Farm-level economic benefits of using oxen for plowing and weeding in Sierra Leone

by

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Abstract

Work oxen were introduced into the agriculture of Sierra Leone in 1928. Projects promoted the use of animal traction in the 1950s and 1970s, but had little impact. Since the 1980s the Sierra Leone Work Oxen project has been researching and promoting the use of draft power. Field trials were undertaken at Njala University College in which pairs of N'Dama oxen were used in the cultivation of maize, groundnuts, upland rice, swamp rice and cowpeas.

N'Dama oxen proved very efficient at plowing in swamps and upland soils. Ox cultivation is an effective method of weed control. Two treatments in which ox plowing was followed by between-row cultivation with ox-drawn tines had significantly less weed regrowth than treatments that used only hand weeding.

Using trial data and current prices, illustrative budgets were prepared and showed that hand cultivation was most expensive (US$ 188), followed by tractor cultivation (US$ 157) and simple ox plowing (US$ 100). A farmer using oxen for a range of operations, including weeding, can cultivate land even more cheaply (US$ 66). Whilst tractors depreciate in value, oxen increase in value as they put on weight. Given that tractors are heavily dependent on foreign exchange, as oil prices rise and imported machinery costs increase, it is likely that ox plowing and weeding will become an even more economically attractive proposition.

Introduction

The West African country of Sierra Leone has an area of 73 000 km^2 and lies between latitudes 7º and 10º north, and longitudes 10º and 13º west. The tropical climate has six months of rain (May–October) and a six-month dry season. Average rainfall is 2600 mm a year. Rainforests are the common vegetation type in the southern and eastern parts of the country, and savannah woodlands are found in the north. Farming is mainly traditional, based on the bush fallow system of upland cultivation. The staple food crop, rice, is intercropped with a variety of other crops such as sorghum, millet, maize, pigeon peas, groundnuts and cassava. The inland valleys and bolilands (flat wide depressions subject to seasonal flooding) are also cultivated with rice. The normal fallow period of 7–15 years is fast reducing to 3–5 years due to pressure on land and the increase in human population. There is a big move to cultivate the inland valley swamps, bolilands and mangrove swamps. Animal traction would be appropriate in these ecological regions.

Draft animals provide a major source of power for agriculture and transport in Africa. In Sierra Leone, the use of work oxen in agriculture has proved very important and farmers are steadily accepting the technology. With the increased demand for local production of food, efficiency of production methods is very important.

The use of work oxen to replace hand labour for primary cultivation is therefore not only important but a priority for the Department of Agriculture and Forestry. It is in this context that the Sierra Leone Work Oxen Programme was established with donor support. The work and experiences of this programme have been described and analysed by Starkey and Kanu (1986), Kanu (1988), Bangura (1990) and Starkey (1994).

Historical perspectives

Horses were introduced to the colony of Sierra Leone in the 19th century, for pulling carts and for horse racing. The road leading to the old race track is now a main street (Race Course Road) in the capital city of Freetown. However, a serious outbreak of trypanosomiasis between 1856 and 1858 decimated the horses, and the population never recovered. In the 1920s, oxen pulled refuse carts for the Department of Health (Starkey, 1981). Nowadays, small carts in Freetown are pulled by hand.

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Work oxen schemes 1928–1950

Work oxen were introduced into the agriculture of Sierra Leone in 1928 when the colonial government abolished domestic slavery which until then had been the main source of agricultural labour. Technicians were sent to Guinea to learn ox-training skills. On their return they were distributed to various agriculture stations to train farmers and oxen. Plows were imported from Nigeria and the Gold Coast (now Ghana), and from across the Guinea border. Ox traction was successfully introduced to specific areas for plowing. In 1947 oxen were working an average of 585 hours a year at Njala. Even though the ox programme was successful with farmers, from 1954, the government placed emphasis on imported tractors. Oxen ceased to be used on research stations (Starkey, 1981).

The Mabole Valley Ox Scheme

The Mabole Valley is an extensive stretch of bolilands along the Mabole River, where animal traction was introduced in 1928. Between 1950 and 1955 the government introduced an oxen loan scheme allowing farmers a loan of £10 to buy oxen and a plow. About 60 Ransome Victory plows were ordered from Nigeria and 70 farmers were involved in the scheme, plowing 200 ha of farmland. The loan was repayable in three years (Starkey, 1981).

When the government stopped importing plows and spares, village blacksmiths maintained and repaired the implements. Plows used by farmers 40 years ago are still being used today. In the absence of veterinary services, farmers used traditional cures to keep their oxen healthy.

Even though the technology was successful, most young men in the villages were attracted by the 'diamond boom' in the eastern parts of the country, and migrated in search of diamonds. The villages were left empty except for old men, women and children. There was an acute labour shortage with women and children only working on the farms (Allagnat and Koroma 1984).

Integrated Development Projects

During the 1970s, donor aid to rural development in Africa involved the 'Integrated Agricultural Development Project' approach. Sierra Leone was divided into six regions, each having an Integrated Agricultural Development Project (IADP) with external donor funding. During the planning stages animal traction was not included but was considered later due to farmer demand. Some projects, such as the Koinadugu Integrated Agricultural Development Project, North Western Integrated Agricultural Development Project and the Magbosi Agricultural Development Project, had animal traction units. At the end of donor funding, the impact of the IADPs was small, but the oxen continued to work.

Sierra Leone Work Oxen Programme

The European Union has been supporting the Sierra Leone Work Oxen Programme in aiding ox units in agricultural projects in Kambia, Port Loko and Koinadugu Districts. The Work Oxen Programme provides support staff and oxen packages to farmers' associations. One oxen package includes one pair of oxen, one plow, one ox cart, one harrow, one set of harnessing ropes and one veterinary health package for one year. Although weeding techniques are demonstrated, weeding equipment has not yet been included in the package, because weeding using animal traction has yet to be widely accepted at farm level.

On-station field trials

Various animal traction trials were undertaken at Njala University College from 1979 to 1984. Pairs of N'Dama oxen, fitted with horn/head yokes were used in the cultivation of maize, groundnuts, upland rice, swamp rice and cowpeas. Detailed records were made of the time taken for cultivation operations, and using three replications per treatment and randomised block designs the use of ox cultivation was compared with hand cultivation and also with tractor operations (Starkey, 1981; Starkey and Verhaege, 1982).

This paper draws on the analysis of these trial results prepared by Starkey and Verhaege (1981). The tables with data relating to costs have been updated. However, inflation in Sierra Leone is very high. At the time of the original calculations in 1981, one Leone was approximately equal to one United States dollar. In the calculations used in this paper US$ 1 = 600 Leones. Subsequently the Leone dropped below 1000 Leones to the US dollar. Thus relative costs and comparisons between treatments are more important than the cost figures presented.

Table 1: Time required for specific farming operations

Operation	*Hand (work h/ha)*	*Oxen (team h/ha)*	*Tractor (tractor h/ha)*
Primary cultivation (cereals and legume crops)			
Upland plowing	na	30	2.5
Harrowing twice	na	10	1.25
Total primary cultivation	**750**	**40**	**3.75**
Maize cultivation			
Planting	130	9	na
Weeding (twice)	680	18 + 200 person h	na
Harvesting	240	na	na
Groundnut cultivation			
Planting	100	12	na
Weeding (twice)	806	40 + 111 person h	na
Lifting	152	12 + 28 person h	na
Harvesting	250	na	na

Source: Starkey and Verhaeghe, 1981

Primary cultivation

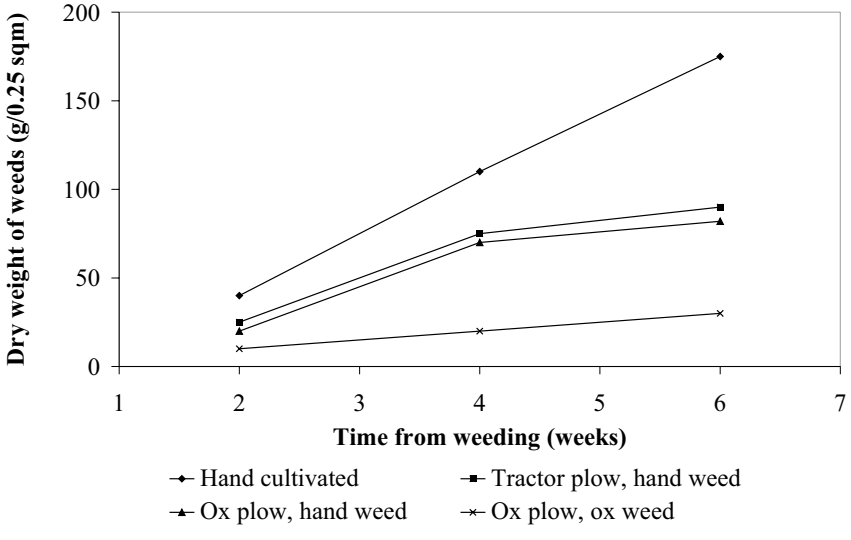
N'Dama oxen have proved very efficient at plowing in swamps, in bolis and in upland soils where there are not too many stumps The phrase 'upland soil' does not imply hilly areas, but is used in contrast to wet swamp conditions. The data were collected on upland soils that had previously been destumped, but it is considered that the results are applicable to other stump-free upland soils, swamp margins and even non-saturated swamp and boli soils.

A pair of oxen can comfortably plow 0.17–0.20 ha in a five-hour working day (25–30 team hours/ha), and using a triangular spike-tooth harrow, one hectare can be harrowed in five hours (10 team hours/ha for two harrowings, see Table 1).

A major justification for plowing in Sierra Leone is for weed control. Effectiveness of plowing can be determined by the degree of weed control achieved, and also from the eventual crop yield. Figure 1 shows how quickly weeds grew after different cultivation methods in one of the trials at Njala (using maize). Weed growth was greatest following hand cultivation. Tractor plowing and ox plowing followed by one hand weeding led to almost identical weed regrowth. While tractor disc plowing was generally deeper than ox plowing, the mouldboard of the ox plow gave better soil inversion than the disc plow.

The treatment in which ox plowing was followed by between-row cultivation with ox-drawn tines had significantly less weed regrowth than the treatments that used hand weeding instead of ox weeding. Comparable results were found in groundnut trials where weed growth was less following ox cultivation (Starkey, 1981).

Figure 1: Growth of weeds between rows of maize with different methods of cultivation (Source: Starkey and Verhaeghe, 1981 and 1982)



Since weed competition is a major factor influencing crop yield, and weeding can account for over 20% of the labour requirement for food crop cultivation, the fact that ox cultivation can lead to more effective weed control must not be overlooked. In the trials with groundnuts and maize at Njala, crop yields for the various treatments did not differ significantly, although ox cultivation led to the highest yields, and so it is possible to use the information obtained on the requirements to compare the work inputs required to achieve similar yields (Table 1). From these figures it can be seen that preparing a hectare of land for the sowing of grain or legume food crops can take 750, 40 or 3.75 hours using manual labour, a pair of oxen or a tractor, respectively. This information may be used to compare the costs of different methods of cultivation.

Comparative costs of primary cultivation

So that economic comparisons could be made between the different systems, some basic assumptions were made on realistic average costs. In Table 2 a budget is drawn up for small farmers who might use oxen to plow 0.6 ha of swamp and a total of 3 ha of upland crops, eg, 1.5 ha of groundnuts followed by 1.5 ha of maize. For these operations, which might be performed partly for themselves and partly for their neighbours, they would need to use their oxen for just 42 working days a year.

In preparing this and other budgets capital equipment is written off (amortised) over a realistic number of years and interest is charged on the working capital (the prevailing agricultural interest rate of 28% has been used). The mean value of the amortised asset is used to calculate annual simple interest charges. Equipment costs are based on available implements, either locally-made Pecotool toolbars or imported Senegalese equipment.

Similar calculations are used for ox equipment and also for tractors, but the same calculation for oxen appears different as, even at constant prices, oxen increase in value due to weight gains. If they are used for five years, they may increase from 180 to 280 kg, and so while interest costs still apply, the annual amortisation in budget is negative, representing an appreciation rather than a depreciation in value.

Table 2 gives the annual capital requirements for a smallholder farmer using oxen, as well as possible feeding costs, veterinary costs, ropes, equipment repairs, wages and risk of an accident. Using these calculations, the average annual cost becomes 316 000 Leones (US$ 527), or 1500 Leones (US$2.50) per working team hour (210 working hours at five hours per day, for 42 working days, each year).

Added benefits of weeding

The same farmers could cultivate exactly the same amount of land, but in addition to plowing and harrowing they could use oxen to plant in straight rows and use weeding tines to cultivate between the rows. In this case they would require more equipment, with a modest amount of extra capital per year in addition to extra wages and feeding costs. However, as they would use their animals for 77 working days (384 working team hours a year), their costs per hour of work would be reduced to 985 Leones (US$1.65). This has cut the effective cost by one third. Details of this example are given in Table 3.

The same farmers could reduce their hourly costs further by cultivating more land (their own or their neighbours') or by using ox carts for transport. However, the two examples given are sufficient to give a realistic picture of what farmers can achieve. It must be stressed that the relative costs, rather than the actual values used, are important, and demonstrate the value of increasing annual usage.

In order to compare the cost of ox cultivation with the cost of hand cultivation, the farm labour rate has been taken as 150 Leones/hour or 1200 Leones (US$ 2) per 8-hour day. To determine the cost of tractor cultivation it has been assumed that a 65 HP tractor costing 20 million Leones (US$ 33 000) with its equipment will, on average, last for five years, running 1000 hours a year to plow and harrow 133 ha of unconsolidated land. From the budget given in Table 4 it can be seen that the effective hourly cost of the tractor is 25 000 Leones (US$ 41). Using the information given in Tables 1–4, it is possible to estimate the cost per hectare of primary upland cultivation for crops such as maize, groundnuts or upland rice.

It can be seen from Table 5 that hand cultivation at 112 500 Leones/ha (US$ 188) is most expensive, tractor cultivation costs 94 320 Leones/ha (US$ 157) and simple ox plowing 60 200 Leones/ha (US$ 100), whereas the farmer using oxen for a range of operations can cultivate land more cheaply at only

Table 2: Example of a budget for small farmer using work oxen for primary cultivation only

Assumed cropping programme	*Operations*	*Time (hours/ha)*	*Total time (hours)*
0.6 ha swamp rice	Plowing and puddling	130	78
0.3 ha dry season swamp cultivation	Plowing and harrowing	40	12
1.5 ha groundnut	Plowing and harrowing	40	60
1.5 ha maize (2nd crop)	Plowing and harrowing	40	60
Total working hours			**210**

Average budget for year

Capital costs	*Annual cost*
Oxen (pair)	*(Leones*)*
5 year amortisation (Purchase price Le 220 000 each, sale price Le 360 000 each)	-28 000
28% interest on mean annual value	81 200
Total annual cost	**53 200**
Equipment (plow and harrow**)**	
5 year amortisation (Price Le 116 925, Sale price Le 0)	23 425
28% interest on mean annual value	16 398
Total annual cost	**39 823**
Total capital cost	**93 023**
Running costs (for 42 working days per year)	
Supplementary feeds at Le 120/day	5 040
Grazing at Le 266/non-working day (323 days)	85 918
Veterinary costs	46 500
Ropes, yokes, equipment repairs and maintenance	30 000
Ox-handlers at Le 800/working day	33 600
Insurance at 10% value oxen	22 000
Total running costs	**223 058**
Total capital and running costs	**316 081**
Cost per hour for 210 hours	**1 505**

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

39 400 Leones/ha (US$ 66). However, while oxen feed on renewable sources of energy, contributing their dung to the soil, tractors use imported oil and it can be seen from Table 6 that the foreign exchange cost of a hectare of cultivation is about six times that of ox cultivation. As oil and machinery costs increase, ox plowing will become an even more economically attractive proposition.

Use of planters and weeders

Even greater benefits are achieved if oxen are used to plant crops in straight rows and to weed between the rows. At Njala, the *Super Eco* Seeder, manufactured in Senegal, has been used to successfully row-plant a range of crops, including upland rice, but the greatest advantages have been found using the seeder to plant groundnuts and maize.

Using oxen to pull the planter and seeder, and subsequently using oxen to walk between the rows pulling weeding tines, reduces the labour requirement for post-tillage maize cultivation by around 50 % (Table 7). A simple attachment can be fitted to the ox-drawn toolbar to lift groundnuts, and using this as well as a seeder and weeding tines, a small farmer can make significant time and cost savings, in the order of 40%, in the secondary operations of groundnut cultivation (Table 8). Since weeding is such an important operation in farming in Sierra Leone, the use of oxen for weeding

Table 3: Budget for small farmer using work oxen for plowing seeding and weeding

Assumed cropping programme	*Operations*	*Time (h/ha)*	*Total time (h)*
0.6 ha swamp rice	Plowing + puddling	130	78
0.3 ha dry season swamp cultivation	Plowing + harrowing	40	12
1.5 ha groundnuts	Plowing + harrowing	40	60
	Seeding	12	18
	Weeding (twice)	40	60
	Lifting	12	18
1.5 ha maize (2nd crop)	Plowing + harrowing	40	60
	Seeding	12	18
	Weeding (twice)	40	60
Total effective working hours			**384**

Average budget for year	
Capital costs	*Annual cost (Leones*)*
Oxen	
5 year amortisation (Purchase price Le 220 000, sale price Le 360 000)	-28 000
28% interest on mean annual value	81 200
Total annual cost	**53 200**
Equipment (plow, harrow, seeder, weeder, lifter)	
5 year amortisation (Purchase price Le 234 000, sale price Le 0)	46 824
28% interest on mean annual value	37 198
Total annual cost	**84 072**
Total capital cost	**137272**
Running costs (for 77 working days per year)	
Supplementary feeds at Le 120/day	9 240
Grazing at Le 266/non-working day (288 days)	76 608
Veterinary costs	46 500
Ropes, yokes, equipment repairs and maintenance	30 000
Ox-handlers at Le 800/working day (77 days)	61 600
Insurance at 10% value oxen	22 000
Total running costs	**245 948**
Total capital and running costs	**378 425**
Cost per hour for 384 hours	**985**

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

could greatly increase the effectiveness of the human labour, allowing perhaps significant increases in the areas cultivated per work-day or crop yield per work-day.

Comparative costs of production systems

Information has been presented on the labour requirements and the costs of primary cultivation up to seedbed preparation (Table 5) and for subsequent operations for maize (Table 7) and groundnuts (Table 8). By combining these figures it is possible to examine the comparative costs of different cultivation systems for maize and groundnuts (Tables 9 and 10). From these figures it is clear that a complete ox-cultivation system is about 40% cheaper than entirely manual operations, or tractor plowing operations followed by manual operations. It is also interesting to note that while ox plowing is cheaper than tractor plowing, if tractor plowing is used, cost savings can still be made by using oxen for seeding and weeding. Thus, while full ox cultivation would seem to be most desirable, if a tractor plowing service were readily available to farmers, they might still consider using oxen for planting and weeding operations and for swamp plowing. It

Table 4: Estimated cost of tractor usage in Sierra Leone

Assumed work programme

65 Hp tractor, disc plow and disc harrow costing 20 000 000 Leones; Average life 5000 hours over five years; 1000 running hours per year, 500 effective cultivation hours per year; 135 hectares unconsolidated land plowed and harrowed each year

Capital costs	*Annual cost (Leones*)*
5 year amortisation of 20 000 000 Leones	4 000 000
28% interest on average value	2 800 000
Total capital cost	**6 800 000**
Running costs (1000 hours/year)	
Fuel (7 litres/hr at 260 Leones/litre)	1 800 000
Lubricants (7% fuel value)	126 000
Tyres (1 front and 1 rear per year)	60 000
Repairs & maintenance (75 % of capital cost at 15 %/year over 5 years)	3 000 000
Driver (salary and allowances)	50 000
Insurance (2% mean value)	200 000
Total running costs	**5 776 000**
Total capital and running costs	**12 576 000**
Cost per hour for 500 hours	**25 152**

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

Table 5: Comparative cost per hectare

Method of cultivation	*Time (h/ha)*	*Cost (Leones*/h)*	*Cost (Leones*/ha)*
Hand	750	150	112 500
Work oxen (42 days/year: Table 2)	40	1 505	60 200
Work oxen (77 days/year: Table 3)	40	985	39 400
Tractor	3.75	25 152	94 320

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

Table 6: Comparison of foreign exchange costs of primary cultivation

System	*Cost (Leones*/ha)*	*Estimated foreign exchange component (%)*	*Foreign exchange cost (Leones*/ha)*
Hand	112 500	0	0
Work oxen (42 days/year: Table 2)	60 200	16	9 632
Work oxen (77 days/year: Table 3)	39 400	28	11 032
Tractor	94 320	90	84 888

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

should be noted that if the government subsidies on tractor plowing continue at their present high level (30 000 Leones/ha or US$ 50/ha) the use of oxen after tractor plowing becomes extremely attractive, although even at present subsidy levels full ox cultivation is cheaper than normal tractor-plowing cultivation systems.

Discussion and conclusions

The examples presented, which have been based mainly on the cultivation of upland soils in Sierra Leone, illustrate the economic attractiveness of using work oxen for food and cash-crop production. Other trials have shown the great potential for using oxen to cultivate crops grown on ridges, and the particular

Table 7: Comparison of ox and hand operations for the post-tillage cultivation of maize

	Hand operations only		*Oxen/hand operations*	
Operation	*Time work h/ha*	*Cost Leones*/ha*	*Time h/ha*	*Cost Leones*/ha*
Planting	130	19 500	9 team h	13 545
Weeding (twice)	780	117 000	18 team h +200 work h	27 090 30 000
Fertiliser application	90	13 500	90 work h	13 500
Harvesting	240	36 000	240 work h	7 200
Total cost (Hand)	**1 240**	**186 000**	**27 team h +530 work h**	**40 635**

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

Table 8: Comparison of ox and hand operations for the post-tillage cultivation of groundnut

	Hand operations only		*Oxen/hand operations*	
Opearation	*Time taken (work hours/ha)*	*Cost (Leones*/ha)*	*Time taken (h/ha)*	*Cost (Leones*/ha)*
Planting	100	15 000	12 team h	18 060
Weeding (twice)	806	120 900	20 teams h +111 work h	30 100
Lifting	152	22 800	12 team h +28 work h	16 650
Harvesting	250	37 500	250 work h	18 060
Total	1 308	196 200	44 team h + 389 work h	4 200 37 500
Total cost (Hand)		**196 200**		
Total cost (Ox/hand)				**124 570**

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

Table 9: Comparison of cost of different methods of maize cultivation

Plowing		*Weeding*		*Total cost*
System	*Cost (Leones*/ha)*	*System*	*Cost (Leones*/ha)*	*(Leones*/ha)*
Hand	115 500	Hand	175 500	288 000
Tractor	94 320	Hand	175 500	269 820
Oxen	60 200	Hand	175 500	235 700
Tractor	94 320	Oxen	58 000	152 320
Oxen	39 400	Oxen	58 000	96 400

** Based on 600 Leones = US$ 1, but attention should be paid to comparative costs and not absolute values*

benefits of using oxen to plow, puddle and level swamps for rice production. There is, however, no suggestion that work oxen are 'the answer' to Sierra Leone's agriculture, merely that as work oxen can be used efficiently and economically in certain circumstances, more attention should be paid to them.

The vast majority of farmers still use traditional shifting cultivation and in such circumstances neither ox plowing nor tractor plowing is possible due to the large number of roots and stumps. Thus, where farmland comprises mainly upland bush, before plowing can be recommended it is necessary to ensure that crop rotations are identified that justify the enormous labour involved in destumping, and which can maintain soil fertility and avoid severe erosion problems. An ecologically acceptable system of integrated farming needs to be established as an alternative to the bush-fallow system in areas

where fallow periods are becoming short, and the use of oxen in such a system might prove valuable. Rotations can be planned to allow crop residues, such as groundnut straw, to be used for feeding purposes while animal wastes can be used to maintain soil fertility. In such systems the use of the multipurpose legume shrub *Leucaena leucocephala*, which is growing very well at Njala, might be considered since it can provide not only a high protein feed supplement and browse for cattle, sheep and goats, but also can be used for bush sticks (eg yam poles), fencing and as a fuel source.

While the development of alternative farming systems may be a long term prospect, at the current time there is more than enough swamp land, boliland, natural grassland and cleared bush to justify the use of work oxen in existing farm systems. In particular oxen could be used in swamp development programmes, thereby allowing significantly greater rice production per unit of human labour. It is the author's opinion that the major benefits of animal power both for the nation as a whole and for individual farmers, will come when oxen are used to increase rice production in swamps, in conjunction with the cultivation of row-planted food and cash crops such as groundnuts.

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