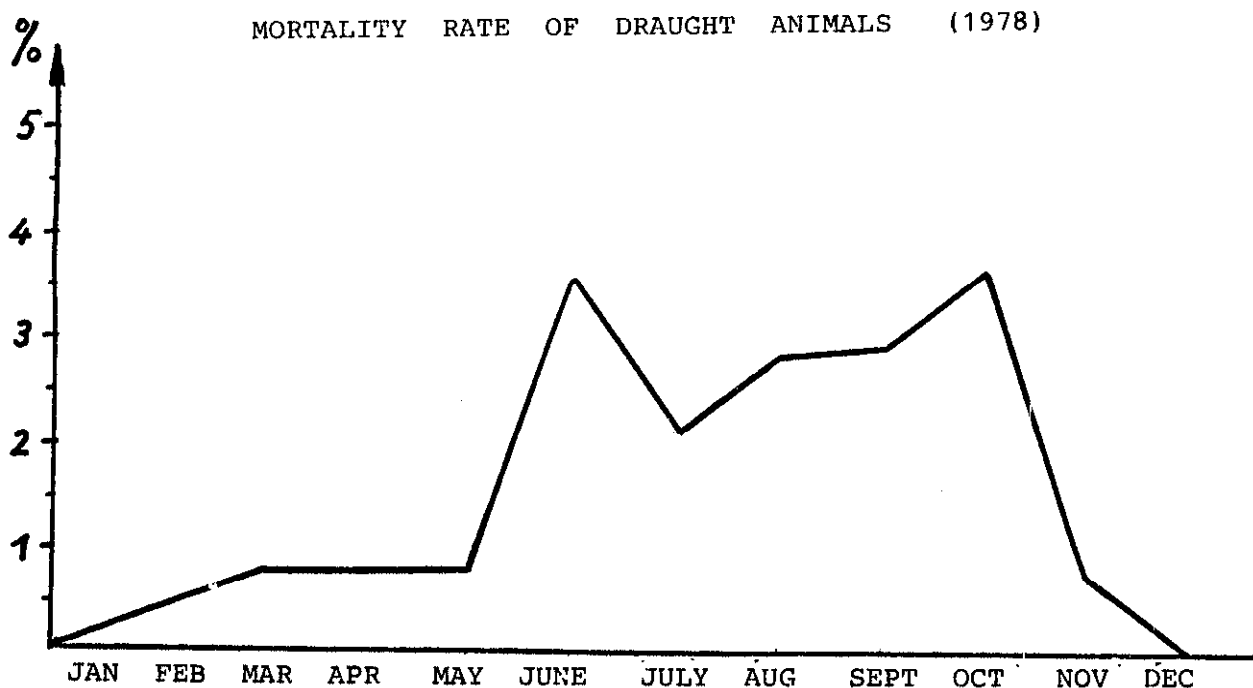
Feeding the animals seldom presents problems. Due to the 8-month rainy season there is sufficient natural grass as a fodder basis. The grass should be cut from time to time in view of the fact that the nutritional value of the local grasses (mainly *pennisetum purpureum*) clearly decreases the older the vegetation becomes. During the working periods, the cattle are given rice bran in addition. However, cases of poor animal feeding, resulting in illness, have often occurred among resettled bullock farmers. This could usually be attributed to the fact that, due to mutual distrust, these farmers did not allow free communal grazing and kept their animals tied up during feeding. The state of nourishment of the animals whose owners allowed communal grazing was distinctly better.

3.5 Spread of cattle diseases

The spread of disease is not a limiting factor in the project region. Trypanosomiasis bovin occurs only in lower-lying areas outside the project region; the other diseases occurring (e.g. foot and mouth

disease) can be treated by the local veterinary service and - more recently - by a veterinary assistant attached to the project. However, it is of paramount importance that diseases be recognized and treated in good time, and this calls for regular checks by the veterinary personnel since the farmers do not yet have the necessary experience and knowledge. It is planned, therefore, that the extension workers dealing with the farmers should be additionally instructed in the most important aspects of animal keeping and animal hygiene in order to guarantee better checks and advice for the farmers in this sector.

Treatment of ticks is particularly important. The animals are affected to an especially great extent during the rainy season i.e. during their working period. Ticks not only transmit diseases (e.g. haemoglobinuria enzootica, streptothricosis) but also cause infections and formation of sores. A daily check for ticks must therefore be carried out as a matter of course. It has become clear that use of chemical preparations not only involves a cost burden and problems as regards regular procurement and distribution to the farmers, but also prevents the farmer from establishing close contact with his animals. Removal of ticks by hand, however, promotes close contact with the animal which the farmers - who have no tradition of cattle keeping - must develop. Farmers who became used to treatment by means of chemical preparations stopped bothering about the conditions of their animals if the chemical could not be supplied at the correct time.



Average mortality/year	17.8 % (June-October: 35.6 %)
comprising:	
Normal (disease)	8.5 %
Negligence (strangulation, no tick treatment etc)	9.3 %

Ratio of Bororo to Aku cattle 50 : 50.

The overwhelming majority of deaths can be attributed to negligence i.e. poor care.

This reveals deficiencies in training and in the farmers' experience as well as in the follow-up supervision.

Regular checks by a newly appointed veterinary assistant have in the meantime improved the situation considerably.

4. Evaluation of the use of draught animals in the Wum Region

4.1 Profitability of using draught animals on the farms

It is not yet possible to carry out exact profitability calculations. The most recent surveys of the amount of work which must still be performed manually on farms using draught animals have revealed an exceptionally high degree of variation depending on the length of the farmers' experience.

Data with any information value cannot be anticipated until around 2 years after the farmers have been settled, since the ground must usually be tractor-ploughed in the first year of cultivation. Moreover, it cannot be assumed that the farmers will fully master the cultivation techniques until the third year. Initial experience has shown that during this year the cultivation area is expanded and additional tillage performed on a wage basis.

A profitability calculation based on various types of model farms has shown that it is possible to at least double the average agricultural income through the use of animal traction. It must be pointed out, however, that economic effectiveness in the sense of a substantial increase in the monetary income need not necessarily be a decisive criterion for the adoption of a new technique. Most of the

farmers do not yet have a particularly market-oriented way of thinking.

Assessment of the labour force in monetary terms - on which a profitability calculation is based - is also foreign to the farmers since subsistence agriculture does not produce a cash income in the narrower sense of the term.

More important to the farmer is the credit burden since it is mainly this which forces him to earn a relatively high cash income. A disproportionately large credit burden can very easily lead to resignation and cause the farmer to give up the innovation or to be slow in making his repayments. It is therefore advisable that the amount of money which a farmer owes should be kept within reasonable limits and that, if necessary, he should be supplied with a simpler range of implements and other agricultural production requisites (which can be supplemented as he becomes more successful).

4.2 Animal traction versus tractors

When decisions are being taken on the possible uses of animal traction the question of alternative forms of mechanization, in particular tractors, inevitably arises. In the case of WADA this is particularly important since tractors are used in other extension programmes and also in the Draught Animal Programme for initial ploughing. Comparative cost calculations for the Wum Region have revealed that the use of tractors is far more expensive than tilling the soil using animal traction. The main reason for this is the unfavourable running-cost ratio. In the case of tractors high repair costs and long idle times on account of the poor spare part supply are set against utilization possibilities which are limited in terms of time (approx. 4 months) and area. The few large cultivated areas are for the most part a long distance away from one another and necessitate long travelling times.

The fact that the farms are on average very small means that tractors can be used only above single-farm level, which results in additional administration costs.

It can therefore be stated that the use of tractors in the Wum Region is not a feasible alternative for the smallholders as a target group,

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and the spread of this technique in neighbouring regions thus provides little competition for the use of draught oxen.

The use of large machines, however, is still a problem in peripheral rural areas for other reasons. The tractor's high productivity per unit of area means that an increasing commercialization interest suddenly arises in these regions with regard to the land. Subsidized tractor hire stations in particular provoke misuse of the traditional land laws. Large reserves of land are controlled by the traditional ruling groups who have little capital. These groups have the opportunity to misuse their position to acquire land in order to sell it or use it for their own purposes with the aid of the machinery offered. This would then prevent a structure based on smallholdings from ever developing at all.

It may, therefore, be a serious error to make cost-benefit considerations the only criterion for determining the type of mechanization. Macroeconomic considerations (e.g. foreign exchange budget) and development policy goals should be of decisive importance in this context.

4.3 Draught animals versus traditional hoe agriculture

The comparison between farms engaging in traditional hoe agriculture and those using draught animals, as shown in Table C/I/4, is intended to illustrate the contrast between the use of draught animals and traditional agriculture by means of the major production factors - soil, labour and capital - and thus show the complexity of the innovation in the Wum Region.

It thereby becomes clear that animal traction already represents a major development step which initially can only be accomplished by a limited target group.

Wider diffusion of animal traction, i.e. above all the involvement of the women traditionally engaged in arable farming, will not only call for increased orientation towards traditional techniques (ridge cultivation, mixed cultivation etc.) but will also require cooperation between the men and the women in accordance with the traditional division of labour. In this case the men, as the draught animal owners, would be responsible for soil preparation, ploughing, harrowing and, if possible, weed control and use of the animals. The women, in their

position as traditional land users, would carry out sowing, manual weeding and harvesting in accordance with the prevailing division of labour.

However, such a radical change in the present situation can only gain acceptance in the long run. Project planning thus has the important task of creating the conditions for long-term and long lasting changes by means of an appropriate innovation model.

TABLE C/1/1V: COMPARISON BETWEEN TRADITIONAL CULTIVATION METHODS (MANUAL LABOUR) AND USE OF DRAUGHT ANIMALS

I. PRODUCTION FACTOR: LAND

REQUIREMENT	TOPOGRAPHY	SIZE OF AREA	PASTURE	WATER	INFRASTRUCTURE	UTILIZATION	LAW
FOR TRADITIONAL CULTIVATION	-	0.5 OF A HECTARE	-	-	-	SHIFTING CULTIVATION	COMMUNAL PROPERTY
FOR DRAUGHT ANIMALS	GRADIENT NOT MORE THAN 15%	MIN. 2.5 HEC-TARES INCL. FALLOW LAND	NECESSARY	NECESSARY	ACCESS TO WORKSHOP	PERMANENT	INDIVIDUAL LAND TITLES

II. PRODUCTION FACTOR: LABOUR

REQUIREMENT	DIVISION OF LABOUR	COOPERATION	LABOUR FORCE	QUALIFICATIONS	MECHANIZATION
FOR TRADITIONAL CULTIVATION	SEX-BASED	LINE OF KINSHIP	1	NO FORMAL TRAINING	-
FOR DRAUGHT ANIMALS	-	NUCLEAR FAMILY	MIN. 3	TRAINING COURSE	TEAM OF ANIMALS, PLOUGH, EQUIPMENT

III. PRODUCTION FACTOR: CAPITAL

EXPENDITURE	CAPITAL INVESTMENT	INPUTS	PROCESSING	MARKETING	TRANSPORTATION	CONSTRUCTION OF STORAGE FACILITIES
FOR TRADITIONAL CULTIVATION	-	-	-	-	-	-
FOR DRAUGHT ANIMALS	TEAM OF ANIMALS EQUIPMENT LIVESTOCK HOUSING FENCES	FERTILIZER SEED VETERINARY COSTS	RICE HULLING	RICE GROUNDNUTS	RICE GROUNDNUTS	MAIZE

5. Concluding remarks

This case study of the WADA draught animal project is intended to show how extensive the introduction of animal traction can be under certain natural and socio-economic conditions.

It has become apparent that a certain amount of experience has been gained during the approximately 3 years the project has so far operated which necessitates modifications in a number of important areas. However, experience is not yet sufficient to permit definitive statements concerning, for example, the profitability of the actual use of draught animals.

Nevertheless, the programme as a whole can already be considered a success. This is clearly substantiated by the increasing readiness for innovation on the part of various target groups, both within the project region and beyond the boundaries of the Division, as well as by the programme's resulting opportunities for expansion.

Moreover, the fact that draught animals are now being used by farmers who previously made use of the opportunities for subsidized tractor work provides impressive proof of the superiority of draught animals over other more advanced forms of mechanization.

The use of draught animals in the Wum Region is thus extremely important for the development of a smallholder-based structure, which can prevent the creation of vast disparities within the general process of social change in the direction of increasing commercialization of agriculture.

Further diffusion of the innovation and better linkages to the traditional land use system may certainly result in the sustained spread of the innovation. However, final success in terms of development policy goals depends here - as it does everywhere - in the long run on the amount of support and encouragement provided both by the donor countries and the political and administrative circles in the country itself.

C/II

**Promotion of draught animal traction
in Mali through the supply of simple
agricultural equipment**

Case study C/II

PROMOTION OF DRAUGHT-ANIMAL TRACTION IN MALI THROUGH
THE SUPPLY OF SIMPLE AGRICULTURAL EQUIPMENT

(H.Haug/I.Gerner-Haug)

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1. Mechanization situation

Draught animals represent the major sources of traction power for farms in Mali.

The largest group of draught animals is formed by the draught oxen, the number of which has roughly doubled over the past 10 years*), amounting today to around 280 000 - 300 000 animals. Donkeys and horses are also used to a smaller extent as draught animals, the latter mainly in and near the towns.

The number of agricultural implements in 1976 was as follows**):

Multicultivators:	40 555	Harrows:	10 739
Ploughs:	100 704	Seed drills:	9 707
Hoes:	54 700	Ox/donkey carts:	52 204

The above-mentioned numbers of draught animals and appliances must be set against the total of around 450 000 farms. It can be deduced from this that around 20-30% of farms in Mali use draught animals, whereby there are considerable regional variations. In the Sikasso and Ségou regions the proportion of farms with draught oxen is approximately 45%, while in the Kayes (7%), Bamako (19%) and Mopti regions the proportion of farms using this type of mechanization is substantially lower.

The sharp increases in the prices of draught animals and appliances in recent years are at present hindering the further spread of animal traction. Many farmers can only make this investment if credits on favourable terms are available.

In contrast to the use of draught animals, motorization has been introduced on very few farms. Only the development organization "Compagnie Malienne pour le Développement des Textiles" (C.M.D.T.) has since 1977 been using simplified 20 HP (DIN) small tractors made by Bouyer on top-class farms in order to gain initial experience as regards technical and economic aspects.

*) 1963: 90 000 draught oxen - according to Plan Quinquennal 1973-78
1971: 141 000 draught oxen - according to Plan Quinquennal 1973-78
1974: 224 600 draught oxen - according to Rapport de l'Enquête Agricole 1974-1975 dated June 1979
1978: 288 000 draught oxen - target figure according to Plan Quinquennal 1973-1978

**) Problèmes posés par la Mécanisation dans les Pays Membres du CILSS, Déc. 1977, p. 77.
New figures are not yet available.

2. Previous history

The use of draught animals was introduced by the French colonial administration and originally became widespread mainly on the irrigated farms in the interior delta of the Niger and in the tsetse-free area south of the Niger (the Ségou and Sikasso regions).

During World War II the French administration neglected promotion of draught oxen which led to a sharp drop in the number of animals kept. After the war animal traction was promoted again but this development work was interrupted several times by motorization campaigns which, however, proved unsuccessful. The failure of the motorization programmes resulted each time in major boosts for the promotion of animal traction.

In 1957/58, for example, so-called "Centres d'Encadrement Rural" (C.E.R.) and "Centres de Recherche Zootechnique" (C.R.Z.) were set up with the aim of gaining experience and solving problems as regards the use of draught animals, crop rotation, fertilizer and silage preparation, green manuring, forage growing etc.*).

After independence the Government of the Republic of Mali resolved to speed up agricultural modernization with the emphasis on the use of animal traction. The result of this policy, which has been continued until the present day (cf. Plan Quinquennal 1973-1978), is that the use of draught animals in Mali is comparatively advanced.

3. Conditions in Mali

3.1 Natural conditions

The climatic zones range from the Sahel zone to the Sudan and Guinea zones. The natural vegetation varies accordingly from the thorn-covered steppes with their short grass in the north to bush savannahs and subsequently to tree-covered savannahs in the south.

The rainy season in the south starts in late April/May and ends in October, while in the north it lasts from June to October.

*) Bilan des Expériences de la Culture Attelée en Afrique Occidentale d'Expression Française, Tome II, p. 1-9.

The long dry season lasting 5-8 months creates major problems, in particular as regards feeding the animals, since the water and fodder supply is frequently inadequate. Keeping the animals in the cattle sheds with the aim of producing manure for the most part fails due to a shortage of water in the villages and a lack of fodder. The climatic conditions are thus a major barrier preventing integration of cattle-keeping into arable farms.

The soils in Mali are in general easy to till on account of their high sand content. Only the heavy clay soils in the flood plains and valleys (Bas-fonds), which are used for rice-growing, often require 2 teams of animals.

The fertility of the light soils, which have a low nutrient and humus content, can only be maintained and improved through regular addition of organic substances (harvest waste, manure etc.) and mineral fertilizers. Regular manuring is widespread in regions with substantial experience of the use of draught oxen, whereas it is found only in rudimentary form in other areas.

Green manuring as a means of enriching the humus has not yet become common and to date has only been carried out on a trial basis.

3.2 Conditions on the individual farms

The agrarian structure in Mali is based on the smallholding system*):

23 % of farms cultivate less than	1 hectare
55 % of farms cultivate	1- 4 hectares
15 % of farms cultivate	5- 9 hectares
6 % of farms cultivate over	10 hectares

The average plot size is 0.9 of a hectare*); in almost all cases there are opportunities to enlarge the farm.

The cultivation structure is still largely geared to subsistence farming. The main crops are millet, sorghum, groundnuts, maize and rice; fonio, batate and manioc are also grown to a small extent. The cash crops are groundnuts in the north and north-west and cotton and kenaf in the south. Rice is grown mainly in the flood plain of the Niger delta but is also cultivated under irrigation in the south of the country and is used both as a food and a cash crop.

*) Rapport de l'Enquête Agricole 1974-75, published in June 1979.

The predominance of subsistence farming coupled with a relatively low yield level and low, government-fixed product prices, means that income from agriculture is low. The available purchasing power only rarely permits acquisition of mechanized equipment. Provision of credits on reasonable terms is therefore a major prerequisite for further mechanization of small farms.

Two reports*) produced in 1976 and 1977 and a 1979 study**) have demonstrated that the use of draught oxen is economically viable.

3.3 Technical conditions

Hoe-based agriculture in Mali traditionally uses short-handled hand hoes to till the soil (Soli type) and perform hoeing and ridging work (Daba type).

A relatively broad range of suitable appliances made by the S.M.E.C.MA***) company (based in Bamako) is available for use with draught animals. A simple plough (Bajac TM) has in the meantime also been built by local craftsmen, mostly using various pieces of scrap as the raw material.

The village blacksmiths are as a rule able to sharpen plough shares and manufacture simple wearing parts (plough soles, landsides). They also manufacture double neck-yokes (Joug Garrot).

The following are used in Mali as draught oxen:

- a) Zebus (mainly Pheul zebus)
- b) Taurines (Ndama)

Ndama cattle are kept in the areas infested by tsetse-flies on account of their trypano-tolerance.

Although the relatively light Ndama cattle (weight approx. 230 kg) are less suitable for heavy traction work, they nevertheless generally make very good draught animals on account of their build and temperament.

*) H.BOSUNER: Evaluation report on the project "Supply of simple agricultural production requisites (1976).

J.LAGEMANN: The agricultural credit situation in the project "Supply of simple agricultural production requisites" (1977).

**) GERNER-HAUG/HAUG: The profitability of draught oxen in comparison to the use of hand hoes and tractors (example: Mali).

***) Société Malienne d'Etudes de Construction du Matériel Agricole.

Zebus are characterized by their substantial traction power, which is a result of their high body weight, but have the disadvantage of being susceptible to trypanosomiasis.

State breeding farms have crossed Pheul zebus with Ndama cattle with the result that improved draught oxen are now being brought onto the market which largely combine the advantages of both breeds and can also be used in regions infested by tsetse-flies.

The draught oxen are trained by the farmers themselves.

3.4 Social conditions

The traditional separation of arable farming from stockkeeping is still a highly noticeable feature in Mali and only 40% of farms keep cattle*). Animal breeding is still the domain of the nomadic herds-men, while arable farmers usually keep only a few small animals.

As a result of this the farmers

- usually have to buy draught animals,
- have little or no experience in handling animals and
- are almost totally unfamiliar with sedentary stockkeeping as regards obtaining manure and stockpiling fodder.

Training programmes are therefore necessary in order to improve the farmers' knowledge of animal-keeping and feeding.

Ownership of draught oxen, however, brings great prestige and all sectors of the population acknowledge the advantages of animal traction.

The families in rural areas are for the most part extended families (7-12 persons/farm) with a pronounced age-based hierarchy which appears to be one of the reasons for the rural exodus.

The social status of young farmers within their families can be improved through the granting of credits for purchase of the much sought-after draught oxen.

*) Rapport de l'Enquête Agricole 1974-1975 (June 1979).

3.5 Provision of credits

Credits are granted via the state "Société de Crédit Agricole et d'Équipement Rural" (S.C.A.E.R.) which either provides agricultural supplies and appliances itself on a credit basis or has them distributed to suitable farmers by the state development associations ("Operation"), which operate over almost the entire country.

Whereas working supplies such as seed, mineral fertilizer, plant protection agents etc., are provided purely as harvest credits, down-payments amounting to 20-30% of the equipment value must usually be made in the case of agricultural appliances. The remaining portion of the credit must be repaid in 2 or 3 instalments depending upon the organization. In general, draught animals have to date been almost totally excluded from the credit system. Only the "Office Niger" (for farmers in its own area of intervention) and the German development project (for farmers trained at C.A.R.) finance draught animals on a credit basis.

4. Project approach

4.1 Paramount targets of agricultural policy

The 1973 - 1978*) five-year plan gives the following paramount aims for the agricultural sector:

- Meeting of the entire population's basic food requirements out of national production.
- Maximizing of the economic surplus through exports of meat and agricultural produce.
- Building-up of the livestock population and formulation of methods aimed at intensifying stockkeeping and integrating it into arable farming.

The strategy recommended for achieving these objectives is intensification of modern production methods with a view to increasing labour productivity in agriculture.

*) Plan Quinquennal de Développement Economique et Social 1973-78.

A major means of implementing this strategy is formed by agricultural training and promotion of draught animals as an appropriate form of agricultural mechanization; this is the target of the project executing agency.

4.2 Project executing agency

The "Direction Nationale de Formation et Animation Rurale" (D.N.F.A.R.), which is acting as the project executing agency, is responsible to the "Ministère du Développement Rural" (cf. organization chart).

It performs the following functions:

- a) Training of "moniteurs" at the "Centres d'Apprentissage Agricole" (C.A.A.).
- b) Training of young farmers at the "Centres d'Animation Rurale" (C.A.R.).
- c) Training of school students at the "Centres d'Orientation Pratique" (C.O.P.).

Mali at present has 48 C.A.R., the main features of which are as follows:

The C.A.R. are teaching farms with their own agricultural production and are largely self-sufficient in food thanks to the crops harvested. In addition to cultivation of subsistence and cash crops, crop trials are also carried out to a small extent. The aim is that over a 2-year training period each C.A.R. should familiarize 20 young farmers with modern agricultural production techniques and improve their general education. When they have completed their training they are equipped with a mechanization unit (draught oxen and appliances) on a credit basis as part of the German project.

It is anticipated that the farmers trained at the C.A.R. will subsequently set an example for the other farmers in their native villages and act as "multipliers" (animateurs), in the course of which they will receive follow-up supervision from C.A.R. teaching staff.

The C.A.R. were created in 1966 as the result of a fusion between the "Ecoles saisonnières" and the "Camps civiques", the former having been set up following independence with the aid of the European Development Fund and the F.A.C. Whereas the aims of the "Ecoles saisonnières" lay solely in the area of agricultural training, the "Camps civiques" contained a strong paramilitary element.

This is the reason why even today, in addition to the primarily agricultural training, the initial period includes paramilitary training which is recognized as a substitute for military service.

The teaching programme covers:

Basic reading and writing skills

Practical mathematics (e.g. field surveying, weighing out and calculating seed quantities etc.)

Crop growing

Animal keeping and nutrition (silage preparation, production of fodder reserves)

Animal training

Fertilizers (dung making, use of fertilizer)

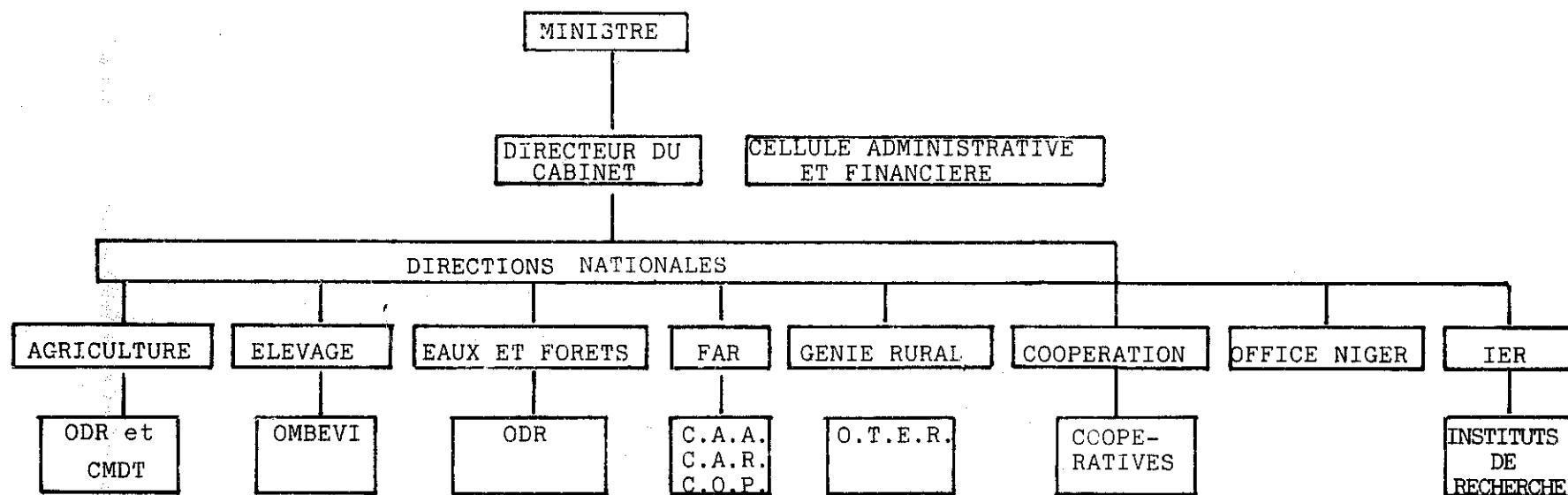
Simple techniques (latrine construction etc.)

During the rainy season the field work is carried out under the supervision of an experienced "moniteur" (instructor).

5 of the 48 C.A.R. have to date been expanded so that married couples can be trained as well. The women are instructed in craft skills (dyeing, sewing etc.), nutrition, child rearing, hygiene, small-animal breeding and horticulture. They are also taught basic reading and writing skills. At the end of training all the women are given materials, dyes etc. (on a credit basis) so that they may continue to use the skills they have learned.

The outcome of the good results obtained at the "C.A.R. mixtes" is that additional centres are shortly to go over to training married couples as part of this project. The aim is that within 3 years another 15 C.A.R. should be transformed into "C.A.R. mixtes".

ORGANISATION CHART OF THE MINISTRY FOR RURAL DEVELOPMENT



Abbreviations:

F.A.R.	: Formation et Animation rurale
ODR	: Organisation du Développement Rural, e.g. Opération Coton, Opération Riz
CMDT	: Compagnie Malienne pour le Développement des Textiles
OMBEVI	: Office Malien du Bétail et de la Viande
C.A.A.	: Centre d'Apprentissage Agricole
C.A.R.	: Centre d'Animation Rurale
C.O.P.	: Centre d'Orientation Pratique
OTER	: Opération des Travaux d'Equipement Rural
IER	: Institut d'Economie Rurale

4.3 Target group

The target group of the C.A.R. is formed by young, mostly still single men, who subsequently wish to work in agriculture. The aim of recruiting sufficient volunteers for training has never been achieved, either by the C.A.R. or their forerunners. Although the proportion of volunteers in many centres is continuing to increase a large number of the students have to be recruited by the administration.

The number of volunteers is inadequate for the following reasons:

- Many of the young men aged around 20 are married, not in the eyes of the law, but according to tribal custom. Training at a C.A.R. would result in a 2-year separation from their wives which would bring family problems.
- Within intact extended families young farmers are urgently required to work on their parents' farm.
- The financial advantages of temporary migration to the conurbations in the neighbouring countries (Ivory Coast, Senegal etc.) are rated more highly than the advantages of training.

The expansion of training to cover married couples at more C.A.R. constitutes an attempt to eliminate one obstacle preventing young men from volunteering and at the same time to improve the training of the female population.



Fig. C/II/1: Students of a C.A.R. working with a Three-Teeth-Cultivator. The well-formed withers-yoke is more suitable for the zebu cattle than for the Ndamas rarely used here in Mali. (Photo: GTZ Archives)

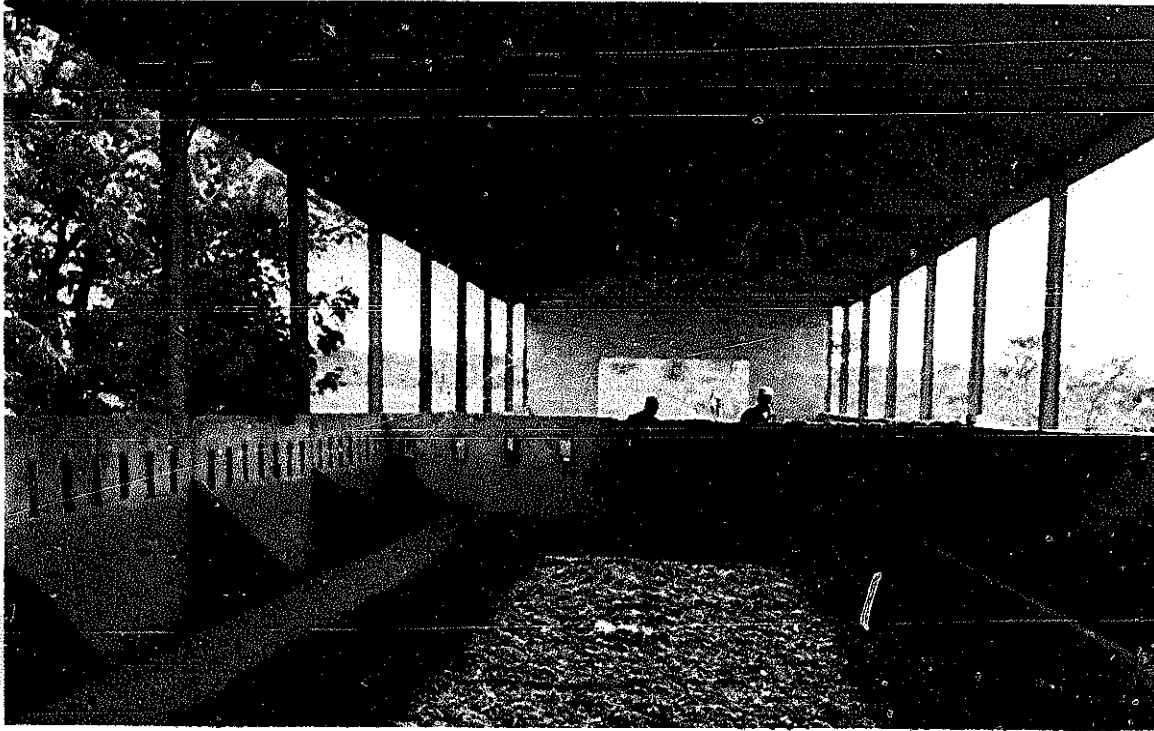


Fig. C/II/2: Stable of a C.A.R.: In order to collect manure the draught animals are kept here at nights and often during their noon-time rest. From the very start of their training young farmers are being taught to recognize the importance of organic fertilizer for plant production. (Photo: Munzinger)



Fig. C/II/3: Appropriate storage of harvest residues - here of peanuts - is not only important to feed the animals during the dry season but also to get more manure after being used as bed-down to cattle. (Photo: Munzinger)

4.4 Financing and distribution of draught oxen and appliances to former C.A.R. trainees

The Federal Republic of Germany has financed 5 deliveries of equipment since the project started in 1974.

These deliveries made it possible to equip around 4 300 former trainees with:

- 8 576 draught oxen
- 152 donkeys
- 4 200 ox/donkey carts
- 3 507 universal implements (multicultivators)
- 889 ploughs
- 178 seed spacing drills
- 220 harrows
- 320 plant protection devices

Procurement and distribution of draught animals and equipment to the former C.A.R. trainees takes place in close collaboration between the German project management, the D.N.F.A.R. and the state "Société de Crédit Agricole et d'Équipement Rural " (S.C.A.E.R.)*), which is responsible for procuring all items required.

The procedure is as follows:

- a) The D.N.F.A.R. and the German project management draw up a requirement plan in which the former trainees' individual equipment wishes are taken into account. A limit is placed on the amount of equipment for each former trainee. The requirement plan gives the quantity and type of the equipment required and the delivery locations are specified. The S.C.A.E.R. then submits an offer. An order is placed by the project management once agreement has been reached on prices and delivery conditions.
- b) The S.C.A.E.R. obtains the equipment from the Bamako machine factory "Société Malienne d'Études de Construction du Matériel Agricole" (S.M.E.C.M.A.) and delivers it to the planned distribution points.
The S.C.A.E.R. commissions local livestock dealers to procure the draught animals; they should ideally purchase them in the

*) In 1981 the S.C.A.E.R. was changed into a Rural Development Bank. Due to its new nature the procedure has been modified slightly.

same area in which they will subsequently be distributed. Once the quality of the animals has been checked by S.C.A.E.R. representatives and by the D.N.F.A.R. or the project management they are inoculated and kept in quarantine for 40 days, after which they are driven to the distribution points.

- c) The S.C.A.E.R. takes out a 3-year animal insurance policy for the draught oxen supplied with the state insurance company "Caisse Nationale d'Assurance et Réassurance du Mali" (C.N.A.R.).
- d) The S.C.A.E.R. makes a borrower's notes (in several copies) for the farmers granted credits, specifying the nature and size of the credit as well as the installments and times for repayment. All parties involved in granting and repayment of credits receive copies of these borrower's notes.
- e) The equipment is distributed in the presence of the local authorities as well as D.N.F.A.R. and S.C.A.E.R. representatives. The credit recipients confirm receipt of the equipment by making a fingerprint on the borrower's note.
- f) Transportation of the equipment to the farm, which often involves long distances, is the responsibility of the former trainee's family.

4.5 Repayment and re-use of credits

A project implementation agreement between the Mali Ministry of Agriculture and the German Agency for Technical Cooperation (GTZ) lays down, among other things, rules concerning granting and repayment of credits and re-use of the revolving fund:

- a) The equipment is issued on a credit basis on the following terms:
 - 30% of the value of the equipment is given as a subsidy
 - Following 1 repayment-free year (moratorium) the credit must be paid back in 3 or 4 annual installments depending on the region.
- b) The credit repayments go into a blocked account at the Mali Development Bank and are used as a revolving fund to provide similar equipment credits on favourable terms for farmers completing C.A.R. training at a later date.

Only the General Manager of the D.N.F.A.R. and S.C.A.E.R. have access to the blocked account and must sign together. This type of power of signature has proved to be practical.

- c) The S.C.A.E.R. is responsible for collecting credit repayments and administrating the repaid credits from the revolving fund.

Past experience has shown, however, that the present structure of the S.C.A.E.R. does not permit it to perform this function without assistance from other institutions (cf. Section 5).

The following table illustrates the situation as regards repayment of credits:

Table C/II/2: Credit repayments in Malien francs (FM)

Region	Target 1978/79	Actual 1978/79
I Kayes	12 524 000	1 439 000
II Koulikoro	28 660 000	1 715 000
III Sikasso	24 199 000	29 423 700
IV Ségou	43 931 000	44 804 900
V Mopti	10 726 000	4 387 635
VI Tombouctou	No credits granted in this region in the 1st and 2nd phases	
VII Gao	No credits in this region	
Total	120 040 000	81 770 000

In terms of the target for 1978/79 the average credit repayment rate is thus 68%. It is noticeable that in the Ségou and Sikasso regions, for example, the 1978/79 credits have been repaid in full and repayment of the 1979/80 credits has already started. In the Kayes and Koulikoro regions, on the other hand, few repayments have been made. In addition to the poor harvest in the Sahel areas of these regions, this may be attributed to:

- a) the lack of commitment to date on the part of the bodies concerned with credit repayment,
- b) the tendency of the population in these areas to be unreliable in making payments.

There is every reason to assume that credit repayment can be encouraged and substantially improved even in these regions. The provisional

repayment figure in the Bamako region (Koulikoro) for 1979/80 is already around 8 million FM and will probably increase still further. This is due to the committed involvement of C.A.R. personnel who are actively promoting credit repayment for the first time.

5. Problems and potential solutions

Procurement and distribution of draught animals and equipment at the right time is difficult.

The major obstacles are as follows:

- a) In some cases the draught oxen presented by the livestock dealers are of poor quality and must be replaced, which causes substantial delays in distribution.
- b) Procurement of such a large number of draught oxen causes problems if they must be put in quarantine during the dry season. The fodder and water supplies during this period are often so poor that the animals must remain at watering places until the start of the rainy season. If the oxen are distributed at the beginning of the rainy season, however, there is often insufficient time to train them before the field work starts.
- c) Many places cannot be reached by vehicle during the rainy season.
- d) Deficiencies in the equipment delivered (missing bolts etc.) often delays distribution of the rest of the equipment and the animals.
- e) Once they have left the C.A.R. the envisaged credit recipients cannot be contacted during the dry season because they are engaged in extra non-agricultural work in an attempt to improve their income.

Organization of credit repayment also creates a number of problems. As already indicated in Section 4.5 the S.C.A.E.R. has neither the financial resources nor the necessary personnel to be able to collect the credits itself. Various courses have therefore been taken in order to guarantee satisfactory credit repayment.

At the start of the project it was agreed that the state development associations (Operations) would assist in the collection of credits. These organizations have a village-level network of extension workers

who advise the farmers and supply them with working credits. They are also responsible for marketing the cash crops. It was planned that when marketing the produce they should deduct the credit instalments to be paid by the former C.A.R. trainees as well as their own credits.

This approach must be considered a failure since the development associations were primarily concerned with their own credits. Moreover, the reaction of the farmers was to try to bypass official marketing channels on account of the expected deductions and to sell their produce at local level or across the border.

In view of the fact that the country has no other organizations with a suitable structure the local administrations were then issued with "repayment documents" and instructed to assist in credit repayment or to collect the credits themselves.

The following procedures are at present used for credit repayment in the various regions:

- Collection of credits by the local administration and payment of the amounts to the S.C.A.E.R.
- Collection of credits by S.C.A.E.R. or C.A.R. staff.
- The most successful method:

The administrative authorities ask the credit recipients to visit them after the produce has been marketed and S.C.A.E.R. and D.N.F.A.R. representatives take this opportunity to collect the payments. An advantage of this is that joint decisions can be taken by all parties involved in cases of hardship.

6. Prospects

On the basis of the positive experience gained to date it can be expected that draught oxen will continue to maintain their position in Mali's agriculture. This is all the more likely since the economic conditions for motorization (increasing prices for industrial products and operating supplies, shortage of foreign exchange) are continually deteriorating and the necessary infrastructure, e.g. spare-part and fuel supplies as well as workshops, will not be available in the foreseeable future.

The provision of credits on favourable terms for the purchase of draught oxen, appliances and operating equipment is an important contribution towards improving the income of small farms because this facilitates in particular an increase in labour productivity. It is essential, however, that these activities be backed up by training and information schemes for broad sectors of the population and that the necessary prerequisites (e.g. water supply) be created in order to guarantee real integration of cattle keeping into arable farms.

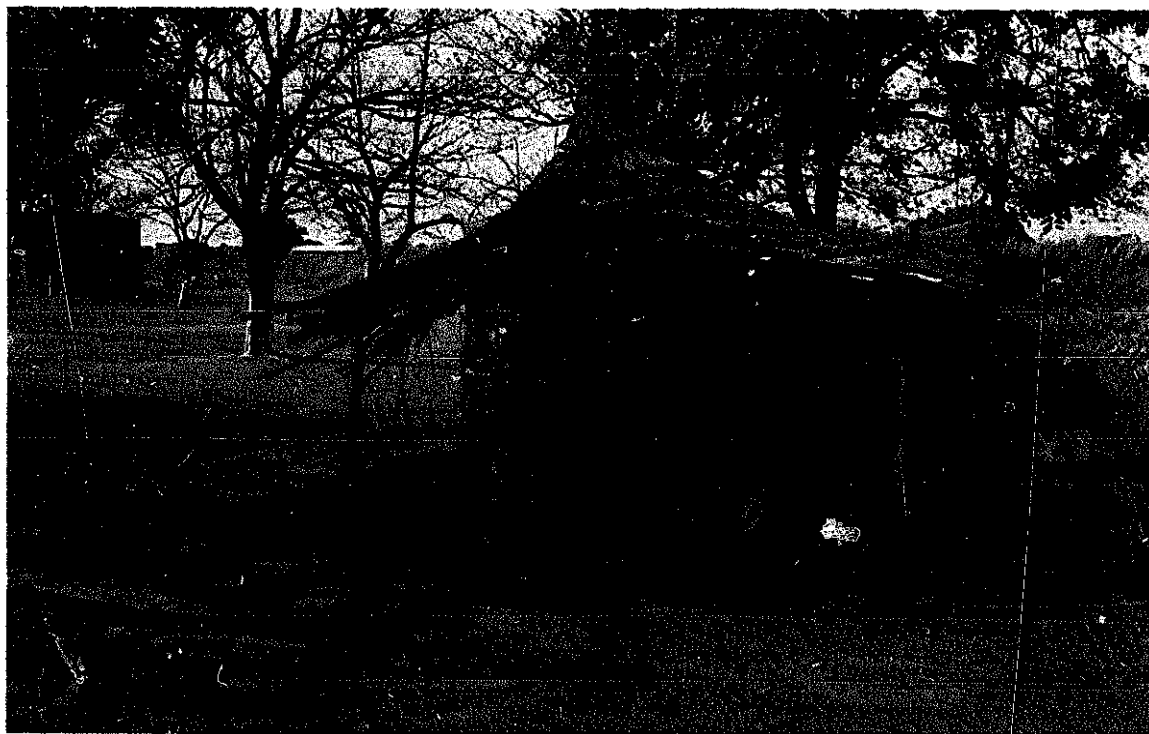


Fig. C/II/4: In some northern parts of the country transport of drinking water with draught animals gains more and more importance. "Tank vehicles" able to hold about 500-600 litres are still rather seldom. If they are - as shown here - properly protected against sunshine the contents last for some time reducing especially one aspect of heavy labour for women. (Photo: Munzinger)

C/III

Animal traction in Madagascar

Case study C/III

ANIMAL TRACTION IN MADAGASCAR

(J. Tran van Nhieu)*

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1) The author of this report worked as a technical advisor at the Centre d'Etudes et d'Essais de Machinisme Agricole in Madagascar from 1965 to 1973 within the framework of French Technical Cooperation.

1. Introduction

Animal traction has been known in Madagascar for many years. During the regency of Queen Ranaivalona I (1928-1861) it was introduced in the Mantasoa region, 60 km east of Tananarive, and around 1870 spread to the regions near Lake Alaotra and Tananarive and was used in particular for preparing swamp-rice areas for cultivation.

The use of draught animals has since spread throughout the island; they are used in the uplands as well as for the cultivation of swamp rice in the lowlands. The preconditions for the use of draught animals in Madagascar are extremely favourable:

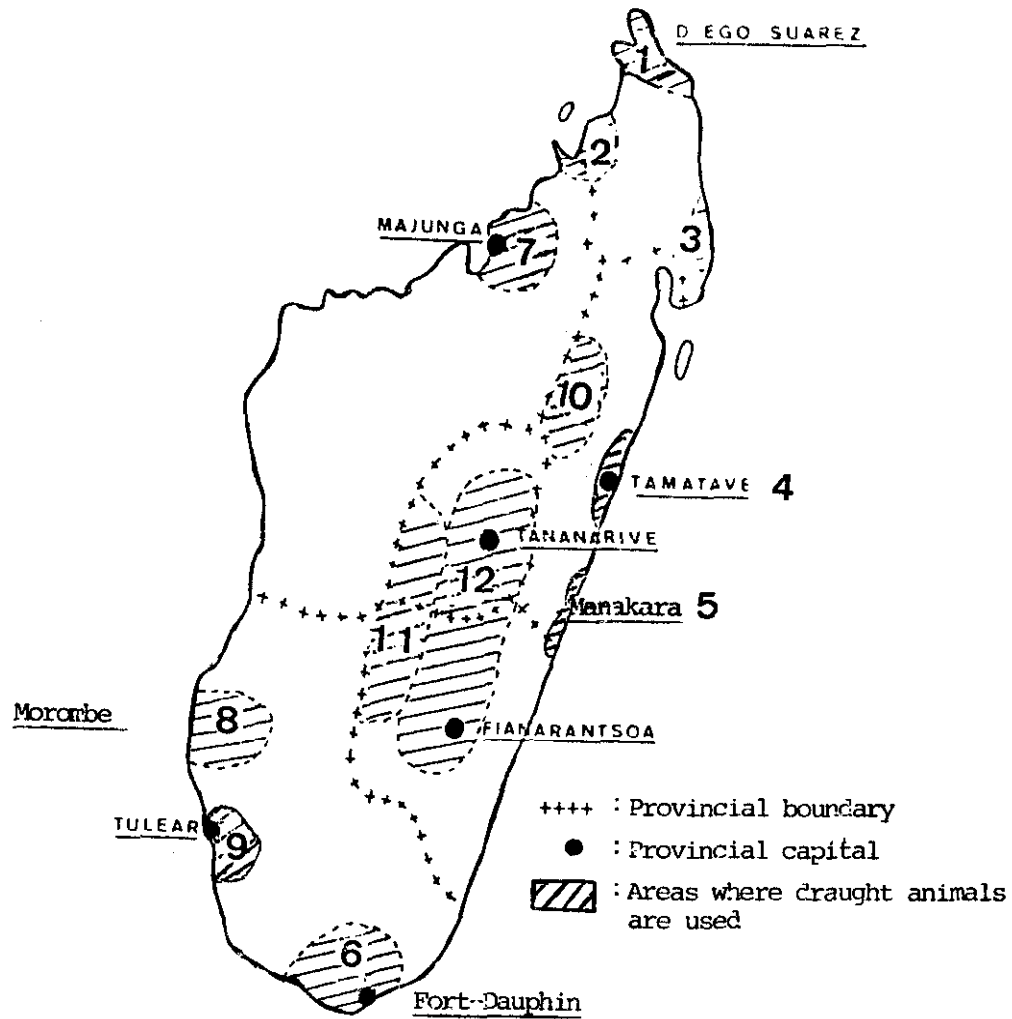
- An extremely large number of cattle (over 10 million in 1971),
- Local traditions favouring stockkeeping (e.g. theft of livestock in Madagascar is very severely punished both by law and according to custom).

In contrast to other attempts to promote the use of draught animals in Africa, it was possible in Madagascar to start the assistance at a specific level and it was not necessary to first accustom the farmers to keeping animals. This formed the basis for the most important measures listed below and implemented by various promotional organizations - mainly French institutions and the FED*) - whereby the paramount aim was in general improvement of the situation of the rural population:

- Introduction of improved animal-drawn implements
- Setting-up and development of local craft industries and local manufacture of the above-mentioned agricultural implements
- Support of the extension and veterinary services (e.g. in introducing new tools and simple machines)
- Breeding and the selection of improved draught animals.

*) F.E.D.: FONDS EUROPEEN DE DEVELOPPEMENT - 200, rue de la Loi - BRUSSELS (Belgium)

LOCATION OF THE MAJOR REGIONS USING DRAUGHT ANIMALS



- | | |
|----------------------------------|--|
| 1 - Diego Suarez region | 7 - Majunga region |
| 2 - Antsohihy region | 8 - Morombe region |
| 3 - Antalaha region | 9 - Tuléar region |
| 4 - Tamatave region | 10 - Lake Alaotra region |
| 5 - Manakara - Mananjary region | 11 - Mid-West region |
| 6 - Fort-Dauphin (Androy) region | 12 - Tananarive - Antsirabé -
Fianarantsoa region |

2. Available draught animals

Almost all the existing draught animals are cattle, although donkeys are also used in the southern regions to transport people or agricultural produce. The introduction of water buffalo in the Tamalave region around 1955 did not prove successful since the Madagascan farmers were not used to these animals.

2.1 Breeds

Most of the cattle are of the following types:

- Pure-bred zebus (*Bos indicus*)
- Cross-breeds for milk production (crosses between zebus and various European dairy cows, numbering approximately 30-50 000)
- The Renitelo breed (a Limousin/Afrikander/Zebu cross-breed, mainly for threefold use)
- Brahmas and small numbers of other cross-breeds (approx. 5 000).

a) The Madagascar zebu

This zebu has a characteristic neck hump and is a stocky, rectangular medium-sized animal with crescent-shaped horns. Its coat may be of various colours.

The zebu is kept mainly for meat production but can also be used for agricultural work such as soil tillage or pulling carts.

Its working life starts at the age of around 4, when it weighs about 300 kg. The average measurements of a 7-year-old bull are as follows:

Weight:	300 - 400 kg
Height at withers:	125 - 130 cm
Chest:	170 cm

b) Cross-breeds used for milk production

These are kept mainly in the highlands or in the vicinity of large towns. Milk production is reasonable and amounts to between 5 and 8 litres per day during the lactation period (6 months).

c) Renitelo

This breed is used in particular as a draught animal because it is larger than the zebu.

Weight of a 7-year-old bull: over 700 kg
 Height at withers: 140 cm
 Chest: 205 cm

d) Brahmas and cross-breeds

The crosses between Brahma cattle (which are themselves the result of crossing American breeds with various breeds of Indian zebu e.g. Onkole or Guzirat) and the Madagascar zebu have special features: crescent-shaped horns, a thick neck, a marked dewlap and an upright hump.

Measurements: (4-year-old bull)
 Weight: 450 kg
 Height at withers: 135 cm
 Chest: 175 cm

2.2 Weight and power of draught animals

The trials performed by the C.E.E.M.A.T.*) in Madagascar have revealed that there is a direct correlation between the animals' weight and their tractive effort. The following average values can be taken as a basis:

Tractive effort: approx. 1/8 of the weight of the animals harnessed, over a working period of 5-6 hours, on agricultural land free of stones and roots.

Table C/III/1: Power of Madagascan draught animals over long periods

Type and number of animals	Weight kg	Age Years	Average effort kg	Max. effort kg	Speed m/s	Power kgm/s	Effect. working hours/day	Duration of trial Days
1 pair of Madag. zebu bullocks	630	4 - 5	80	150	2.5	56	4 h 45	3
2 pairs of Madag. zebu bullocks	1 300	4 - 5	160	400	1.8	80	5 h 45	2
1 pair of Brahma oxen	1 060	6	147	310	2.4	97	4 h 40	11
1 pair of Renitelo bullocks	1 110	5.5	150	360	2.9	120	3 h 40	-

Source: C.E.E.M.A.T.

*) Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropical, Antony/France

2.3 Selection of draught animals

The double neck-yoke, which is suitable on account of the animals' hump (zebu:), is generally used in Madagascar for tilling the soil and pulling carts. The single neck-yoke, intended mainly for use with only one animal, is employed only to a limited extent, particularly for light work (sowing, plant protection measures) etc.).

The following features are of particular importance on a young draught animal: sturdy bone structure and joints, strong muscles and a broad chest. Ill-tempered or weak animals must be excluded from the outset.

Young animals aged between 2 1/2 and 3 1/2 are chosen for training; it is preferable to use oxen since they are quieter than bulls.

An animal's working life lasts between 4 and 9 years, following which it is sold for slaughtering.

Training and working hours

Training centres are located in various regions of Madagascar and are either run by the Ministry of Agriculture or by various agricultural development programmes. The farmers are usually offered the following two choices:

- They can purchase already trained animals or
- they can bring their own animals to the training centre and participate in the training there for around one month under the supervision of the instructors.

Training is generally carried out using pairs of oxen on the basis of a clearly defined programme:

- Phase 1:
Wearing and accepting the yoke
- Phase 2:
Walking forwards, stopping, continuing in a straight line and making turns
- Phase 3:
Agricultural work such as ploughing, pulling carts etc.

The animals should subsequently work regularly on the farms so that they remain used to obeying commands. Once the field work is complete they should be used outside the crop season for pulling carts.

It is frequently possible to find outstandingly trained animals which obey verbal commands. In the Lake Alaotra region, for example, where the double two-way turnover plough has been used for decades, teams comprising 3-4 pairs of oxen are driven solely by one man and an assistant.

Working hours

The animals work for between 5 and 6 hours each day with a break of 3-4 hours after around 3 1/2 hours of work.

In the coastal regions it is better to work early in the morning in order to avoid the afternoon heat.



Fig. C/III/1: Ploughing of heavy soils with cross-breeds. The soil is not turned completely with the plough used. (Photo: Esche)

2.4 Feeding and housing the animals

The Madagascan farmers give their animals additional fodder only in the evenings when they have returned to their pens. The animals are usually given green fodder (cut on the irrigation dams), harvest residues, green rice straw or, more rarely, green manioc.

During the rainy season the animals spend the day grazing in the natural pastures, while in the dry season they live principally on their reserves and must otherwise content themselves with the little additional fodder given them (hay, dry rice straw, groundnut stalks etc.).

The daily requirement of a resting animal weighing 300 kg is estimated at 3 fodder units, while a working animal requires 7 fodder units (see Section B/I for definition of fodder units).

On the high plateaus, where night-time temperatures may be as low as 4°C during the cold time of the year, the animals on the larger farms are kept in cattle sheds. On small farms they generally spend the night on the ground floor of the farmer's house, while he and the other people in the house use the floor above. In the coastal regions, where it does not become so cold, the animals are simply driven into enclosures or pens in the evening.

Both methods of accomodating the animals make it possible to obtain a substantial quantity of cattle-shed or pen manure which is urgently required in agriculture.

In the areas with extensive stockkeeping (mid-west and south) the animals are left practically in a semi-wild condition and wander across the land, watched over by herdsmen.

3. The agricultural population

Around 85% of the Madagascan population, i.e. approximately 7 million in 1974, are either arable farmers or stockkeepers and thus constitute a decisive factor in the country's agricultural development.

A Madagascan farmer is involved in the utilization of draught animals in various ways:

- Use of the animals: selection, training, care, feeding, attention.

- Use of equipment: selection and maintenance.
- At farm level: marking out plots, observing crop rotation sequences, soil conservation measures, fertilizing etc.

It must be stressed, however, that traditional habits and customs often hinder the introduction of new cultivation techniques or new, more efficient equipment. This means that continual advice and supervision for the farmers are essential.

In the south of the island a farmer's prestige is directly related to the size of his herd, the number of animals being more important than their quality (this is also referred to as "contemplative stock breeding"). The farmer will therefore scarcely make rational use of his livestock (selection of animals, keeping of a sufficient number of bulls, fattening etc.) and will not train them. He often prefers to hire trained animals for his field work.

However, in regions where animal traction has long been widespread, the farmers are well aware of its importance, and draught animals are bought specifically for agricultural work.

4. Equipment used

Mention must firstly be made in this context of the SIDEMA*), a semi-state-owned company which has a monopoly in the manufacture of agricultural implements in Madagascar.

4.1 Potential uses

The agricultural implements used can be divided up according to their purpose:

I. Soil tillage

a) Ploughing

The plough has been used in Madagascar since around 1850. The following types are employed, starting from the most simple and progressing to the more complicated appliances:

- 2 versions of the simple Belgian plough (see also Fig. B/II/24):

- . Light-weight version:

- Weight 30 kg, working width 0.18 m, mean working depth 12-

*) S.I.D.E.M.A.: SOCIETE INDUSTRIELLE POUR LE DEVELOPPEMENT DU MACHINISME AGRICOLE - Tananarive (Madagascar).

15 cm. This plough is used mainly on light soils (slightly sandy) which are particularly widespread in the south of the country.

. Normal version:

Weight 35 kg, working width 0.22 m, working depth max. 18-20 cm, generally used on the high plateaus and the loamy coastal plains.

- Turnwrest plough with land wheel, 45 kg (Bourguignon model, Fig. B/II/28).

This 60 kg reversible plough design (Ebra model: working width 20-25 cm, working depth 18-22 cm) is particularly valued by the farmers on the high plateaus who must often plough on slopes.

- Two-way ploughs (Fig. B/II/27) are used extensively on the fertile loamy soils near Lake Alaotra and in the north-west region (Antsohihy), (weight 150-180 kg, working width 0.3 m, working depth up to 35 cm). this plough requires a great deal of traction power and must therefore be drawn by 3-4 pairs of oxen. Recent years have seen the introduction of lighter two-way ploughs, weighing 90-120 kg and requiring only 2 good pairs of oxen.

b) Seed-bed preparation:

In dry-farming the clods produced during ploughing are crushed using toothed harrows (spike-tooth or zig-zag harrows) which are generally manufactured locally (wooden frame but imported teeth; see also Fig. B/II/34 and 35).

c) Preparation of swamp rice fields:

Ploughing is usually carried out using reversible or two-way ploughs when the soil is dry. Before the rice can be planted out the field must be puddled, i.e. the top 10-12 cm of soil must be transformed into a watery layer of mud. The following equipment can be used:

- The toothed harrow
- The spike tooth roller (Tuléar region)
(Fig. C/III/2)
- The blade harrow (upland region)
(Fig. C/III/3)

Fig. C/III/2:

The Madagascan spike tooth roller, which is made of 40 mm angle iron, and mainly used in irrigated rice farming, is intended to supersede treading-down of the soil by animals. Its efficiency is considerably greater after ploughing.

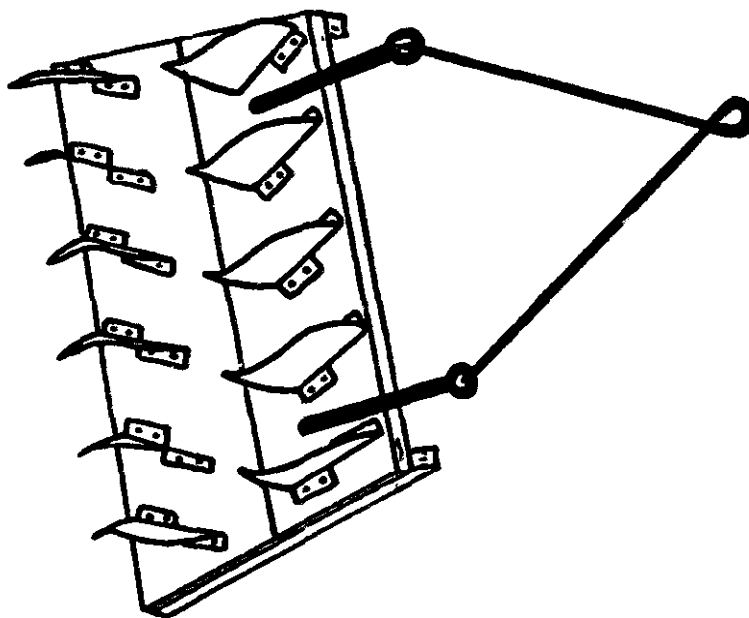
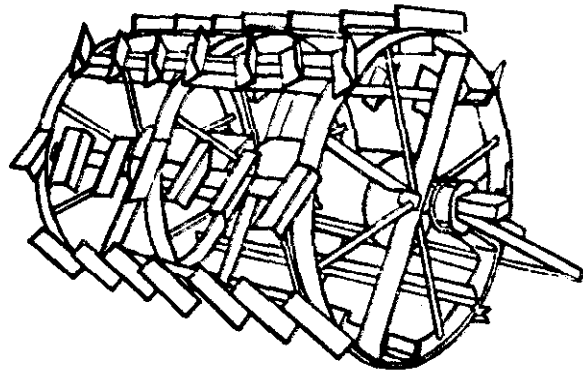


Fig. C/III/3:

The blade harrow is derived from Spanish harrows. It functions in the same way as the spike tooth roller but with a 5 cm deep layer of water on the field. (Source: CEEMAT)

These two implements shown above permit considerable savings on time and labour. 5-6 hours per hectare are required on average after ploughing for puddling the fields using one pair of draught animals.

The conventional technique, i.e. puddling the fields by having animals trample down the soil, is also still widespread in Madagascar. This is intended to bury the weeds in the soil and puddle the surface of the rice field by having the animal repeatedly trample it down with their hooves.

For this purpose a herd of 60-80 animals is driven around the flooded

field for about 4-5 hours, accompanied by loud shouting and cracking of whips. This is tiring for both men and the animals. The herd's weight loss is estimated at 100 kg per hectare trampled and this method can only be used for 2 days a week.

The same field must be trampled down on at least two occasions, separated by a few days, in order to produce a sufficient watery layer of mud.

Seen from the economic angle, this method is extremely expensive since, among other things, it requires a large number of workers and subjects the animals to extreme stresses. If at all possible, therefore, the Madagascan farmers are increasingly changing over from this method to the use of draught animals and the above-mentioned appliances.



Fig. C/III/4: Levelling of irrigation areas with simple animal-drawn wooden levelling-board often built by the farmers themselves.
(Photo: Esche)

II. Sowing

The use of seed spacing drills is not very widespread on the island, although they are employed to sow maize, groundnuts and beans. Two versions are found:

- "Ebra" seed drill: the seed dispenser is a tilted cell wheel,
- "Super Eco" seed drill: the seed dispenser in this case is a horizontal cell plate.

A grain drill is also manufactured locally and is used to sow rain-fed rice. Seed drills can only be used if the farmers have previously been the target of intensive extension work, i.e. have been advised on machine settings (number of grains per hole, distance between holes in the row etc.). Seed drills are therefore particularly widespread in areas where agricultural promotion programmes are being implemented, e.g. by the Gopr*) in the upland zones of by the ODEMO**) in the mid-west.

III. Crop-weeding

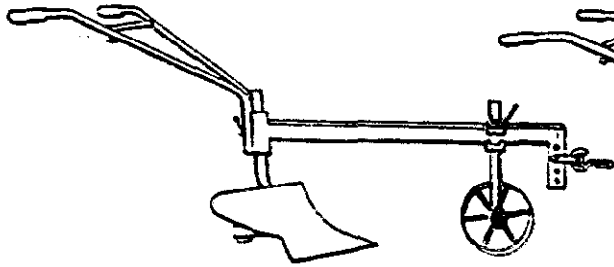
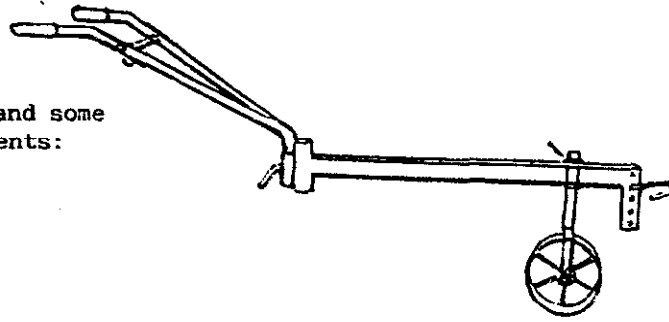
A triangular frame with hoeing and loosening shares and angular expansion facility (Fig. C/III/5) is fairly widespread in the dry-farming regions and is used for tending the maize, groundnut and manioc plantations. The problem in using this tool is that it is essential to have well-trained animals which can walk exactly between the rows.

Multicultivators are also being used to tend the crops (Fig. C/III/6).

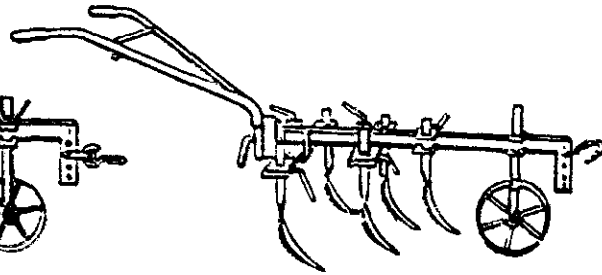
*) Gopr: GROUPEMENT POUR LA PRODUCTIVITE AGRICOLE

**) ODEMO: OPERATION DE DEVELOPPEMENT DU MOYEN-OUEST

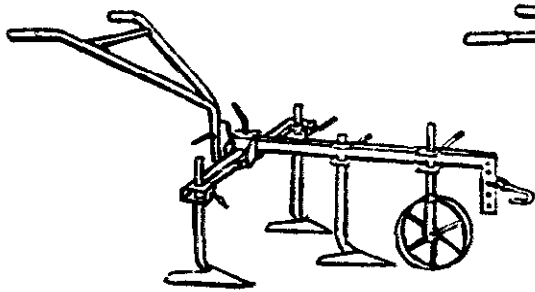
The basic frame and some possible attachments:



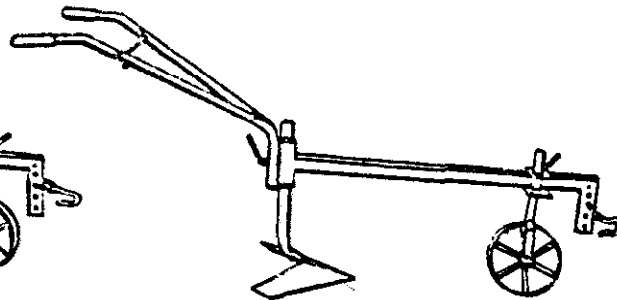
Plough



Cultivator



Hoe



Groundnut-lifter

Fig. C/III/5: Example of a multicultivator

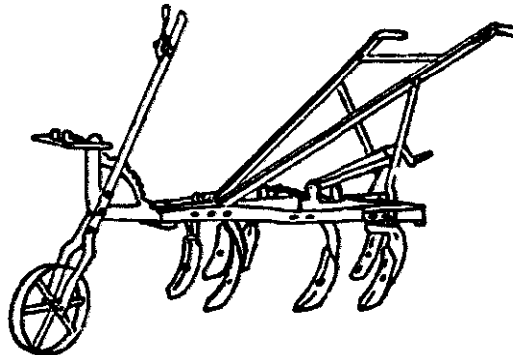


Fig. C/III/6:
Angular expansion hoe

IV. Harvesting

a) Forage harvest

Trials using draught oxen and the "PUZENAT" mowing machine to mow natural and artificial pastures have been carried out at the livestock-rearing stations. This is laborious work requiring a great deal of tractive effort. An alternative method which makes the work easier involves the use of an auxiliary petrol engine to power the cutter bar; traction power is thereby required only to transport the machine.

b) Groundnut harvest

Various types of groundnut lifters have been tested. Only a few were satisfactory, however, on account of the relatively large quantities of groundnuts which were left in the soil.

To complete the picture mention must be made of a few multi-purpose tool carriers of the "Mouzon", "Nolle" and "Ebra" brands introduced in Madagascar by intervention companies. This type of appliance comprises a frame on which the following attachments can be mounted: Plough, hoeing shares, ridger, harrow teeth etc. The most expensive model, which has pneumatic tyres, can be used as a cart if a plank bottom is added.

Despite a great deal of publicity work these multi-purpose units are seldom used on account of their high purchase price.

V. Transportation

Use of hand-drawn or pushed carts was already widespread in Madagascar before draught animals were introduced. 2 main models are found today:

a) Model with loading platform:

This model has large wooden wheels with iron fittings. Dimensions of loading platform: length 2.20 m, width 0.90 m, height of tail-board 0.60 m, total loading space 1.2 m³, pay load approx. 1 tonne.

The craftsmen in rural areas generally purchase the axles from the SIDEMA and then make all the wooden parts, including the wheels, themselves.

Fitting of a crank-type brake was essential to enable the carts to be used in mountainous regions. In 1978 such an attachment already cost over 80,000 Malagasy francs.

b) Model widespread in the Majunga region:

This model is generally drawn by only one ox since it is smaller and has metal wheels with a broad running surface.

In the Sakay region (mid-west) the agricultural services have introduced a type of cart fitted with pneumatic tyres. This version was quickly accepted and adopted by the local population on account of its numerous advantages (e.g. comfort, less traction effort required). Most of the axles used in these carts come from old cars or trucks discarded for scrap.

c) Sleds:

These consist of 2 beams joined together in a V-shaped and are often used by the farmers for transportation in the field. In 1974 there were over 60 000 such sleds on the island.

VI. Other work

A number of capstans have been used in the Mid-West Region to convey drinking water and irrigate small plots.

Capstans are also used to operate sugar-cane presses, and consist of 2 vertical fluted cylinders made of wood or iron. They are particularly widespread in the Tamatave region (sugar cane-growing area) and are used in the production of sugar-cane wine (fermented juice) and red sugar.

4.2 Distribution of equipment to the farmers

Hand tools and the equipment required for the use of draught animals are distributed via both governmental and private channels.

The organizations in the state sector are responsible to the Ministry of Agriculture and include, for example, the C.E.A.M.P. (Centrale d'Equipement Agricole pour la Modernisation du Paysannat) or the "Service des Approvisionnements", which works in close collaboration with the general agricultural extension service (Service de la Vulgarisation Agricole).

The C.E.A.M.P. concludes suitable contracts with the SIDEMA or importers of agricultural machinery and implements and distributes the equipment via its regional or district offices.

The Service des Approvisionnements usually sells the equipment and tools in the areas where there is no C.E.A.M.P. office or where there is an agricultural subdivision (at registered-village level).

Both imported implements and tools as well as those manufactured by local craftsmen of the SIDEMA are in addition sold in the private sector by local dealers, for the most part only in the larger villages.

The SIDEMA, which has a monopoly in the manufacture of agricultural implements, has to date been able to sell all the ploughs it produces. Government subsidies have enabled it to eliminate all competition on the part of local craftsmen.

This policy has unfortunately led to a substantial reduction in the number of rural craftsmen, who have been forced to earn their living in other sectors (e.g. metalworking). This is regrettable in that these craftsmen used to provide maintenance and service for the farmers' implements, e.g. small welding jobs, replacement of worn parts (shares, coulters, swivel rollers etc.). In order to remedy this situation, at least in part, 7 workshops for agricultural machinery have been set up since 1973 in the Tuléar (9), Lake Alaotra (10), Majunga (7), Ambanja (2), Faropangana (5), Sakay (11) and Maintirano regions (cf. Map, page 430).

5. Overall aspects

A certain amount of explanation is necessary as regards the areas shown on the map in which draught animals are used. The most favourable areas are in the Lake Alaotra (10), Upland (12), Mid-West (11) and Antalaha (2) regions, all of which provide the necessary socio-economic prerequisites, the land and a resident population. The eastern coastal areas, however, have high temperatures and high humidity and are in general less suitable for cattle rearing. The dry areas in the west and south are used only for extensive stockkeeping by the majority of the population.

5.1 Type of farms

The farms in Madagascar are very small, with an average area of approximately 1.20 hectares, and the fields are highly fragmented (average plot size 0.32 of a hectare). This prevents the further spread of the use of draught animals. Around 5 hectares can be tilled using a pair of oxen, while the smallest economically feasible area is 3 hectares.

Over 80% of the 1 306 260 farms recorded in 1974 are therefore still cultivated by means of manual labour.

5.2 Agricultural extension services

The provision of extension services for the Madagascan farmers is essential in order to permit the spread of modern cultivation techniques and more suitable implements.

The most widespread method is so-called "mass-approach extension work" in which the farmers in the area concerned are induced to use the technical innovations within a brief, limited period. In order to be successful such a measure must reach around 70% of the farmers and therefore calls for intensive supervision.

Government extension services are provided by the departments within the Ministry for Rural Development and Agrarian Reform (Ministère du Développement Rural et de la Réforme Agraire, M.D.R.R.A.):

a) Stock-Breeding Department:

- Supply of draught animals
- Animal hygiene and care: inoculation campaigns

b) Rural Construction Department:

- Selection of the most suitable implements
- Approval and testing of implements
- Advice on the upkeep of agricultural implements

c) Agricultural Extension Service:

- Supply of seed, fertilizer and plant protection agents
- Instruction and training in improved cultivation techniques

New techniques are also propagated by various semi-governmental or private institutions within the scope of regional development programmes:

a) Upland region (12):

The G.O.P.R. (Groupement pour la Productivité Rizicole = Association for the Increase of Rice Production) has concentrated on extension services dealing with the use of fertilizers, plant protection agents and agricultural implements (e.g. light-weight hoes, simple ploughs, turnover ploughs etc.). Its success has been the result of highly intensive extension work among the farmers and support from foreign personnel of the S.A.T.E.C.*).

b) Mid-west region (11):

The work of the O.D.E.M.O. (Development programme for the mid-west region) essentially involved settling people from the overpopulated areas around Tananarive on the high plateaus of the mid-west. Support was given to this work by the B.D.P.A.**).

c) Lake Alaotra region (10):

The main tasks of the S.O.M.A.L.A.C. (Madagascan Association for the Development of Lake Alaotra) was the settlement of farmers on 2-3 hectare rice farms. The farmers were settled on land which formerly constituted estates bought back from large French landowners.

The land in question covers an area of around 30 000 hectares.

d) Cotton-growing areas

(Tuléar, Mangoky and Majunga province):

The C.F.D.T.***) joined forces with companies in Madagascar in order to promote the development of cotton-growing; this included to a large extent the use of draught oxen.

The FIFATO organization in Tuléar looked after 5 000 farmers, each of which cultivated one hectare of cotton using draught animals. Their equipment comprised: the 30 kg SIDEMA plough, the triangular multi-purpose unit with loosening and ridging tools, and a knapsack sprayer.

It should be added that centres for demonstrating the use of the implements have been set up within the scope of various regional

*) S.A.T.E.C.: SOCIETE D'AIDE TECHNIQUE ET DE COOPERATION - 110, rue de l'Université - 75340 PARIS Cedex 07 (France)

**) B.D.P.A.: BUREAU POUR LE DEVELOPPEMENT DE LA PRODUCTION AGRICOLE - 202, rue de la Croix Mivert - 75738 PARIS Cedex 15 (France)

***) C.F.D.T.: COMPAGNIE FRANCAISE POUR LE DEVELOPPEMENT DES FIBRES TEXTILES - 13, rue Monceau - 75008 PARIS (France). (French Textile Fibre Development Company).

development programmes (e.g. in the mid-west). Their main activities cover:

- training of draught animals
- use of agricultural implements (according to the crops grown in the region).

5.3 Organization of granting of credits for the purchase of draught animals and equipment

To obtain credits independent farmers had to apply to their nearest branch of the B.N.M. (Banque Nationale Malgache) which has a special department for the granting of agricultural credits.

8% interest had to be paid on short-term credits (approx. 3 years). The B.N.M. requested the following guarantees for loans:

- For long-term loans: title of ownership to the land cultivated
- For medium-term loans: examination of the application by a special committee.

Short-term loans for one harvest period were also available.

Other farmers who collaborated with a specific regional development programme in their area (e.g. ODEMO or SOMALAC) usually obtained their equipment on a credit basis via the sponsoring organization and were obliged to sign corresponding agreements (often borrower's notes) laying down the arrangements for repayment, which varied depending on the organization.

5.4 Problems encountered in the use of animal traction

a) Animals used:

The use of certain implements calls for several pairs of oxen (e.g. two-way ploughs). Trials carried out in the I.E.M.V.T.*) station in Kianjasoa revealed that there is a certain loss of power if, for example, 3 pairs of oxen are used instead of 2. This results in:

- a drop of around 12% in the working speed
- a non-proportional increase in the tractive effort: 2 pairs

*) I.E.M.V.T.: INSTITUT D'ELEVAGE ET DE MEDICINE VETERINAIRE DES PAYS TROPICAUX-10, rue Pierre Curie - 94700 MAISONS-ALFORT (France).

of oxen produce 160 kg, whereas 3 pairs produce only 200 kg, corresponding to an increase of 25% instead of the 50% theoretically expected.

b) Breeds:

On account of their greater body weight (between 450 and 700 kg) the Renitelo cattle and the Brahma cross-breeds develop a greater tractive effort than the Madagascar zebus (approx. 1/8 of their body weight during continuous working). However, economic factors hamper the spread of these highly suitable breeds.

c) Overworking and undernourishment of the animals:

The animals are subjected to a great deal of use in the main cultivation period between September and October; they are often forced to work for more than the recommended 6 hours. This situation is made still worse by the fact that the animals are undernourished, mainly because:

- the farmers are unaware of the animal's requirements and
- there is little motivation for additional expenditure on extra food for the animals on account of the low sales prices for agricultural produce.

6. Prospects

As a result of the continual worldwide price increases for petroleum products and the fact that no new petroleum deposits have been found despite intensive prospecting, the use of draught animals will still remain the major source of traction power for agriculture in Madagascar for a long time to come.

Various measures could contribute towards increasing the profitability of animal traction:

- Advice on and spreading of improved breeds (Renitelo, cross-breeds, Brahmas) on a large scale;
- Improvement of the veterinary services and feeding of the animals;
- Provision of suitable agricultural implements for the farmers;
- Guaranteeing of an efficient maintenance service through the setting-up of repair workshops and the provision of financial support and equipment for rural craftsmen.

Lastly, large-scale introduction of tractors in the country, as is at present taking place within the scope of the programme to increase rice production, will provide an opportunity to investigate promising combinations of the three forms of mechanization:

- manual labour
- animal traction
- motorized traction power

which, depending on the crops cultivated, would be suitable means of improving the farmers' incomes.

C/IV

Use of draught oxen in Northern Ghana

Case study C/IV

USE OF DRAUGHT OXEN IN NORTHERN GHANA

(J. Smid)*

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*) Former Extension Officer, Nyankpa'a Agricultural Station 1978/79.

1. Introduction

As early as 1934 the British attempted to introduce the use of draught oxen in the then Northern Territories of the Gold Coast. The main obstacle, the tsetse-flies, had been driven out of the region; moreover, sufficiently strong animals were available. Demonstration farms were set up at several agricultural stations, e.g. Zuarungu, Bawku, Navrongo, Babile and Nyankpala/Tamale, and the use of draught oxen encouraged in conjunction with other innovations, while similar work was also started in schools.

Once Ghana had attained independence in 1957 and under the then President Nkrumah, the use of draught oxen was regarded as backward ("total break with primitive methods"), inefficient and colonialistic, and priority was given to tractor-based mechanization of agriculture ("gigantic agricultural schemes"). The direct result of this policy was that the then around 3000 farmers using oxen in Northern Ghana could not obtain an adequate supply of ploughs and spare parts. The use of draught oxen was totally neglected and many farmers were forced to stop using this method. Only in the extreme north-east, in the Bawku District, did the number of farmers using oxen increase; these farmers probably smuggled in ploughs from Nigeria, Upper Volta and Togo and were subsequently supplied by the church-run agricultural station in Garu (1963).

Following the fall of Nkrumah and once it was clear that tractor-based agricultural mechanization was nevertheless encountering excessive problems, attention in the seventies was once again focused on animal traction:

- Practical courses in the use of draught oxen were held at the Nyankpala Agricultural College;
- The Christian Service Committee (in which a number of Protestant churches joined forces) opened the Yendi Agricultural Station and made the use of draught oxen, combined with the supply of ploughs and spare parts, the main elements in its agricultural extension service;
- This was followed in 1974 by the Ghanaian-German Agricultural Development Project (GGADP) in the Northern and Upper Regions with the Gushiegu and Banile Agricultural Stations, in which the use of draught animals did not gain momentum until the second phase of the project.

2. Conditions for the use of draught animals

2.1 Natural locational conditions

The Northern Region is located between the 9 and 10°N lines of latitude, covers approximately 70 000 km² and has around 730 000 inhabitants. The population density is only approx. 10 inhabitants per km² and is relatively low in comparison with the average population density in Ghana of 49 inhabitants per km².

There is only one rainy season, lasting from mid-April until the end of October, with 1100 mm of precipitation on average. The temperatures range between 25 and 30°C. The major feature of the dry season, which lasts from mid-November until the end of March, is the Harmattan, a hot wind from the Sahara, which brings a great deal of dust with it. The relative humidity is extremely low at approx. 15% and daytime temperatures can be as high as 45°C.

3 main soil types can be distinguished: groundwater laterites, savannah ochrosols and acid gleisols in the river valleys. Groundwater laterites are pale sandy to silty loam soils with a depth of up to 60 cm which rest on a hard, almost impervious layer of clay with a high iron content. The drainage in these soils is poor; water accumulates during the rainy season, while during the dry season the soils dry out completely.

The savannah ochrosols are of better quality and consist of red to reddish-brown soils which drain well. In the valleys these soils are deep; elsewhere they are sometimes extremely shallow, comprising approx. 25 cm of crumbling, porous loam soil. Underneath are water-permeable laterites containing iron.

The white, usually acidic gley soils in the river valleys are highly suitable for rice cultivation.

Common features of all the soils are leaching during the rainy season and evaporation in the dry season. Leaching causes valuable minerals to be lost, while the high degree of evaporation leads to formation of a layer of laterite (deposition of phosphorus) near the topsoil. Almost all soils have a low humus content which may be attributed, among other things, to the yearly bush fires. During the dry season the soils are rock-hard and the first rain runs off before it can be absorbed by the sprouting vegetation.

The vegetation consists of bush savannah with fire-resistant trees with a thick bark, such as baobab, shea, acacia, dawadawa and nim, and thick grass up to 4 m high. The Northern Region is a slightly hilly plain, approximately 300 m above sea level, and is divided by the river valleys of the White Volta and the Oti.

2.2 Structural locational conditions

Only around 4% of the total area - approx. 280 000 hectares - of the Northern Region have to date been used for agriculture. Half of this area is still lying fallow or is used extensively as live-stock pasture. The region contains around 60 000 farms with an average cultivated area of 2.5 hectares. The size of a farm depends on the number of family members, particularly young men, who can help with the work. The land is usually cultivated in the traditional manner using hoes and maize, millet, sorghum, yams and cassava are grown as subsistence crops. Groundnuts, rice and cotton are the major cash crops; tobacco, kenaf, vegetables (tomatoes) and spices are of secondary importance.

Mixed cultivation predominates; only rice is grown over wide areas as a single crop.

Despite the vast reserves of land, still remaining shifting cultivation is found only in a few areas in the Northern Region; semi-permanent and permanent agriculture are the predominant types.

Animal husbandry as an actual production method is of no importance. However, 30-40% of all farms own cattle, which are kept for the most part for reasons of prestige, as a means of accumulating wealth and as a stand-by for obtaining cash in an emergency. The most common breed is the West African Shorthorn, which is sometimes crossed with zebus. It is sufficiently trypano-tolerant and strong enough to be used to provide traction power. The livestock population is estimated at 700 000. Ownership structures are complicated; there are essentially 2 types of livestock ownership:

- a) Family-owned livestock (joint ownership), where the head of the family determines how it is to be used;
- b) Privately-owned livestock, where ownership is sometimes kept a secret from the extended family for fear that they will claim that they are entitled to use the animals.

The social structure in rural areas is still determined by the traditional hierarchical structures. The chief and paramount chief of a tribe have almost unlimited power over what goes on within their sphere of influence. Together with their council of elders, the divisional and village chiefs maintain social order in their villages and settle land disputes and other arguments between their "subjects".

The government reimburses the chiefs for their expenditure, in return for which they are required to carry out certain duties such as collection of poll tax. The extended family, with the traditional patriarchal structure, is predominant throughout the Northern Region.

Land ownership

In accordance with traditional practices the "tendana", the priest of the earth god, has at his disposal all the land in the Northern Region and anyone wishing to own land must obtain his approval. In return the person acquiring the land must bring a gift, e.g. a basket of millet. Land acquired by a family in this manner remains the property of the family as long as the latter exists. Even the recently introduced commercial rice cultivation has not changed this traditional form of land ownership. Land may be acquired only with the approval of the tendana, the chief and the council of elders.

2.3 Economic locational conditions

Although Northern Ghana has a relatively well developed network of main roads, there is nevertheless no satisfactory access road system to connect remote villages. Many areas cannot be reached by truck, particularly during the rainy season. The women must carry the agricultural produce and production requisites to and from the distant markets on their heads. The market prices for agricultural products in these areas are accordingly low.

However, farmers living in villages located directly on the main roads do not encounter marketing problems. A system of around 60 main and subsidiary rural markets, with markets held every 6 and 3 days respectively, ensures that the agricultural produce is sold. Private dealers and market agents buy up the produce and have it transported to the towns. Although the government has introduced fixed prices for almost all products, these are of importance only

to the state marketing institutions, such as the state rice and oil mills etc. The market prices are governed by supply and demand and sometimes there is talk of black-market prices.

Ghana's economy has been stagnating since the early sixties. The per-capita income has decreased and the value of the currency - the cedi - has dropped continuously. The main cause of this was the economic policy started under Nkrumah, which was excessively geared towards "industrialization" and "mechanization" and which then led to Ghana's present economic decline as a result - among other things - of ever-increasing corruption. Ghana had nevertheless been in a relatively good position at the time of independence. The land is rich in natural resources, such as wood, bauxite, gold and diamonds and has a relatively good infrastructure as far as roads are concerned. In 1957 Ghana's balance of trade surplus was £ 300 000 000 sterling in gold. However, the over-hasty industrialization, coupled with purely tractor-based agricultural mechanization, proved to be a failure and by 1966 the country already had a balance of trade deficit of £ 600 000 000 sterling. The high degree of agricultural mechanization on a collective basis had been carried out for political reasons: "small-scale private farming is an obstacle to the spread of socialist ideas. It makes for conservatism and acquisitiveness and the development of a bourgeois mentality" (4, p. 40). By the mid-fifties an attempt to use tractors in agriculture in the savannahs of Northern Ghana had already proved to be an expensive error (4). By the mid-seventies it was clear that the introduction of tractors had not paid off. There were not enough skilled tractor drivers and it was almost impossible to import spare parts due to a lack of foreign exchange; many tractors were left standing around in a state of disrepair and could no longer be used. In recent years, moreover, there has been a shortage of diesel fuel, oil and lubricants so that even tractors in working condition could no longer be used for ploughing. As a result of this bitter experience it was only too logical that the use of animal traction should be encouraged again, particularly as there was a good example of this in the Bawku District.



Fig. C/IV/1: Good ploughing with home-bred oxen. The very good harnessing (the yoke has complete frames around the necks) and the use of drag-ropes allows guidance by one person. (Photo: Wessolowski)

3. The GGADP approach

3.1 Previous history of the project

The GGADP was started in 1970 as the German Fertilizer Programme. The project's aims were to improve the standard of living and rural incomes and to increase agricultural production (in particular of rice) by distributing mineral fertilizers and advising the farmers on correct use. The scope of the project was broadened in subsequent years and the following departments were added:

- Seed production (mainly rice, later maize, sorghum and groundnuts)
- Maintenance workshop for project vehicles
- Information system
- Rice mill department (repair and construction of rice mills)
- Advice on mechanization
- Agricultural trials department (in particular fertilizer and variety trials)
- Land clearance (initially only for rice cultivation over large areas, later for cotton-growing by smallholders and construction of drinking-water dams)
- Agricultural economics (collection of socioeconomic data)

Until 1974, however, the activities were concentrated solely on promoting mechanized rice-growing over large areas, a topic which at that time still occupied a position of priority in national policy. The Ghanaian Government wanted to become independent of rice imports, which was in fact achieved in 1975 for a brief period. The German project played a major part in achieving this target and was held in high esteem in both Ghanaian and German government circles. The vast majority of smallholders, however, were not involved and played little part in the successes during the rice boom.

As from 1974 the project concept was gradually modified and activities concentrated on promoting the smallholders. This change of objective was accepted, particularly as the Ghanaian Government started a similar campaign called "Operation Feed Yourself". Thanks to the distribution of mineral fertilizers, the smallholders were familiar with the project which could thus build upon an existing basis of trust. The prerequisites for reintroduction of draught oxen were thus favourable from both angles: the Ghanaian Government was in agreement with the move and the farmers had a certain amount of faith in the project.

3.2 Modified project plan for promoting the use of draught oxen

The project's new objective was to improve the standard of living of the smallholders, i.e. their income from agriculture. This was to be achieved primarily through introduction of appropriate technology, combined with training and extension services for the farmers, a better supply of agricultural production requisites for the smallholders and improved storage of agricultural produce. Promotion of the use of draught oxen thus occupied a position of major importance in this "package", since this had been defined as the "appropriate technology" in question. Seen as a whole, the conditions were favourable:

- Animals are available; 30-40% of all smallholdings have cattle.
- The breeds of cattle in question are relatively trypano-tolerant.
- A Veterinary Service exists, even at local level.
- The government programme entitled "Operation Feed Yourself" involves substantial promotion of smallholders.
- The men are traditionally responsible for tilling the soil.
- Use of animals is traditionally not rejected.

- Not enough tractors are available in view of the fact that they often cannot be repaired due to a lack of spare parts; the private tractor services are becoming very expensive and are almost out of the reach of smallholders.
- The use of draught oxen does not have to be introduced as a new technique; in some areas the method has been retained and has even spread and is being used with success.
- The church-run agricultural station at Yendi has already achieved success in reintroducing the use of draught oxen.

The size of the project area with its various tribes led to a regional approach being planned. The requirements of the Northern Region were to be met on a long-term basis by around 20 agricultural stations, each of which is responsible for the surrounding district over an area of approx. 30 km. The main tasks of the agricultural stations are as follows:

- Agricultural extension services with emphasis on promotion of draught oxen.
- Providing the farmers with agricultural production requisites such as improved seed, mineral fertilizers, ploughs and spare parts, hoes etc.
- Setting-up of a demonstration farm.
- Awarding of credits and organization of repayment.

The stations are run by a Ghanaian Technical Officer, assisted by 1 or 2 development aid volunteers. The DED (German Volunteer Service) agreed to participate, as did the Canadian volunteer service (CUSO) and the American Peace Corps. In order to gain experience a 2-year pilot phase with only 2 stations preceded the actual project, following which a start was to be made on setting up the other stations. The aim was to open 2 stations each year.

The GGADP project management decided in favour of introducing the use of animal traction in this way since the existing general agricultural extension service would have been overtaxed if called upon to perform this task. A system of well-equipped agricultural stations and substations at the same time provides an opportunity to involve the extension workers again and gradually integrate them into an extension programme with the main emphasis on draught oxen.

During the initial phase the programme is coordinated by a coordinator

with a Ghanaian counterpart; the work is subsequently to be divided on a regional basis so that one coordinator is responsible for up to around 6 stations. The responsibilities of the coordinator and his counterpart cover the following areas:

- Planning and evaluation of the programme.
- Adequate and prompt supply of finances and equipment for implementing the programme.
- Choice of locations and setting-up of the agricultural stations.
- Coordination of the work of the stations with each other and with other departments of the project.
- Procurement of material (in Ghana, Federal Republic of Germany, Upper Volta), issuing of material and settlement of accounts for the agricultural stations.
- Collaboration with church-run stations (assistance in the form of material and transportation).
- Channelling of credits for the Agricultural Development Bank.
- Holding of monthly and yearly staff meetings.
- Participation in the planning and setting-up of an equipment factory in Tamale.



Fig. C/IV/2: Transport and distribution of water. In this field draught animal utilization saves a lot of labour, especially for women in rural areas. (Photo: Wessolowski)

4. The agricultural stations as implementing institutions for the use of draught oxen at local level

4.1 Background and experience to date

Agricultural stations aimed at promoting local agriculture had already been set up during British colonial days, for example in Tono/Navrongo, Zuarungu, Babile, Bawku and Nyankpala/Tamale. Church-run development aid organizations later set up similar stations e.g. in Garu, Langbensi, Wale Wale and Yendi. Use of draught oxen was and still is a major area in the extension work. In coordination with the Christian Service Committee (church-run development aid organization) the first GGADP station was built in Gushiegu, around 50 km north of Yendi. This area had a substantial agricultural development potential. 12 farmers trained by the CSC station in Yendi were already using draught oxen and the numerous farmers were interested in adopting the new technique. In Babile (Upper Region) it was possible to take over an old station, where the work in practical terms involved reintroduction of draught oxen. These two stations, located in greatly differing regions containing various tribes, were selected for the pilot phase in order to gain as broad a range of experience as possible. The results achieved at these two stations formed the basis for the framework programme which was subsequently drawn up at a seminar by development aid volunteers and experts. This programme was binding as regards choice of location, setting-up and running of a station.

The following are important criteria when selecting a location:

- Sufficient agricultural development potential
- Existence of infrastructure with emphasis on water supply and accessibility
- Suitable tribal and social structure (i.e. adequate number of villages and farms)
- Availability of animals
- Efficient trading system and good administration.

4.2 Setting-up of an agricultural station

The setting-up and running of the Nyankpala Agricultural Station will be described below as a practical example. Nyankpala is situated

10 miles west of Tamale in the region of the Dagomba tribe. Since 1940 it has been the site of the Crop Research Institute and the Nyankpala Agricultural College, which have promoted agriculture in North Ghana to a great extent. The agricultural station comprises a 4-hectare demonstration farm, a local compound with 4 huts, a kraal for 30 oxen, 1 mineral fertilizer store with 5 external depots, 1 tool shed with carpentry shop for sales and 1 farmhouse with an office. In cooperation with 1 or 2 development aid volunteers the station is run by 1 Technical officer, 1 third-year learner and 1 field assistant. The station personnel also include 7 ploughmen, 3 of whom are supervisors, plus 3 labourers, 1 watchman and 1 herdsman.

The station's demonstration farm is intended - particularly in the initial phase - to serve as a practical example to help in winning over farmers interested in using draught oxen. The station personnel are at the same time to gain experience in using new varieties (seed production) and employ improved cultivation methods. The labourers use the station's own oxen for work in the fields; good workers are promoted to "ploughman" after approx. 1 1/2 years and then provide extension services for the trained farmers. At least 4 different field crops (1 acre per crop) which are grown generally by the farmers in the area are cultivated on each station farm. In contrast to the traditional mixed cropping, the system used at the stations is single cropping with crop rotation (in Nyankpala: groundnuts - sorghum - maize - millet and beans). Next to the demonstration fields is an enclosed 2-hectare pasture and next to this a mango plantation covering 0.5 of a hectare on which trials using legumes (Cotolaria and Stylosantes) are carried out. The farm covers a total area of 12.5 hectares and is surrounded by teak trees.

The compound is used to accommodate the farmers to be trained, who attend 3-week training courses and live too far away to be able to go home each day. The large entrance hall is used for meetings and as a classroom.

The oxen are kept overnight in the bullock kraal, where they are additionally supplied with fodder concentrate (maize, sorghum, groundnut and millet straw) during the dry season. The straw serves simultaneously as litter; the dung is taken to the fields at the beginning of the rainy season. 12 oxen are kept; 4 of them belong to the station, while the other 8 form the "oxen bank". These oxen are in some

cases given to farmers on credit, but are usually exchanged for other oxen too small to be used for ploughing. In this case the farmers must pay a corresponding additional charge.

Together with the Ministry of Agriculture the station organizes the distribution of mineral fertilizers in its extension area. It has been possible to store around 10 000 sacks in the 5 external depots; in 1979 approximately 50 000 sacks of mineral fertilizer were distributed to around 7 000 smallholders. The distribution of fertilizer meant that the agricultural station immediately became known to all the farmers and was able to win their trust to a certain extent. Farmers using oxen are given preference during distribution, whereby mineral fertilizers constitute a powerful incentive (large-scale farmers must buy mineral fertilizer in Tamale). The tool sales room is used to store the plough-ridger combinations (ST 22 Eberhardt) and spare parts for the yoke sets made by local carpenters (2 yokes: one 5 feet wide for ploughing, one 7 feet wide for ridging, nylon ropes for guiding the oxen); it also contains locally-made hoes, sometimes sacks, plant protection agents and chemicals for improving the storage life of grain etc. The station farm itself is equipped with the following: 2 ploughs including a ridging plough, 1 ox cart, 1 dressing drum, 1 knapsack sprayer, 2 wheelbarrows and various tools. The following means of transportation are available for the ploughmen and the station management: 9 bicycles (1 per ploughman), 2 motorcycles and 1 VW platform truck with double cab.

4.3 Extension work

Practical implementation of the draught oxen programme by the agricultural stations can be divided up into 3 phases:

- a) The setting-up and start-up phase
- b) The expansion phase
- c) The consolidation and handover phase

a) Setting-up phase

During the start-up phase (approx. 2 years) the station must be set up and the personnel selected and trained. At the same time the first farmers to attend the training courses during the dry season must be recruited. The decisive factor is the personal

contact with the farmers and chiefs. The chiefs of the Dagombas, for example, are saluted by their "subjects" twice a week, namely on Mondays and Fridays. The draught oxen programme is introduced at one of these large meetings, whereupon it is essential to point out to the chiefs and farmers the advantages of draught oxen:

- The use of draught oxen makes farm work easier.
- More land can be cultivated if oxen are used (one man can theoretically cultivate up to 12 acres using a pair of oxen as against 3 acres using a hoe). The "Promotion of draught oxen" programme in Northern Ghana is based on the theoretical assumption that an individual farmer can double his crop area within 5 years if he adopts the new technique. The GGADP personnel and those at the church-run oxen station are, however, sceptical as regards this target, since draught oxen are not used correctly in all respects by the trained farmers due to inadequate follow-up supervision of the farmers completing the courses and problems in the input supply (6).
- It is then described how a "hoe farmer" can become a "bullock farmer": he must own two strong bulls and buy a pair of yokes and a plough-ridger combination. During the dry season he then attends a 3-week training course at the station with his animals. He is given preference during distribution of scarce agricultural production requisites and during the rainy season is advised on the cultivation of field crops and instructed in correct ploughing and mechanical weed control by the ploughmen in his own fields. The initial explanations are usually followed by long discussions during which questions are answered and problems such as procurement of oxen discussed. At the end of the discussion attention is drawn to film and slide evenings during which the techniques mentioned are shown in practice. The farmers are later invited to the station which holds several "Farmer Days" when the station farm is explained and ploughing and mechanical weed control demonstrated. The names of the farmers attending these "Farmer Days" are recorded and the farmers are then visited and advised in their villages or in their fields. Their draught oxen or bulls are inspected and problems concerning the financing of draught oxen discussed. During the start-up phase it is mainly the station management (i.e. the Technical Officer, third-year learner, field assistant

and development aid volunteers) who are responsible for winning-over the farmers for the programme. They work in close cooperation with the Information Unit, which has a mobile cinema with films and slide series showing the use of draught oxen.

In Nkyankpala 5 farmers were recruited and trained in the use of draught oxen during the first year and 28 during the second. A 3-week training course divides up roughly as follows:

Days 1 and 2: Leading the oxen on the rope
Days 3 - 5: The oxen must walk while wearing the yoke
Days 6 -14: The oxen walk while wearing the yoke and draw weights which become heavier from day to day
Days 15-21: The oxen draw the plough over dry ground

The farmers at the same time receive theoretical instruction supplemented by discussions. The following problems are dealt with: guiding of oxen, animal health, animal nutrition; ploughing and mechanical weed control, improved seed, use of mineral fertilizers, planting distances; erosion prevention, development of humus, green manuring, production and use of compost and manure. Following instruction the farmers must dismantle and reassemble the ploughs and maintenance (lubrication) and replacement of worn parts are explained.

Internal station meetings are held twice a month to permit joint discussion of the work for the coming weeks (for both the station farm and the extension service).

b) Expansion phase

During the second year the good farm workers are promoted to "ploughmen" and help to advise the farmers. They give particular assistance during the practical part of the training courses and during the rainy season instruct the farmers in their own fields on the use of the plough and ridger. Towards the end of the rainy season they learn how to castrate animals and fit nose rings. Good follow-up supervision of the trained farmers is considered highly important. The bullock farmers are given preference in the distribution of scarce agricultural production requisites such as mineral fertilizers and improved seed; they are visited regularly once a week by ploughmen and/or the station management and given further training in correct ploughing,

ridging and mechanical weeding. Crop varieties, planting distances, use of fertilizers and animal feeding are repeatedly discussed.

A farmer informs the station if he has problems e.g. if his animals are ill. A member of the station management and a ploughman then visit his farm immediately and treat the sick animals in cooperation with the veterinary service. The first "bullock farmers" in particular are intended to provide a good example of the successful use of these animals since they are observed above all by their relatives, friends and neighbours who then also want to participate in the programme. An investigation carried out in the course of evaluation of the oxen programme also established very clearly that the farmers using oxen act to a large extent as models in their social environment. In this context we can say that successful bullock farmers really do have a "multiplier" effect (6, p. 84ff).

During the expansion phase the training courses no longer take place simply at the station but are held more and more in the villages for groups of up to around 10 (old and new) bullock farmers. The ploughmen are given particular encouragement and are urged to carry out work on their own. They are allocated their own extension areas and farmers (up to 14 old and new bullock farmers) for which they are responsible. Pairs of ploughmen are equipped with a castration set (castration tongs, nose-ring inserter, nose rings); they recruit new farmers and prepare their animals for training. Around 130 farmers have been recruited and trained in this way in Nyankpala over the last two years.

Activities during the year can be summarized as follows:

January - April:

Training courses, sale of appliances and spare parts, fertilizers and seed.

April - June:

Visits to farms - advice in the fields (ploughing, ridging, mechanical weed control etc.), sale of input materials, hoes and spare parts.

July - August:

Advice on treatment of weeds, organization of field days at the station's own demonstration farm, animal hygiene.

October - December:

Recruitment of farmers for the next training courses using Super-8 films and slide series, assistance in the selection of animals, animal hygiene, sale of ploughs and spare parts.

The normal work on the demonstration farm continues alongside these activities.

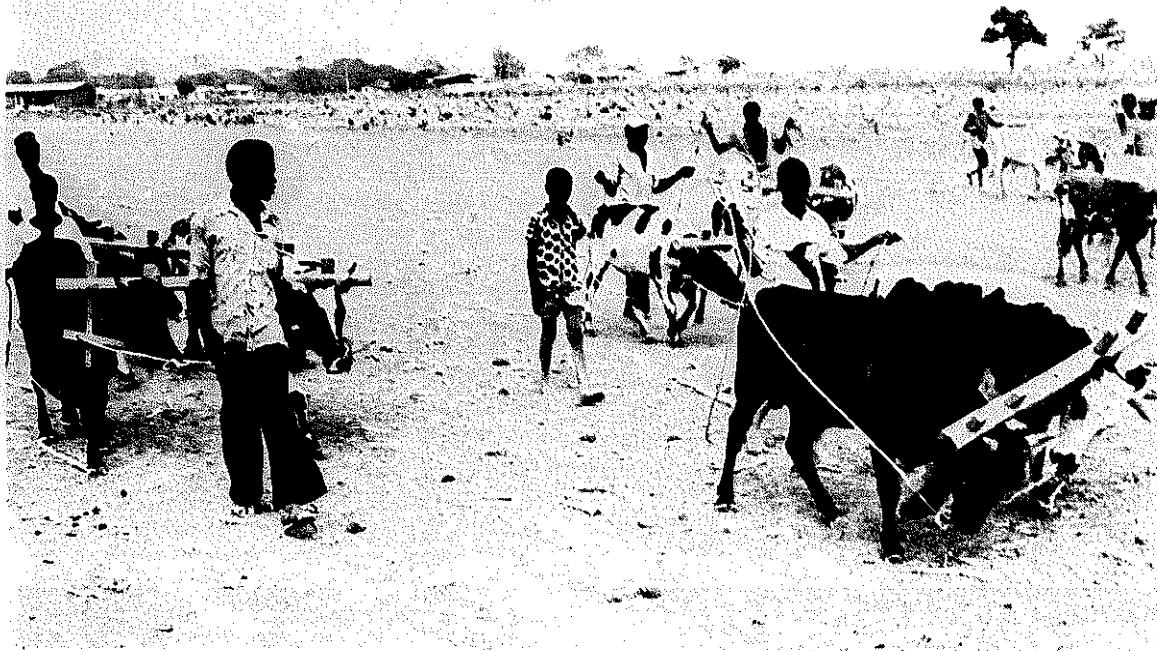


Fig. C/IV/3: So-called "Ploughmen" help the farmers when training oxen. The helping youngsters loose their fear of the animals and they too learn to handle them at an early stage. (Photo: Wessolowski)

Sub-centres belonging to the agricultural station and run by Technical Officers were set up during the expansion phase. One sub-centre consists of a store, a house for the Technical Officer and a demonstration farm of approx. 2 hectares. The sub-centres are visited regularly by the station management at least twice a month; during these visits ideas are exchanged, problems discussed and the extension work for the coming month dealt with. The Technical Officers have attended training courses and are intended to promote the use of draught oxen in their sub-districts in a similar manner.

c) Consolidation and handover phase

Whereas the main concern in the first two phases is to set up the station and its sub-centres, recruit as many farmers as possible and train them to become skilled in the use of draught oxen, attention must be paid during the consolidation phase to ensuring that the programme can continue on its own after approximately another 4 years. The farmers already using draught animals are to train their own oxen themselves and, if possible, help to instruct the farmers subsequently adopting the new technique and train their animals (possibly in return for payment). Hoe farmers

are to learn from bullock farmers. In order to lend weight to their justified demands to the Ministry of Agriculture as regards the supply of ploughs, ox carts, seed and mineral fertilizers etc., the bullock farmers should join forces in cooperatives. The Nyankpala Bullock Farmers Association was founded in Nyankpala at the end of 1979 for this purpose. The association's membership comprises 155 bullock farmers from the extension area covered by the Nyankpala Agricultural Station; 15 of them are district leaders (1 district leader is elected by 10 bullock farmers from his district), of whom 3 have been elected as managers of the cooperative and 1 as secretary.

The ploughmen either become bullock farmers themselves and promote the use of draught oxen as "private agents" or remain at the station and act as extension agents to promote the use of oxen in their areas. After 6 to 8 years the station should be run by a Senior Technical Officer on his own, while Technical Officers continue the work at the sub-centres on their own responsibility. It is important that the farmers should always be able to buy reasonable-priced ploughs and spare parts at the stations or sub-centres. Other simple agricultural production requisites (such as mineral fertilizers, plant protection agents, hoes and sacks) should likewise always be available in sufficient quantities for all the farmers.



Fig. C/IV/4: Teaching the farmers the proper care of the implements is as important as the good handling of the draught animals. (Photo: Wessolowski)

4.4 Situation as regards introduction of animal traction by the GGADP in the Northern Region as at the end of 1979

Number of farmers who have participated in an oxen training course

Agric. Station ²⁺³⁾	1974	1975	1976	1977	1978	1979	1980 ¹⁾	Total
Tono	(40)	(48)	54	60	45	-	-	approx. 1 000
Wa ³⁾			6	28	57	61	-	approx. 150
Babile ³⁾								
Gushiegu	15	37	65	53	45	67		approx. 300
Nyankpala				5	28	59	75	approx. 200
Savelugu				3	25	53	68	approx. 180
Sawla					13	6	15	approx. 40
Bimbilla					3	6	12	approx. 20
Karaga							15	approx.
Zabzugu							7	

Notes: 1) The 1980 figures are estimates.

2) Development aid volunteers worked at the Tono station for 4 years; courses had already been organized earlier by the agricultural extension service.

3) The Babile, Tono and Wa stations are situated in the Upper Region where the World Bank started a regional agricultural project in 1977. In the past 3 years the stations in this region have been handed over to the URADEP (Upper Regional Agricultural Development Project) and the GGADP confined its work to the Northern Region.

Use of draught oxen may be considered as having established itself in the Gushiegu area, where the station will be run by the Ghanaians on their own as from 1980. The use of draught oxen has met with great interest in the areas covered by the Nyankpala and Savelugu stations and in the long term the programme is to continue independently in these areas as well. The southern part of the Northern Region contains the Sawla and Bimbilla stations; the population density is lower in these areas, the vegetation more lush and the introduction of draught oxen will take longer since there are not enough properly cleared areas available.

The diffusion of the use of draught oxen as a new technique in the Northern and Upper Regions can be said to have progressed favourably to date. The target population is showing a very high degree of general interest in this new method and it has not been possible to pinpoint any sociocultural factors which could hinder further spreading of the use of draught animals.

The socioeconomic aspect, however, deserves particular attention. The economic situation of the smallholders in Northern Ghana exhibits a high degree of diversity. The diffusion process for the new technique is at present still in its initial stages; the total number of bullock farmers in the Upper Region is estimated at 5 000 and that in the Northern Region at 1 000. Surveys have shown that the farmers using oxen at present must probably be regarded as innovators or "early users". A characteristic feature of these farmers is that their economic situation - seen in relative terms - is better than that of the other smallholders.

The justified conclusion appears to be that the economic situation of the individual farmer is the decisive factor in determining whether he goes over to the use of draught oxen. It must be assumed at present that still more of these better-off smallholders will participate in the training courses in the near future and adopt the innovation. Suitable programme measures (e.g. an efficient small credit programme) must therefore be employed to guarantee that in the less immediate future the adoption and diffusion process does not stop when the better-off smallholders have all become involved and only (the majority of) the worse-off smallholders are available for further propagation of the technique (6, p. 64 ff and p. 70 ff).

In order to ensure that the bullock farmers are supplied with the necessary equipment, the GGADP has since 1979 been setting up a plough and appliance factory in Tamale which is to manufacture 2000 plough-ridger combination units per year (to date ploughs have been imported from the Federal Republic of Germany). This factory and its supply of material will be the main factors determining whether the use of draught oxen can become established as a whole. It should not be forgotten that it was a shortage of ploughs and spare parts which led to the failure of the first attempts to introduce draught oxen in many areas of Northern Ghana at the end of the fifties.

5. Experience and results gained using the promotional approach

5.1 Experience within the promoting organization

The GGADP is fully integrated into the Ministry of Agriculture and introduction of draught oxen via agricultural stations has proved successful. These stations, together with their sub-stations, simultaneously serve as supply centres for distributing agricultural production requisites to the smallholders. The following main problems nevertheless emerge:

- a) Supplying the smallholders with production requisites presents problems on account of the present poor economic situation in Ghana. It is doubtful whether the supply can be maintained as it has been to date.
- b) The personnel of the general agricultural extension service do not have adequate means of transport or living accommodation and are also underpaid so that there is little motivation for the extension officers to perform their work well (at the Nyankpala Agricultural Station all members of personnel were given 1-2 hectares of land for their own use which could be cultivated using the station's oxen).
- c) The development aid volunteers work at a station for only around 2 years. The turnover is too high, resulting in a lack of continuity. The volunteers require a year in order to adapt to their new surroundings, the farmers and the work and recognize the problems.
- d) The staff turnover among the experts was also too high in 1978/79. The entire team in Tamale has been replaced within a short period, which has had a detrimental effect on the continuity of the project.

5.2 Experiences with the farmers and effects on the situation on the individual farms

Almost all of the trained farmers (95%) changed over directly to using oxen for ploughing. Ridging, mechanized weed control and the use of ox carts for transportation, however, have to be given particular prominence during the extension work. Investigations and the experiences of the GGADP personnel have shown that only a relatively small number of the trained bullock farmers use the new technique for these purposes (6, p. 66 f and p. 83 f).

The area cultivated by one family was previously determined by the number of young men in the family who could help with the work. One man using a hoe could cultivate only around 3 acres in a year. If draught oxen are used, however, he can theoretically cultivate up to 12 acres of cereals and legumes and also plough the fields for yams and cassava. Much of the weed control is carried out today mechanically by means of reridging. During the short period of tractor-based mechanization the smallholders had at least at the end of the sixties had their fields ploughed either by government or private tractor companies, whereby a labour bottleneck then nevertheless occurred in the use of hoes for weed control and led to reduced yields.

Bullock farms generally extend their crop area since sufficient land has still been available to date. They can till their fields more quickly and therefore sow earlier and in better time. The fact that they can carry out all tilling and tending work at the right time means that they achieve higher area yields. Once the cost of equipment and oxen has been deducted they are left with an income which is on average twice as high as that achieved by comparable families (i.e. of the same size) engaged in hoe-based cultivation.

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**General literature,
articles and project studies
on animal traction
in Africa**

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