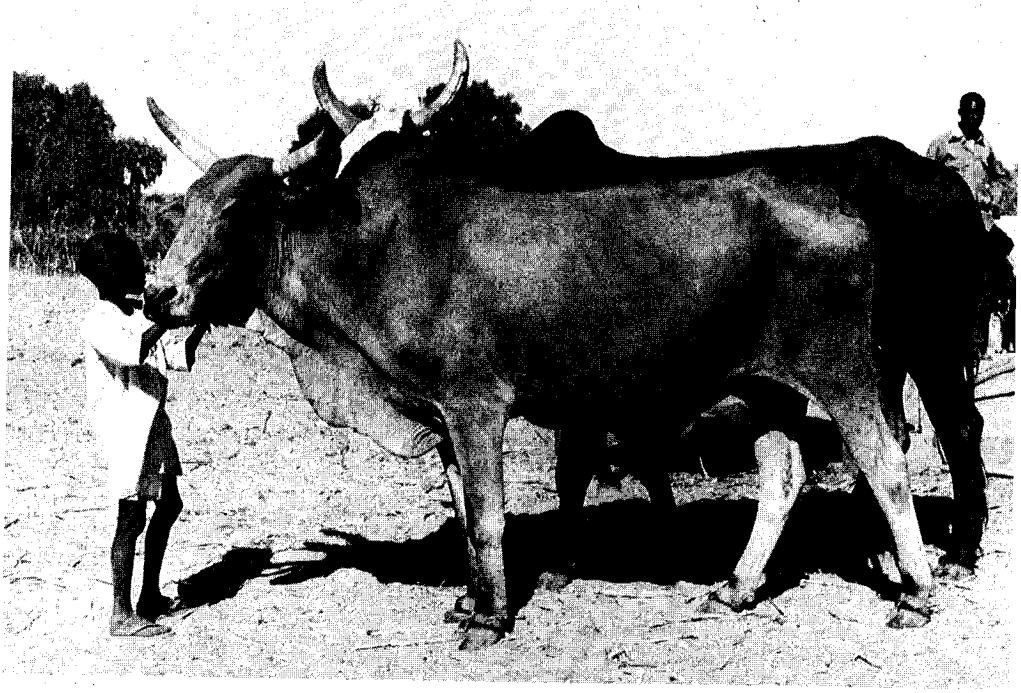
Animal Power in Nigeria



Economic implications of animal power at the small-scale level in the savannah zone of northern Nigeria: a linear programming simulation of farmer circumstances

by

D.O.A. Phillip, G.O.I. Abalu and S.A. Ingawa

Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria

Abstract

Aspects of the farming systems in northern Nigeria are briefly described. Farming is undertaken largely by small-scale operators. Most labour, management and capital come from household sources. Only a fraction of total production is marketed by the household, and despite agronomic and extension efforts to the contrary, farmers have persisted with mixed cropping. Labour is the major constraint particularly during the June-August period. Animal traction is an option for removing the labour constraint, yet only 5.5% of the area is cropped using animals, while 86% is cultivated by hand hoe. Data suggests area increases would be possible using animal power for cultivation.

Working with sole crop enterprises and a set of representative farmer situations, linear programming (LP) techniques are used to determine the optimal enterprise combination if animal traction were introduced on a hiring-in or borrowing basis. The LP model was varied over farm sizes, hourly costs of hiring oxen, hourly costs of hiring May-August labour, and different levels of non-cash oxen borrowing. The LP model included six sole crop enterprises and limits were placed on farm size and labour availability.

In the model only maize and groundnut appeared in the optimal solutions, although Guinea corn, millet, cowpea and cotton were options. Increase in farm size enhanced gross farm income but when the farm size was doubled from 2 ha to 4 ha, only 2.9 ha could be used because of the limits imposed by May-August hired labour. Production and income possibilities shrank as the cost of hiring oxen increased. January-April and May-August continued to represent labour surplus and labour shortage periods respectively. Even when oxen were readily available at low cost, labour constraints dominated the model. This model suggests that oxen cannot fully replace manual labour at critical times.

There is a need to refine the model to investigate animal traction in mixed cropping systems, and incorporate credit constraints, purchasing oxen and implements, and oxen maintenance requirements.

Introduction

The farming system in northern Nigeria comprises crop, livestock and off-farm subsystems, each with a complex interaction of interdependent component parts. Quite often each of the sub-systems is location-specific in terms of sets of elements that come to play in the achievement of the objectives of the farmer. As a consequence the farming system may be seen as consisting of a cropping system involving production of one or more commodities, a livestock subsystem involving the production and rearing of one or more species of livestock, and an off-farm subsystem involving activities carried out outside the farm.

Farming systems assume their identity from the operating cropping and livestock subsystems. However, in northern Nigeria livestock

appears to be a minor component of the farming system. The cropping subsystem is dominant as the main source of livelihood of the peasants in the area whose main economic activities involve the growing of staples and cash crops. The livestock subsystem performs the secondary role of occasionally providing farm power and transport and is a ready source of liquid assets which the family can dispose of for cash during times of need.

Rainfed agriculture is the predominant form of crop husbandry in the area. Most farmers are smallholders with total farm sizes averaging about 2.5 hectares. The zone has a growing season of 160-200 days and this makes possible the production of a wide variety of crops with many of them being produced in mixtures. Farmers in the area prefer to grow their crops in mixtures because a mixture of two or more crops which grow most rapidly at different times during the growing season almost always produces more total output than the same area of sole crops, whatever the level of management (Abalu and Etuk, 1986).

Most cropping operations are done manually and there is a peak labour demand period between June and August when land preparation and weeding are taking place. Consequently, the amount of land that can be brought into cultivation each year per farming household is determined largely by the availability of family and/or hired labour during the peak labour demand period to handle land preparation and weeding. The present system of cultivation relies heavily on traditional hand tools such as hoes and cutlasses.

Most studies in the zone have identified labour as the major constraint within existing levels of technology. There is also well-documented evidence about the seasonality of labour and the serious bottlenecks it causes during the June-August period (Norman, 1972).

Farmers have responded to the labour bottlenecks in land preparation and weeding activities in a number of ways including: working more days and longer hours per day on farm activities; reducing time spent on on-farm activities; using more labour of women and children; when possible hiring labour; growing crops in mixtures; and planting cash crops after food crops.

Most of these strategies have serious limitations in northern Nigeria. Land preparation and weeding are the most tedious of farming activities and there is a limit to the amount of land a farmer can cultivate. Because the area is predominantly Moslem and seclusion of women is practised, the availability of women for farm work is greatly reduced. The compulsory, Universal and Free Primary Education system in operation in Nigeria effectively removes the availability of children from farm work. Hiring labour requires cash but the period of June-August when hired labour is needed most coincides with the period when farmers' cash reserves are at their lowest ebb.

However, these strategies do provide useful clues as to how farmers in the area might maximize yields per unit area or increase the area cultivated by relaxing the labour bottleneck during the June-August period.

Tractor use as a means of ensuring that the two key agricultural operations are appropriately and timely carried out has considerable limitations as of now. The tractors are often ill-suited to the soil and environmental conditions prevailing in the area, they break down frequently, and spare parts for their repairs are hard to come by. In short, there are still a number of technical problems with tractor use in the area to be sorted out and even if these problems were successfully addressed, the economics of tractor use are very questionable in the area (Ukpabio, 1978). The high failure rates of the various Tractor Hiring Units that were set up in the area provides corroborating evidence.

In addition, the existing literature on technical change in the agricultural sectors of developing countries would appear to suggest that

even if tractorization could be labour-saving, it would most likely not be accompanied by much impact on yield in Africa (Binswanger, 1984). It is in this regard that animal traction suggests itself as a potentially useful and appropriate means of improving upon the efficiency of the hoe system in northern Nigeria.

Animal traction provides a well-tested and proven option for removing the farm constraints of non-availability and/or timeliness of labour in the area. As a substitute for hoe cultivation it has the potential of permitting the farmer to expand his acreage and improve upon his yields. However, despite the fact that it is a farmer-generated and farmer-adapted technology with a successful history of adoption elsewhere, it has not been widely adopted by Nigerian farmers.

In this paper, we examine the potential of animal traction as a means of increasing the efficiency of peasant farming in the savanna ecological zones of Nigeria through timely agricultural operations and we explore the economic implications thereof. Our interest in this regard is based on the hope that intensification of animal traction, and intermediate-level technology will not only ease the labour bottlenecks of the peak work season, but may also pave the way for the enhancement of farm income and living standards of rural households in northern Nigeria.

Improving farming efficiency through animal power

Agricultural production in northern Nigeria is characterized by the following (Norman, 1975, 1972 and Abalu, 1976):

- It is undertaken largely by small-scale operators.
- The bulk of the labour, management and capital resources comes from household sources.
- Given its subsistence needs, only a fraction of total production is marketed by the household.
- Despite agronomic and extension efforts to the contrary, farmers have persisted in growing their crops in mixtures.

The use of animals, particularly oxen, in agriculture is relatively recent in northern Nigeria, dating back to only the mid-1920s. Ox farming was introduced in northern Nigeria through "mixed farming" for obtaining cash crops such as groundnut and cotton and also for improving soil fertility (Kalkat and Kaul, undated). Animal traction, as an alternative source of farm energy, has been recognized many centuries ago in southeast Asia, the Middle East and Mediterranean countries (FAO, 1972).

Table 1. Estimates of area under different cultivation systems

	Cultivation systems		
	hoe	**animal power**	**tractor**
Number of farmers (million)	7.5	0.1	0.015
Area cultivated (ha/farmer/year)	1	5	50
Total area cultivated annually (million ha)	7.5	0.5	0.75
Per cent of total area (%)	86.0	5.5	8.5

Source: Dunham (1980)

Several benefits, actual and potential, have been identified with the use of animal power at the farm level in an environment such as that prevailing in northern Nigeria. First, while the area under animal cultivation is only about 5.5% of total cultivated area, recent evidence (Table 1) suggests that a man and his family with a pair of workbulls can handle 4 to 5 times the area of a hand-cultivated farm.This result had earlier been independently obtained by Haswell (1979). Second, all the known

Table 2.
Total operational hours per hectare for growing different crops under trial

Crops	Oxen	Manual
Guinea corn	58	225
Groundnut	32	1200
Maize	42	285
Millet	44	203
Cotton	46	565
Cowpea	77	210

Source: IAR (1974)

operations that are involved in each crop production cycle (seedbed preparation, ridging, fertilization, planting, irrigation, weeding, crop protection, harvesting, threshing and carting) are generally possible with animal-drawn equipment (Kalkat and Kaul). Third, not only is animal traction reasonably affordable, it is made attractive by the fact that the household has the option of selling the workbulls for meat, after the bulls are considered to have exhausted their work life. Fourth, a complex, almost symbiotic relationship could develop in the event of an intensive use of animal power. While the workbulls are fed on the grains and greens of the cultivated fields, the bulls contribute in the form of enriching the soil fertility with their wastes, in addition to being used to perform the farm operations for which they were primarily intended. Thus this relationship is akin to the beneficial coexistence known to have developed between pastoral and sedentary people of northern Nigeria (see Van Raay, 1973). Fifth, recent field evidence (Table 2) suggests that the total operational hours required for growing one hectare of crop are considerably fewer under animal traction when compared to manual labour. Thus, animal-drawn implements when utilized for farm operations can constitute a potential labour-saving strategy.

Table 3. Measures of the net price row

Activity	Yield (kg/ha)	Price (N/kg)	Labour cost (N/hour)
Guinea corn	1007	0.48	
Groundnut	2006	0.75	
Cotton	752	0.56	
Maize	2237	0.56	
Cowpea	45	1.00	
Labour hiring			
January-April			0.60
May-August			0.85
September-December			0.70

On the other hand, the introduction of animal traction is not without its limitations (Barratt *et al.*, 1982). For it to be successfully implemented farmers have to: learn to manage large animals; use new implements and agronomic techniques; intensify land use; change their cropping patterns; and borrow to finance the purchase of the animals and equipment.

Farm plans incorporating animal traction

A considerable amount of research effort has been devoted over the past one-and-half decades to the rationale and modalities of farm level operations among the farming families of northern Nigeria. Studies have already focused on such issues as the economic, social and cultural rationale of mixed cropping (Norman, 1975; Abalu, 1976), and the feasibilities of alternative levels of technology for growing sole crops (Abalu and Etuk, 1986). Linear programming techniques have also been applied to determining the optimal enterprise mixes under indigenous conditions of northern Nigeria (Ogunfowora, 1972).

Linear programming (LP) techniques were applied in this study to determine the optimal enterprise combination for the average northern Nigerian household when animal traction was introduced into a system of sole cropping. While mixed cropping is largely prevalent among farmers of northern Nigeria, non-availability of relevant coefficients with regard to animal traction invariably restricted the scope of our investigations.

The basic LP formulation consisted of six sole crop enterprises: Guinea corn, groundnut, cotton, maize, millet and cowpea. The typical

household was constrained to face the following situation: a maximum farm size of 2 hectares (ha); a maximum of 500 person-hours (hr) of family labour, available during each of the periods January-April, May-August, and September-December; a maximum of 100 person-hours available for hire during each of the above periods; and the household had no oxen team of its own, thus requiring it to hire each additional hour of animal traction utilized. Table 3 shows some of the information used in the construction of the net price row.

The resource levels indicated above, while potential in nature, are not empirically farfetched. For example, in the Funtua area of Kaduna state, about 75% of all households surveyed possessed less than 4 hectares of cultivable land (Balcet and Candler, 1981). Note also that the monthly labour requirements of the sole crop enterprises have been regrouped into sub-periods of four months each to avoid the so-called work-overlapping problem (Mbonda, 1983). The set of LP simulations obtained, using the basic formulation, largely revolved around certain questions, for which we were seeking answers. For example, what were the effects on the optimal enterprise mix, labour and oxen team requirements and farm income, of varying (a) the farm size, (b) the hourly costs of hiring an oxen team, and (c) the hourly costs of hiring the May-August labour? Furthermore, if the household had access to additional hours of oxen usage, which it did not necessarily pay for in cash, what were the implications for its enterprise mix, labour requirements, ox hiring and gross farm income?

Information on resource levels, resource requirements of each activity and the measures of net prices were obtained, not unexpectedly, from multiple sources: interpersonal communications, published work and unpublished survey data on farm level operations in northern Nigeria.

Table 4. Effect of varying the farm size

Farm size (ha)	Activities in the plan	Unit	Level	Objective function
2.0				
	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	110	N2340
4.0	Groundnut	ha	0.164	
	Maize	ha	2.746	
	May-August labour hiring	hr	100	
	September-December labour hiring	hr	100	
	Ox hiring	hr	127	N3149

Table 5. Effect of varying the hourly cost of hiring oxen team

Oxen hire cost hr^{-1}	Activities in the plan	Unit	Level	Objective function
0.0	Groundnut	ha	1.276	
	Maize	ha	0.724	
	Labour hire	hr	100	
	Ox hiring	hr	135	N2741
3.0	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	109	N2340
6.0	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	109	N2010
9.0	Maize	ha	2.0	
	Ox hiring	hr	83	N1757

Discussion

This study has the broad objective of determining the best enterprise mix for the average northern Nigerian household, given the set of conditions assumed to face it. A more specific objective was to assess the feasibility of introducing and intensifying animal traction within a sole cropping system.

Variation in the farm size

Table 4 presents the results of varying the household's farm size over two levels (2 ha; 4 ha). At 2 ha, all the available land was planted to only groundnut and maize. When the farm size was doubled (4 ha), only 2.91 ha was used because of the limits imposed by May-August and September-December hired labour and hired oxen team. Note the require-

ment for more oxen team hours as the farm size increased.

Variation in the hire cost of oxen team

In Table 5, we present the results of parametering over alternative hourly costs of hiring an oxen team. We included a zero hire cost merely to assess the technical limit, if one exists, to ox hiring, given the conditions assumed to prevail.

The overall pattern emerging from Table 3 is that the production and income possibilities of the household shrank as the hourly costs of hiring an oxen team increased. Furthermore, an approximately well-behaved normative demand relationship was established for ox hiring (see Table 5).

Variation in the hire costs of May-August labour

As indicated earlier, we investigated the likely impact on the optimal plan of varying the hourly costs of hiring the May-August labour. The choice of the May-August labour out of the three labour subgroups was based on the common knowledge that labour is most limiting during the peak work seasons (May-August) in northern Nigeria.

As the cost/hour of hiring the May-August labour was increased from N0.25 to N0.85, the optimal mix of the enterprises changed from 1.28 ha of groundnut and 0.72 ha of maize, to 0.66 ha of groundnut and 1.34 ha of maize. In the process, labour hiring dropped out of the optimal plan at N0.85 h^{-1}, while ox hiring remained in the plan. Also, note the drop in the level of ox hiring at N0.85 h^{-1} for the May-August labour, perhaps suggesting that ox hiring and labour hiring during the May-August period are likely to be complementary in the performance of certain farm operations.

Variation in available "non-cash" oxen hours

At least three options face a potential user of animal traction in northern Nigeria. The first option, which is still very much constrained by credit availability, is for households to buy and own their oxen team and implements. The second choice, the most common, is to hire the oxen team at mutually agreed cost either per hectare or per hour. The third option is for a household to "borrow" the oxen team and implements from a neighbour who has one. The last arrangement ranges from getting to use the oxen team free of charge (provided the actual owner was not in need of the team at the time of borrowing), to some prearranged pay-

Table 6. Effect of varying the hourly cost of hiring the May-August labour

Labour hire (N hr-1)	Activities	Unit	Level	Objective function
0.25	Groundnut	ha	1.276	
	Maize	ha	0.724	
	Labour hire	hr	100	
	Ox hiring	hr	135	N2396
0.50	Groundnut	ha	1.276	
	Maize	ha	0.724	
	Labour hire	hr	100	
	Ox hiring	hr	135	N2371
.85	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	109	N2341

Table 7. Effect of varying the available non-cash oxen hours

Non-cash oxen (hrs)	Activities in the plan	Unit	Level	Objective function
zero	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	109	N2340
50	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	60	N2490
100	Groundnut	ha	0.656	
	Maize	ha	1.344	
	Ox hiring	hr	10	N2640
200	Groundnut	ha	1.276	
	Maize	ha		0.724
	Labour hire May-Aug	hr	100	N2741

ment inkind at a future date. In some variations of this arrangement, the oxen team borrower is obliged to contribute forage and grain towards the feeding of the oxen team. This study assumed the case in which the household acquired additional oxen hours via the third option above. We referred to this as "non-cash" oxen hours to distinguish it from option two, the ox-hiring case.

From Table 7, increasing the level of non-cash oxen hours available to the household not only decreased the level of ox hiring, it enhanced the farm income. At 200 hours of non-cash oxen usage, the May-August hired labour became highly limiting, possibly suggesting that availability of large oxen hours, at paltry or significant costs, does not adequately replace the need to perform some of the farm operations by manual effort.

Finally, note that the 2 ha of land, continuing to be limiting, was fully planted to only groundnut and maize, with a clear switch in the optimal enterprise mix at 200 hours of non-cash oxen usage.

Summary and implications

We have attempted, within the limits imposed by the available data, to determine the implications of introducing and intensifying animal traction in northern Nigeria. Working with sole crop enterprises and a set of fairly representative farmer situations, the basic LP model was parameterized over different farm sizes, hourly costs of hiring oxen team, hourly costs of hiring the May-August labour; and different levels of additional oxen hours acquired by the household, which it did not necessarily pay for in cash. From the alternative sets of the LP simulations, the following patterns of results appeared to have emerged:

- January-April and May-August continued to represent labour surplus and labour shortage periods respectively.
- Increase in the average farm size substantially enhanced the gross farm income. However, land was underutilized, even at 4 ha, because of the limitations imposed by the May-August hired labour, hired oxen team, etc.
- The production and income possibilities of the household shrank as the hourly costs of hiring oxen team increased. Also an approximately well-behaved normative demand relationship emerged for ox hiring.
- As the wage rate for the May-August labour was increased from N0.25 h^{-1} to N0.85 h^{-1}, the concurrent results were for the May-August labour hiring to drop out of the optimal plan, while ox hiring, though dropped in its entry level, remained in the optimal plan. Also, an increase in the wage rate for the May-August labour resulted in successive, though slight, penalty of the gross value of the plan.
- Increasing the level of "non-cash" oxen hours available to the household not only decreased the level of ox hiring, it enhanced the gross farm income. But the May-August hired labour became limiting.

The last two of the foregoing results appeared to suggest that availability of a large amount of oxen hours, from whatever source, does not fully substitute for the performance of certain farm operations which traditionally call for the employment of manual labour.

Over the range of conditions for which the basic model was simulated, only groundnut and maize alternately or concurrently entered the optimal plans. These results obviously generate an unquiet concern, especially considering that some 70% of all cultivated land goes into food production (Norman, 1972). However, on a more optimistic note, the prevalent cropping pattern in northern Nigeria is one in which crops, especially millet and

Guinea corn, are grown in mixtures (Abalu, 1976). Thus, with millet- and Guinea corn-based crop mixtures constituting 50% or more of all documented enterprises, and with the establishment that gross returns per hectare are higher under mixed cropping (Norman, 1975), there is a need to further investigate the technical and economic feasibilities of introducing and intensifying animal traction with a mixed cropping system. The urgency for such an investigation partly derives from the recurrent entry of the May-August labour hiring activity into the optimal plans, in this study. There is a need to establish the nature of the relationship between the May-August labour and oxen team utilization (are they strict complements, strict substitutes or some combination of these two relationships?).

Finally, we were mindful of the need to construct our basic LP tableau to incorporate such considerations as credit constraints to purchasing an oxen team and implements; and allowing for the oxen team maintenance (feeding, housing, veterinary services, etc.). We believe that these considerations would prove invaluable as relevant coefficients on them become available in the future.

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