

The use of single oxen for crop cultivation in Ethiopia

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Summary

ILCA's HIGHLANDS PROGRAMME aims to find ways of improving the overall productivity of mixed smallholder farms in the highlands by increasing the technical and economic efficiency of livestock enterprises. Particular emphasis is given to enhancing the complementarity of the livestock and crop components. A substantial part of the work of the Programme focuses on topics related to animal traction, including studies of the use of oxen worked as singles rather than pairs.

Ploughing in the Ethiopian highlands is traditionally done using paired oxen; but surveys showed that half of the smallholder farmers in the highlands owned either one or no oxen. During 1983 ILCA's team developed a yoke and harness and modified version of the local wooden plough, the **maresha**, suitable for use by a single ox of local breed. On-station testing showed that an adequately fed ox could cultivate in a day 60 to 70% of the area ploughed by a pair.

Field days were organised for local farmers from the Peasants' Associations around ILCA's research stations in the Ethiopian highlands. After the field days, farmers were invited to try the adaptation of the traditional method on their own farms at their own risk and expense. ILCA provided assistance in retraining oxen to work as singles, then closely monitored the use of single oxen on the test farmers' land through twice-weekly visits. By October 1983 more than 140 farmers had approached ILCA for assistance in ploughing with a single ox.

Subsequent crop yields on the test farms were similar for land cultivated with single or paired animals. The time taken for cultivation by single oxen was around 30% more than by oxen pairs.

Oxen worked as singles require more feed per head than paired oxen. Research is therefore planned to investigate whether a short duration forage legume can be sown during the early rains prior to the usual cereal or pulse crops in order to have high-quality feed available for draught oxen when it is most needed.

The widespread use of the single ox method of ploughing could dramatically reduce the number of oxen needed to support food crop production, thereby increasing the feed resources available for each working animal. The technique does not put subsistence crop yields at risk and requires only minimal investment—the new yoke and harness can be made cheaply from local materials, while the modifications to the **maresha** can be done at home or by the village blacksmith.

If uptake occurs on a large enough scale, the new technique will have far-reaching implications for the smallholder farmers of Ethiopia who are among the world's poorest people.

Introduction

Research approach

ILCA's Highlands Programme follows a farming systems approach to research. This integrated and problem-oriented approach stresses on-farm technology testing and appraisal, complemented by relevant station research on individual components in cases where greater experimental control is advantageous.

The Ethiopian highlands

To date, research in the Highlands Programme has focused on Ethiopia, a country accounting for almost half of the total African highland zone. Ethiopia also has the largest livestock population in sub-Saharan Africa with some 26 million head of cattle, 24 million sheep, 12 million goats, 7 million equines and 1 million camels. The great majority of the cattle, sheep and equines are found in the highland areas of the country.

Of the total area of Ethiopia (1.22 million km²), half is made up by highlands above 1500 m in altitude. Some 80% of the total human population of about 38 million live in the highlands. Agricultural conditions vary widely throughout the country, according to topography, climate and soils. However, the highlands are generally temperate and comparatively favourable for both crop and livestock production.

Since the mid-1970s, rural development has been organised in a socialist framework. However, collective farming accounts for less than 5% of the total area cultivated. The bulk of agricultural output is still produced by individual subsistence smallholders who have 'farming rights' over the land they till'.

1. In Ethiopia, land is not individually owned, but is allocated by the Peasants' Association (PA) of which each farmer is necessarily a member. The size of individual allocations, comprising several plots depends on family size, local population density and the policies of the local PA. Land distribution takes account of the different fertility levels of the soils within the land area of the PA. Each PA has on average 250 members and controls around 800 ha of land.

Farming in the central highlands

ILCA's field research in the Ethiopian highlands has concentrated on the central highlands where smallholder mixed farming is the dominant mode of production. Rainfall here averages between 600 and 1200 mm/year, of which about 70% falls in the main rainy season between July and September. Farm sizes range from 0.5 to 5 ha, and around 80% of all farm produce is used for subsistence consumption. About two thirds of the cultivated land is sown to cereals; most of the remainder is sown to pulses. The proportion of fallow land in different parts of the highlands is quite variable. In some areas almost no land is fallowed, while elsewhere fallow periods of up to 12 years following 3 crop years are common.

The major crops grown are teff, wheat, barley, maize, sorghum, horse beans, chickpeas and field peas. Grain yields average between 500 and 1000 kg/ha sown. Access to modern inputs is limited; for example fewer than 10% of farmers regularly use either chemical fertilizer or

improved seed. Most farmers own livestock and a typical farm inventory includes two oxen, a cow, a few sheep and a donkey. As most livestock manure is used as household fuel, only small amounts are returned to the fields.

Cattle are kept mainly as a source of draught power and for manure. Milk, meat and hides are less important byproducts. Livestock are privately owned, and as such are an important form of investment and financial security. Usually only oxen are used for cultivation. Productivity of all livestock is low, reflecting an under-exploited genetic resource and generally inadequate nutrition, particularly during the extended dry season of up to 7 months each year. For example, milk offtake from indigenous Zebu cows kept under traditional management rarely exceeds 400 kg for lactations of 7 months and calving intervals average 2 years. Sheep also are comparatively unproductive as, along with cattle, they are subject to heavy endoparasite burdens and to extended periods of nutritional stress.

Research in the highlands programme

Objectives

The basic objectives of the Programme's research are to find ways of improving the overall productivity of mixed smallholder farms by increasing the technical and economic efficiency of livestock enterprises. Particular emphasis is given to enhancing the complementarity of the livestock and crop components. Results and experiences of the research in Ethiopia will, in many cases, have direct relevance to other highland smallholder situations in sub-Saharan Africa.

Research locations

In addition to research undertaken at ILCA's headquarters in Addis Ababa, field work is carried out in two study areas where research stations have been established: around Debre Zeit, 50 km south of Addis Ababa at an altitude of 1800 m, and around Debre Berhan, 120 km northeast of Addis Ababa at an altitude of 2800 m. The area around Debre Zeit is intensively cultivated with virtually no arable land kept fallow. Teff (*Eragrostis teff*) is the principal cereal grown. Debre Berhan is representative of the higher altitude zone of the country. Frosts, hail and a shorter growing season, in addition to low soil fertility cause the area to be less productive than Debre Zeit. Most of the land cultivated around Debre Berhan is sown with barley.

Animal traction

The Programme has allocated a substantial part of its resources to studies on various topics related to animal traction. Work on the research stations includes the evaluation of different cultivation systems using oxen of local origin and crossbreds, the technical and economic efficiencies of using crossbred cows for both draught purposes and milk production, the use of oxen worked as singles rather than as pairs, and the working efficiency of oxen subject to nutritional stress. Different harnesses and yokes are also being developed.

This paper reports the experiences with on-farm trials to assess the use of oxen worked as singles rather than pairs.

Draught power and agricultural production

The primary contribution of cattle to agricultural production in the Ethiopian highlands is as a source of draught power. ILCA's surveys have shown that animal power² used for crop-related work averaged more than 1000 hr/farm/year. Most of this power was supplied by oxen, but other cattle were sometimes employed for threshing. Some 60 to 70% of the total animal power input was for seedbed preparation and planting, with approximately 350 hr/oxen pair used for these purposes.

2. Not including power supplied by donkeys, which are used mainly for transport of agricultural products.

Traditional methods

Throughout most of the Ethiopian highlands the land is tilled using a pair of oxen of one of the indigenous Zebu breeds³ which pull the locally-made traditional cultivation tool, the *maresha*⁴. The power output of oxen pulling this plough is dependent on their body weight, nutrition and health status, the terrain and soil condition, depth of ploughing, working speed, pass number⁵, the training of the animal and the skill of the handler. Depending on the soil type and the crop, the land is cultivated up to six times before planting.

3. An ox in working condition weighs approximately 250–300 kg.
4. The *maresha* is constructed by the farmer from wood and has a metal tip for penetration. This plough does not turn a furrow like the conventional mould board plough, but disturbs the soil to a depth of about 15 cm.
5. Ploughing using the *maresha* is done perpendicularly and diagonally across plots. Pass numbers refer to the number of cultivations done in the season.

Oxen are commonly worked for 4 to 9 hr/ day, depending mainly on the time available for soil preparation⁶. Traditionally, animals within the Debre Zeit area are worked throughout the day with few breaks. In contrast, farmers in the Debre Berhan areas normally give their oxen a rest period at mid-day during which animals are watered and fed.

6. Shorter working days are often associated with longer distances to watering places and with watering frequency which varies with season.

Ox ownership

A major constraint to crop cultivation in Ethiopia is the unequal distribution of oxen/household. Available data for the Debre Berhan area indicate that half the farmers owned two or more oxen, around 30% had one and 20% owned no oxen. In the Debre Zeit area relatively more farmers had two or more oxen, but around 25% of the smallholder had none or only one ox. These results from the two ILCA study areas are representative of the national situation as, according to one study (Ministry of Agriculture, 1980), around 29% of Ethiopian farmers have no oxen, 34% one, 29% two, and 8% three or more. Since oxen are traditionally paired for work, more than 60% of the farmers have to rent or borrow one or two animals for cultivation.

Cultivation strategies

A farmer owning fewer than two oxen has various ways of overcoming this problem of inadequate draught power. For farmers with one ox, the usual arrangement is a *mekanajo* agreement with another farmer also having one ox, whereby the two oxen are used on the partners' fields on alternate days. The drawback of this strategy is that often the ploughing season is so short that the draught capacity is insufficient to allow both farmers to plough at the optimal time. In many locations, especially where soils have a high clay fraction, cultivation can only start after the beginning of the rains because of the difficulty of tilling dry soil. Moreover, the changing of handlers of the pair of oxen and the pairing of different animals causes a substantial reduction in the tractive power developed. It is also often difficult to find a partner living close by.

Another widely used strategy called *minda* is for the farmer to rent one or two oxen in exchange for grain or human labour. Around Debre Zeit it has been observed that farmers with one ox rent another ox from farmers with surplus oxen, at an annual cost of 200 kg of grain or some 15% of total farm production. A farmer can also use an ox of another farmer in return for 1 day's field labour. If a farmer has no oxen, the common exchange system is to give 2 days of human labour for every day a pair of oxen is borrowed. Sometimes oxen will be rented on a cash basis, usually US\$ 1.50/day for a pair, and US\$ 2.50/day if a handler is included.

Ox number and cropping pattern

ILCA's surveys have revealed that the number of oxen owned by a farmer strongly influences the area cultivated and the cropping pattern. The cropping pattern is most strongly influenced if the draught power inputs for land preparation vary substantially among crops. This favours the selection of crops with lower power requirements (e.g. pulses instead of cereals) by farmers with less than two oxen. For the study area around Debre Zeit, for example, substantial differences were observed among ILCA's control group of outside farmers in the crop year. These are summarised in Table 1.

Table 1. *Impact of ox ownership on area cultivated and cropping pattern at Debre Zeit, 1980.*

No. of oxen owned by farmers	Average area cropped/farm (ha)	Percentage of area sown to cereals (%)	Percentage of area sown to pulses (%)
None	1.2	54	46
One	1.9	44	56
Two	2.7	67	33
Three or more	3.6	92	8

These results show an approximately linear relationship between the number of oxen owned and the area cultivated. The differences in cropping pattern reflect the need for more intensive land preparation for cereal crops compared with pulses, and therefore higher labour inputs and draught power. Furthermore, the market value of cereal crops is about twice that of pulses. Together these factors mean that farmers with less draught power at their disposal sowed less land, and also had lower incomes than their counterparts with an adequate supply of draught power.

Around Debre Berhan the situation was somewhat different. The dominant crops in that area all require similar labour inputs for land preparation. The effect of ox ownership on the amount of land cultivated was smaller than around Debre Zeit and the cropping pattern remained similar for farmers with different supplies of draught power.

In both study areas there was no apparent effect of level of ownership on crop yields. This suggests that the problem of timely cultivation is largely overcome when a smaller area is cultivated and farmers choose to safeguard yields on smaller areas rather than risk lower yields over a larger area, which can happen if seedbeds are poorly prepared. Thus the availability of draught power is a major factor affecting food production and income distribution in the Ethiopian highlands.

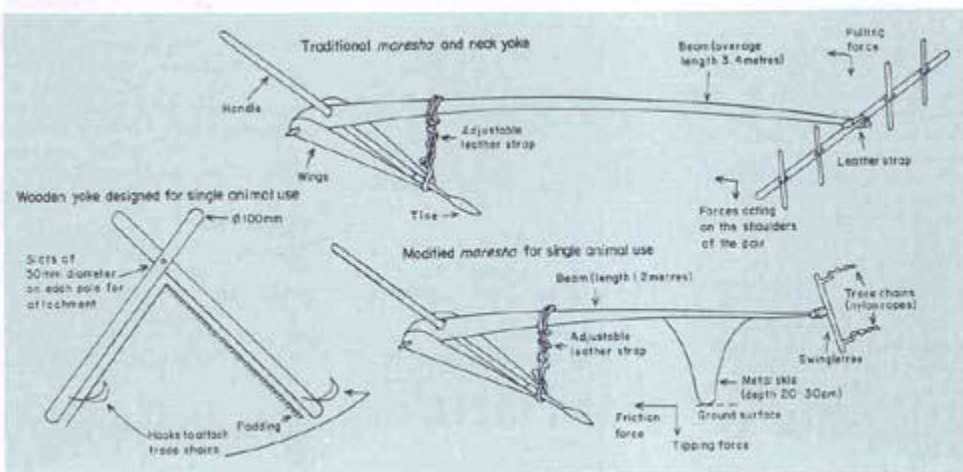
Design and testing of the single ox technique

The tacit assumption by farmers that two oxen are needed for cultivation has precluded solutions to at least some of the production problems associated with a national shortage of draught animals. ILCA had some prior experience in the use of crossbred oxen worked as singles, but these animals are much heavier than local oxen (average liveweight of 500 kg as opposed to 280 kg for local oxen). Elsewhere in the world other animals such as buffaloes and horses have been worked as singles, but their liveweights are also much greater than those of the local Zebu oxen used in Ethiopia. However, ILCA decided to experiment with the use of local Zebus as singles for crop cultivation.

Modified yoke, harness and maresha

During 1983 ILCA developed a yoke and harness and a modified version of the local wooden plough (*maresha*) suitable for use by a single ox of local breed. The traditional neck yoke designed for an ox-pair (Figure 1) was replaced by a simple, 'inverted V'-type yoke and a swingletree joined by two traces made of nylon rope. A simple metal skid was attached under the shortened beam to overcome the tendency of the modified *maresha* to penetrate the ground at an oblique rather than an acute angle.

Figure 1. Traditional and modified yokes and maresha for use in the Ethiopian highlands.



Testing

No particular technical difficulties were encountered during the on-station trials which showed that an adequately-fed ox could cultivate some 60–70% of the area ploughed by a pair in a day. Depth of cultivation was slightly shallower than with the traditional *maresha*, but the desired depth could be achieved by making extra passes. The work output of the singles was considered to be adequate to warrant starting onfarm trials.

In each of the study areas, ILCA's team then organised field days for farmers of the PAs around the research stations to demonstrate the new technique. Local government officials and extension workers and a total of around 150 farmers attended. After the demonstration farmers were invited to try ploughing with the single ox. Many did so, and although the general consensus was that this modification of the traditional system could have its benefits, farmers were doubtful about the ability of local oxen to work singly for extended periods.

Farmers were invited to try the adaptation of the traditional method on their own farms. They were to do this at their own risk and expense but ILCA was to give technical advice and assist in training of the animals to work singly. For those who did not want to modify the implement themselves, ILCA offered to sell the necessary implements at US\$ 5 each, to be paid immediately after the next harvest. At the end of the field day at Debre Berhan 19 farmers volunteered to test the modified *maresha*; at the Debre Zeit field day 12 farmers volunteered.

ILCA held training sessions in which the volunteer test farmers were assisted in retraining their ox previously used as one of a pair. Most oxen adapted without difficulty while others needed up to 2 days' retraining. In April 1983 these farmers started their land cultivation.

ILCA closely monitored their performance and started a data recording system. The farmers testing the single ox were visited twice weekly and data were collected on land holding, cropping pattern, inputs and outputs by plot, cultivation details and feeding levels for the work oxen. Farm assets, personal data and livestock inventories were also recorded.

More farmers became interested in the technique as the season progressed and wanted to join the research programme, but in order to have complete records and to allow for a proper evaluation, ILCA's team limited its involvement with these farmers to technical advice on how to make and operate the implement. By early October 1983, over 140 farmers had approached ILCA for assistance in ploughing with a single ox, and many of these had been experimenting on their own.

Results of the 1983 crop year

Farm characteristics

The single-ox farmers were generally young and innovative. Most belonged to the *Amhara* tribe. The average age of the 31 test farmers (i.e. those farmers whose performance was closely monitored through the data recording system) was 32 years. During the previous crop season, 18 of the test farmers had a *makanajo* or *minda* agreement while 13 owned a pair of oxen. All test farmers who previously had *mekanajo* arrangements reported that making this arrangement took much of their available time, and delayed the time of planting, possibly resulting in reduced crop yields.

The average farm size of the farmers testing the single ox in 1983 was 1.9 ha (all cultivated) around Debre Zeit and 2.5 ha (of which 1.4 ha was cultivated) around Debre Berhan.

Around Debre Zeit, because soils are heavy and rainfall is essentially unimodal, cultivation for the main cereal crops has to be done within a very limited period. Around Debre Berhan the rainfall is more uniformly distributed over the year (weakly bimodal) and soils are lighter than at Debre Zeit, so that ploughing can be done almost year-round.

Around Debre Berhan, however, only 50% of the arable farm land is cultivated each year. The shortage of draught power is therefore a much more pressing and crucial problem at Debre Zeit than at Debre Berhan.

Problems encountered

Some technical problems arose during the farm trials. The original metal skid was not strong enough for work in stony fields and it had to be replaced by one of thicker metal. Also, farmers at Debre Zeit initially worked their single animals only 2 to 3 hr/ day for fear of exhausting them. Farmers, however, observed ILCA's nutrition trials where oxen are worked singly for 4 to 5 hr/ day without tiring⁷. As a result the farmers gradually increased the hours they worked their animals.

7. Nutritionally-stressed oxen are worked as singles on farmers' fields under research supervision in these particular trials. Their performance is being compared with the work output of well-nourished oxen. The stressed animals are fed 75 % of the level of the well-nourished oxen.

Animal nutrition was perceived as a problem by the test farmers. The animals worked as singles required extra feed and therefore many farmers supplemented the normal ration with feed concentrates (wheat bran) which are available locally. In some cases, when the farmer was unable to afford these concentrates, ILCA supplied short-term credits to be repaid immediately after harvest.

Concurrently with this on-farm testing, the Ethiopian Government began a drive towards cooperative production in the Debre Zeit area. Farmers had to work 1 or 2 days/week on the land owned by the cooperative. However, these farmers are followers of the Ethiopian Orthodox Church which prohibits field work on around 160 days each year. Thus the number of days available for cultivating their own fields was sharply reduced.

The unexpected reduction in the time available for the preparation of their plots, combined with their natural caution about the new technique, resulted in all the test farmers using a mix of single and traditionally paired oxen.

Around Debre Berhan where farmers can cultivate almost year-round, timeliness is not so important. As a result, farmers have greater opportunities of finding additional oxen for cultivation. However, soil fertility is a major problem in the area and many fields have a high percentage stone cover. Farmers encountered difficulties in using oxen singly on plots where the stone cover was above 50%, so they resorted to the use of pairs on these fields. Also, the first cultivation on land being cropped after an extended fallow phase of 10 to 15 years proved difficult for oxen worked as singles, and several farmers preparing these plots opted to do the

first cultivation with the conventional pair. The 1983 crop year began later than usual at both Debre Zeit and Debre Berhan and was further shortened by comparatively early frosts at Debre Berhan. Grain yields at Debre Berhan observed by ILCA in 1983 were approximately one third of long-term average yields. Yields in 1982 also had been well below average. The combination of poor yields in 1982 and a late start to the 1983 season contributed to the farmers' cautious response to the single ox method of cultivation. This effect was not so pronounced at Debre Zeit where crop yields in both 1982 and 1983 were similar to the long-term average.

Area and duration of cultivation

At Debre Zeit the average total area cultivated per farm by the test farmers was 1.9 ha of which 3050 m² (16%) was cultivated with a single ox, and 1.6 ha (84%) with paired oxen. At Debre Berhan, the average total area cultivated was 1.4 ha of which just under 1000 m² (7%) was cultivated with a single ox and 1.3 ha (93%) with ox-pairs.

Almost all the land cultivated in 1983 with a single ox was sown with cereals: at Debre Zeit with teff or wheat, and at Debre Berhan with barley or wheat.

Table 2 summarises the time taken for land cultivation for teff and barley at Debre Zeit and Debre Berhan using paired oxen and oxen worked as singles. The time taken for cultivation by single oxen was around 30% more than by oxen pairs.

Table 2. Average time taken for land preparation and seeding of principal crops by single and paired oxen.

No. of oxen in harness	Average time taken (hr/ha)	
	Debre Zeit (teff)	Debre Berhan (barley)
One	260	135
Two	200	100

Crop yields

Crop yields were similar for land cultivated with single or paired animals. These are summarised in Table 3. The slightly higher yields at Debre Berhan on plots cultivated with single oxen could be due to farmers using land of higher fertility for their experimentation.

Table 3. Average grain yields for test farmers and other outside farmers.

Farmer group	Average grain yield (kg/ha)			
	Debre Zeit		Debre Berhan	
	teff	wheat	barley	wheat
Test farmers using single oxen	1150	1200	447	252

Test farmers using paired oxen	1160	1000	350	268
Other outside farmers using paired oxen	1125	1175	312	310

Future prospects

Feed requirements

A major problem reported by farmers using oxen as singles was that they required more feed/head/day than paired oxen. This claim is being investigated in station-based studies as it has implications for the subsequent adoption of the change to the traditional system. Additionally, the oxen are usually worked in Ethiopia at the end of an extended dry season when the animals are most prone to weight loss when worked and when animal feedstuffs are at a premium. For these reasons research is planned to investigate whether a short duration forage legume can be sown during the early rains prior to the usual cereal or pulse crops in order to have high-quality feed available for draught oxen when it is most needed. Although the marginal value of feed at this time of year is high, it is expected that this additional crop will be accepted by the farmer if it can be grown without prejudicing the production of staple foods. This forage crop option will be tested on-station in 1984.

The seasonality of animal feed supplies affects the productivity of all livestock, not only working oxen, so the Programme is undertaking other research to minimise the effects of this constraint. This work includes the evaluation of fodder trees and shrubs in the Debre Zeit area where the area of fallow land is minimal and where the strategic location of trees and shrubs will interfere minimally with land sown to annual crops. The Programme is also studying low-cost ways of raising the productivity of fallow land in the Debre Berhan area. The carry-over effect on the subsequent crop phase of higher-yielding fallow lands will allow intensification of both crop and animal production in this higher altitude area.

Advantages

Widespread use of the single ox could dramatically reduce the number of oxen and their attendant breeding and replacement stock needed to support food crop production, thereby increasing the feed resources available for each working animal. Not only would grazing pressures be reduced, lowering the risk of environmental degradation, but the nutritional status of the remaining oxen would improve. Also, more timely cultivation of larger areas of land would lead to increased food crop production and allow more balanced cereal/ pulse rotations to be practised.

The single-ox technique has two other major advantages which make the prospects for its uptake most encouraging. First it does not reduce subsistence crop yields, and second it requires minimum investment—the new yoke and harness can be made cheaply from local materials, while the modifications to the *maresha* can be carried out at home or by the village blacksmith.

If adoption occurs on a large enough scale, the single-ox technique will have far-reaching implications for the smallholder farmers of Ethiopia, who are among the world's poorest people.

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References

- Gryseels G. 1983. Livestock in farming systems research for smallholder agriculture: Experiences of ILCA's highlands research. Paper presented at the Seminar on Agricultural Research in Rwanda, Kigali, February 1983.
- Gryseels G. 1983. On-farm animal traction research: Experiences in Ethiopia with the introduction of the use of single oxen for crop cultivation. Paper presented at the Third Annual Farming Systems Symposium, Kansas State University, Kansas, 31 October–2 November.
- Gryseels G. and Goe M R. 1984. Energy flows on smallholder farms in the Ethiopian highlands. *ILCA Bulletin* 17. ILCA, Addis Ababa.
- ILCA (International Livestock Centre for Africa). 1983. The single ox: An innovation for the small farmer. *ILCA Newsletter* Vol. 2(2). ILCA, Addis Ababa.
- Provisional Government of Socialist Ethiopia. 1980. Distribution of land and farm inputs among the farmers of Ethiopia, with special reference to the distribution of traction power. Ministry of Agriculture, Addis Ababa.

List of abbreviations

ACP	African, Caribbean and Pacific states
CP	crude protein
CREAT	Centre du Recherche et d'Elevage at Avetonou, Togo
DM	dry matter
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
GTZ	Gesellschaft fur Technische Zusammenarbeit (Agency for Technical Cooperation), Federal Republic of Germany
hr	hour
ICIPE	International Centre of Insect Physiology and Ecology, Kenya
IITA	International Institute of Tropical Agriculture, Nigeria
ILRAD	International Laboratory for Research on Animal Diseases, Kenya
N	nitrogen
PA	Peasants' Association
SODEPRA	Société pour le Développement des Productions Animales, Ivory Coast
t	metric tonne
TCRV	tissue culture rinderpest vaccine
UNEP	United Nations Environment Programme