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9. ABSTRACT

Presents results of a literature search to determine whether the current West African practice of bovine traction and a small unit feeding could increase (1) net cash farm incomes, (2) demand for immature cattle, and (3) rural supplies of red meat. The discussion of bovine traction outlines the economic factors which limit adoption of ox-cultivation, recommends measures for mitigating these constraints, and assesses the effect that an increase in bovine traction would have on the demand for immatures from the northern mainland. The study also addresses the profitability and economic future of small unit feeding and evaluates the effect of both bovine traction and small unit feeding on rural supplies of red meat. It is concluded that while ox-cultivation will remain an important element in Central West African crop and livestock production, more universally effective technologies should also be developed. Numerous tables provide data on related economics, geography, labor-requirements, and yield effects.

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AN ECONOMIC ANALYSIS OF THE ROLE OF OX-PLOWING AND CATTLE-FEEDING IN THE STRATIFICATON OF WEST AFRICAN LIVESTOCK PRODUCTION

by

Jonathan Arthur Sleeper

Thesis submitted to the Faculty of the Graduate School
of the University of Maryland in partial fulfillment
of the requirements for the degree of
Master of Science
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ABSTRACT

Title of Thesis: AN ECONOMIC ANALYSIS OF THE ROLE OF OX-PLOWING AND CATTLE-FEEDING IN THE STRATIFICATION OF WEST AFRICAN LIVESTOCK PRODUCTION

Jonathan Arthur Sleeper, Master of Science, 1978

Thesis directed by: Phillips W. Foster
Professor
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This analysis attempts to determine whether or not ox-plowing and cattle-feeding activities currently practiced in West Africa perform three functions in the regional stratification approach: 1) increase net cash farm incomes; 2) draw off substantial numbers of immatures from northern rangelands; and 3) increase the supply of red beef.

The procedure was to construct indicative budgets and simple herd inventory models based upon a search of the literature for farm management data.

Results indicate that the adoption of ox-cultivation would not substantially increase cash farm revenues for the majority of West African farmers because of the high investment requirement ($500 compared to estimated annual cash revenues net of subsistence of $275 under manual cultivation) and inadequate net increases in production (175 to $300 compared to a $600 value of production under manual cultivation). However, ox-cultivation is profitable for a minority of farms,

but it is not the universal answer to increased food crop production in West Africa. Promotion of other yield-increasing technologies for the mass of West African farmers may be more feasible.

The adoption of cattle-feeding (150 days) substantially increases cash farm revenues: margins above concentrate and interest ranged from $20 to $100 a head.

Ox-plowing activities draw off an insignificant number of immatures (perhaps eight per cent of three year olds). Insufficient data prevented determination of numbers drawn off for feeding activities.

Finally, ox-plowing does not decrease the available supply of red carcass beef (from delayed marketing) and can increase it by forty per cent when combined with cattle-feeding.

Dry season feed shortage is a primary constraint to the general expansion of both activities. Its removal appears only possible through adoption of forage cultivation and/or systems of controlled grazing.

PREFACE

The Concept of Stratification

The "stratification" of a livestock industry in its most restricted sense refers to the arrangement of the process of meat production into separate stages according to vegetative or climatic zones: 1) breeding in the arid zones; 2) growing-out in the more humid zones; 3) and final fattening near terminal markets or at export zone abbatoirs.

Such a chain of activities was established across the grasslands of nineteenth century America--breeding on the arid range, growing-out in transit on bluestem pastures, full-feed fattening in the Corn Belt feedlots, slaughter at the major midwestern packing centers, and shipment to the East Coast for consumption.[1]

A somewhat similar chain of interrelated activities could develop in West Africa, since most of the beef consumed in the urban centers on the Atlantic coast are grazed on Sahelian and Sudanian Zone rangelands and pass more humid zones on the way to market. However, the concept of stratification of livestock production has been expanded to include the planned

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[1] J.C. Malin, "The Grasslands of North America: Its Occupance and Challenge of Continuous Reappraisals," Man's Role in Changing the Face of the Earth, edited by W. L. Thomas (Chicago: University of Chicago Press, 1956), p. 361.

arrangement of all agricultural land-use and management systems according to vegetative or climatic zone: extensive grazing, extensive crop production, intensive fodder/pasture production, intensive crop production, mixed farming (including animal traction), conservation and forestry. These activities would be sited and planned to make the best use of all scarce resources, land-use potentials, existing infrastructure, population density, product demand and other physical, social and economic factors.[1] This concept will be utilized here, since it includes ox-plowing and small farm cattle-feeding as intermediate stage activities in semi-humid and humid zones.[2]

Background to the Problem

The large majority of traditional West African farmers are very poor because of their low level of productivity--most still use the hand hoe in a system of shifting agriculture. This system can no longer keep up with the expanding demand for food in West Africa, and is contributing to ecological deterioration of croplands in the Sudanian Eco-

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[1]D. S. Ferguson and F. Vandemaele, Feasibility Study, Stratification of Livestock Production in Arid Regions (S.O.L.A.R.) West African Sudano-Sahelian Countries, U.N. Environmental Program, Conference on Desertification (September, 1976), pp. 3-4.

[2]See: W. G. Matlock and E. L. Cockrum, A Framework for Evaluating Long-Term Strategies for the Development of the Sahel-Sudan Region, Vol. II, A Framework for Agricultural Development Planning (M.I.T. Center for Policy Alternatives: December, 1974), pp. 29-41; and F. Abercrombie, "A Sectoral Approach to the Cattle Industry in West Africa," Development Digest, XIII (April 2, 1975), p. 77.

Climatic Zone as the fallow period becomes shorter. A stabilized system of permanent land-use is needed.

Overpopulation and over-grazing are contributing to the process of "desertification" in the Sahelian and Sudanian rangelands. There is need for selective destocking of the herds, particularly in the Sudanian Zone, where cultivated lands are expanding into grazing areas. Declining crop yields and the decreasing supply of red meat have contributed to a diminished per capita food supply.

Role of Ox-Plowing and Cattle-Feeding in Livestock Stratification

Because of its success in increasing agricultural productivity in temperate countries, donor and national agencies have promoted animal (bovine) traction in a system of mixed farming as an alternative to shifting cultivation. Manure from oxen would maintain yields, while ox-drawn cultivation would increase yields and/or area cultivated per unit farm.

As an activity which may occur either separately from or conjointly with ox-drawn cultivation, the intensive feeding of cattle on small farms (or small unit feeding) would enable farmers to convert farm by-products into cash by growing out immature cattle to higher weights and values.

Furthermore, it is proposed that ox-plowing and cattle-feeding activities would increase demand (prices) for immature cattle, thus making it more economically attractive for herders to sell their animals at younger ages. This would reduce grazing pressure on the Sahelian and Sudanian

rangelands, consequently reducing the desertification process.

Finally, it is believed that a general expansion of ox-plowing and cattle-feeding activities would increase the rural supplies of red beef carcass meat.

Thus, the role of ox-plowing and cattle-feeding activities in the regional stratification approach is three-fold:

1) through a closer integration of crop and livestock husbandry (in a region where crop and livestock husbandry are generally practiced separately), both bovine traction and small unit feeding activities would increase net cash farm incomes in the intermediate semi-humid and humid zones.

2) a general expansion of these activities would contribute to the destocking of northern rangelands by drawing off immatures.

3) a general expansion of these activities would increase the rural supplies of red carcass meat.

Problem

Despite the ostensible benefits of bovine traction and the considerable efforts on the part of both donor and national agencies to promote it, the expansion of this technology in West Africa has not generally been spontaneous and has in fact only occurred in certain areas of West Africa. Although there is little available data as to the actual numbers of cattle fed out by small farmers or the profitability of small unit feeding, it too appears to be practiced by only a few West African farmers.

Objectives

There are three objectives of this analysis:

1) to determine if the adoption of bovine traction and small unit feeding substantially increases net cash farm incomes.

2) to determine if bovine traction and small unit feeding may potentially draw off a substantial number of immatures from the northern rangelands.

3) to determine if a general expansion of bovine traction and small unit feeding can increase the rural supplies of red beef carcass meat.

Two other sub-objectives are to briefly review the factors which have been present in the few areas where bovine traction and small unit feeding have developed, and to briefly examine selected constraints which continue to prevent the general expansion of these activities in West Africa.

Procedure

This analysis is based upon a search of the literature for farm management data which could be utilized to determine whether or not bovine traction and small unit feeding can meet the three objectives stated above.

A pro-forma farm budget was constructed for a farmer adopting bovine traction (Chapter III). Annual cash farm revenues (net of subsistence) under manual cultivation were then compared to annual net cash revenues over the working life of a team of oxen on the farm adopting bovine traction. Certain conclusions about the timing and magnitude of in-

creases in both cash outlay and cash revenues from the adoption of bovine traction could then be drawn.

Similarly, indicative budgets for small unit feeding were constructed in order to ascertain gross profit margins above feed concentrate and interest costs (Chapter V).

The supply of oxen and the potential for bovine traction activities to draw off immatures from northern rangelands is analysed in connection with other constraints to the wider expansion of bovine traction as a form of livestock production (Chapter IV).

Finally, a hypothetical situation was examined to determined if bovine traction and small unit feeding (both separately and combined) could increase the regional supply of red beef carcass meat (Chapter VI).

A simple model for determining numbers of immatures drawn off and numbers of older oxen marketed was utilized in the latter two analyses.[1]

Justification

Research on this problem will furnish background for decision makers concerned with raising net cash farm incomes of the rural poor and the expansion of integrated crop and livestock production in West Africa.

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[1] J. Coulomb, "Incidence de L'Age de Commercialization des Boeufs d'Attelage sur la Production de Viande," I.E.M.V.T. mimeograph (Paris, 1975), 5 p.

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CHAPTER I

THE POTENTIAL BENEFITS OF BOVINE TRACTION AND SMALL UNIT FEEDING FOR WEST AFRICAN FARMERS

Potential Benefits of Bovine Traction

The adoption of bovine traction (ox-plowing)[1] in a system of mixed farming[2] may increase West African farm incomes through: increases in yields from both the effects of plowing upon the soil and from more timely cultural operations; increases in area cultivated by labor saving in cultural operations; increases or maintenance of yields from manure production and utilization; custom work; and on-farm beef production. These points are briefly discussed below.

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[1]Although future chapters have been limited to the consideration of only ox-drawn cultivation, the potential benefits of ox-cultivation generally apply to cow, donkey and horse traction. Donkey traction has shown to be ideally suited to very arid regions with extremely light, sandy soils. For an economic discussion of donkey vs. ox-cultivation in Upper Volta, see: 180. See also: 32, II. Cows may be utilized in areas where there is a shortage of working-size oxen (149, p. 17; see also: 123; 135; 161). Horses are widely used in Senegal for seeding and light cultivation.

[2]When first introduced in West Africa, mixed farming in its most basic sense referred to the manuring of land with farm yard manure made by keeping cattle at night on bedding (45, p. 18). The objective of mixed farming was to promote a settled system of livestock and crop husbandry in savannah areas with the making of farm yard manure on bedding of grass to maintain soil fertility, and the utilization of the animals for draft (98, pp. 272-73). A definition of the term also usually includes the cultivation of forage/pasture crops in

Potential yield effects of plowing[1]

The French Institute for Research in Tropical Agronomy (I.R.A.T.) has investigated the effects of animal-drawn plowing upon certain zonal soils of West Africa whose texture may be characterized as sandy to coarse loamy.[2] Tillage of these soils may be "minimum" (ten to fifteen centimeters) or "deep" (thirty centimeters). It may be done at the beginning of the rainy season (in the case of long-cycle cereals and cotton) and/or at its end (in the case of short-cycle cereals and groundnuts). Experimental trials have shown that pre- and/or post-season animal-drawn plowing may increase crop yields by improving root density and increasing water infiltration and storage in the soil. Yield increases averaged twenty per cent for groundnuts, twenty to thirty per cent for cereals and over 100 per cent for rain-fed rice (Appendix E). Further yield increases from the plowing under of vegetative matter (green crops, fallow or crop residues) ranged from seven per cent for groundnuts to sixty-six per cent for maize (15, Table IV-18, p. 935).

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rotation on manured land, but to date forage cultivation remains for all practical purposes non-existent in West African agriculture. For the purposes of this paper, the term will simply refer to the stall production of manure.

[1]Data in this section has been drawn from: 14, pp. 153-257. For a more complete discussion of the yield effects of plowing upon West African soils, see: 15, or 129.

[2]These soils generally contain less than eighteen per cent clay, which defines the sandy to coarse loamy soils in the U.S.D.A. textural triangle. Much of this clay is kaolinite, which expands very little upon wetting. Thus the soil tends to harden over the dry season and retain little moisture.

Yield effects from timely planting

Timely land preparation and planting may also increase yields. In Central West Africa, where the rainy season is very short (three to five months), time available for land preparation and planting is very limited. All major crops (sorghum, millet, groundnuts, cotton and rain-fed rice) are highly sensitive to time of planting; yields generally decline in direct proportion to each day's delay in planting (see: 15; 20, Appendix D; 99, p. 2-369; 149, pp. 10-11).

Increase in area cultivated through labor saving

Labor saving through the more rapid performance of cultural operations with animal power depends upon the available tractive power from the animals, type of equipment used, soil conditions (moisture, clay content and amount of stumps) and size of field (turn-around time). Reductions in total labor requirements through the adoption of ox-cultivation may be reduced by at least one-half, which permits the farmer to cultivate twice as much land (Appendix F).

Seeding.--Under traditional methods, broadcast or dribble seeding can be time-consuming and efficient. Through row-planting, animal-drawn seed drills permit more efficient and rapid seeding at uniform depth. They may also improve yields through increasing density of seeding (e.g., see: 32, II, p. 357; 53, p. 369; 99, pp. 2-369-70 and p. 2-217).

Weeding.--Weed control is more difficult in West Africa than in temperate zones. It must be repeated four to six times during the short rainy season. It may be performed with

a ridging plow, although specially designed cultivators (often attached to the basic plow or multi-purpose tool bar), appears to be more rapid and efficient (99, p. 2-368). Row planting and good training on the part of both farmers and oxen are necessary for effective weeding.

Harvesting.--This operation usually applies only to groundnuts. Ridger plows are often utilized, but the groundnut lifter (often attached to the basic plow or tool bar) has proven more rapid and efficient. Their use reduces labor requirements for harvesting by one half to one third (*Ibid.*, pp. 2-351-263).

Manure production and utilization

Manure is locally available and its application does not require the kind of technological knowledge necessary for imported mineral fertilizers. West African farmers have long been aware of the value of animal manures. Many crop-dependent households use small animal manure (as well as nightsoil, compound sweepings, ashes, etc.) in the small, continuously-cropped gardens ("jardins de case") around the villages.[1] Some farmers who own cattle or enjoy contractual relationships with Fulani (Peulh) herders have animals paddocked on their fields over the dry season.

The approach in bovine traction programs has been to pen the oxen year around, collect the manure on litter and spread

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[1]It has been suggested that the size of the compound gardens depends upon the importance of cattle husbandry in the households (14, p. 187).

it in the fields.[1] This requires the construction of stables and manure pit, as well as a cart and hay-making equipment.

There is firm evidence attesting to the favorable yield effects of farm yard manure on a wide range of West African crops (Appendix G).

Custom Work

Custom seeding, plowing and carting may provide additional cash revenues to the animal-powered farmer. Besides the many uses of the cart (hauling and transportation) and its importance in manure utilization, custom-carting may be a profitable means of keeping the oxen trained and accustomed to draft work over the long dry season (124, p. 7).

On-farm beef production

On-farm beef production is the maintenance of cattle by settled agriculturalists on their own farms rather than contracting the management of their cattle out to herders. Immediate returns from investment of on-farm resources (crop residues, labor, etc.) would be the advantages of using the animals for draft, while longer term returns would be the increase in weight and value of the animals and/or or stall-feeding them for sale as slaughter beef (e.g., see: 39, pp. 58n, 97 and 100).

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[1] Early experiments in northern Nigeria have shown that manure produced in cattle pens for a period of 200 days has about the same yield effects upon sorghum and cotton as does paddocking cattle on the fields for 400 days in the traditional manner (131, p. 135 and Table 8, p. 145). Stall production of manure prevents its loss during extensive grazing (135, p. 834).

Experimental feeding trials in Senegal have shown that stall-feeding older oxen for two to three months can result in relatively high daily gains.[1] Feeding out oxen is standard strategy in bovine traction programs (149, p. 29). As a side activity, the farmer would also feed younger animals.[2] Both feeding activities would take advantage of seasonal fluxuations in liveweight beef prices.

Thus the emphasis on beef production as well as draft would persuade farmers to raise cattle on their own farms (135, p. 825; 166, p. 113). This is seen as constituting the first step towards the closer integration of crop and livestock husbandry on West African holdings (32, I, p. 108).

The "ideal" situation from the point of view of meat production would be for the ox-powered farmer to work his animals for only a few years, buy and train a younger team, and sell the older oxen after stall-feeding them. Such a system of replacing the oxen every two or three years is seen as a means of increasing the rural meat supply (24).[3]

Advantages of animal traction as an appropriate technology

Studies of rural development in Africa have indicated that animal traction offers substantial benefits as an

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[1] This information is contained within Appendix H.

[2] E.g., S.O.D.E.V.A. (Society for Agricultural Development and Extension) currently promotes stall-feeding of both older oxen and younger animals on farms in the Sine Saloum region of Senegal (79).

[3] The recent Five Year Plan of Mali calls for replacing working oxen every three years (instead of the usual six to eight) to accelerate meat production (111, p. 4).

appropriate technology through employment and income generation in the agriculture, small industry and service sectors in rural areas (103, pp. 37-38; 40, pp. 25-26). In comparison to tractorization, the benefits of animal traction include: lower requirements for foreign exchange; better adapted to the small farmer in terms of his management ability, as well as lower capital outlay and less need for scale; lower cost of manufacture and repair of equipment; cheap source of fertilizer; and the animals may be raised locally.

Finally, the Michigan State University Study of mechanization in equatorial Africa has concluded that animal traction will continue to remain a major source of power for the emerging African farmer (99, p. xi). In 1960, it was estimated that about eighty-five per cent of world farm draft power was provided by animals, despite the fact that the number of tractors doubled every ten years since 1930 (72, p. 8).

Potential Benefits of Small Unit Feeding

Small unit feeding (the stall-feeding of cattle on small peasant farms) can accommodate the relatively low beef prices in West Africa because of lower costs.[1] Small unit feeding

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[1]Feeding cattle for short-term gains in large feedlots has not been profitable in West Africa, primarily because of low beef prices relative to high capital and operating costs (see: 85, pp. 243-46). Other constraints have been: the limited supply and high price of concentrated feedstuffs (agro-industrial by-products); difficulty in acquiring homogeneous age and weight groups at relatively constant prices (46, p. 89); limited demand for "fattened" cattle; and staffing and other problems. Commercial growing-out ranches have faced similar constraints (see: 47, pp. 74-88).

enables the farmer to convert farm by-products and crop residues into cash. It may function as a "savings account" to hold the farmer's operating capital (revenues from crop sales above subsistence requirements) over the dry season. It may also be a means of employing family labor at certain times of the year when it would otherwise be unemployed (85, p. 246). It may provide a source of manure for his crops. Finally, small unit feeding may help sedentary farmers develop a knowledge of cattle husbandry (49, p. 73).

The French Tropical Veterinary and Animal Husbandry Institute (I.E.M.V.T.) and other agencies have conducted numerous feeding trials on locally available feedstuffs in West Africa (Appendix H). These have shown that most West African breed types of cattle have "good feeding qualities."[1]

Potential Role of Bovine Traction and Small Unit Feeding in Livestock Stratification

Regional stratification is a zonal approach to the introduction of improved beef production in West Africa, where the phases of production (breeding, growing out, finishing and marketing) maximize the physical, economic and social advantages offered within each eco-climatic zone. An integrated approach includes the stratification of all agricultural land-use and management systems according to eco-climatic zone:

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[1]Response to intensive feeding and management depends upon breed, sex, age, health and conformation of cattle, as well as type of feed, length of feeding trial, season, age of castration and other factors.

(climatic zone)	(management system)
Desert and Sub-Desert	very extensive management systems extensive grazing only no cultivation outside oases
Sahel (300-650 mm)	extensive management systems cow/calf herds only some dry farming
Sudan (650-900 mm)	less extensive management systems cow/calf operations some intensive steer feeding some mixed farming (including use of manure, forage crops grown in rotation) some animal traction dry farming with increased use of yield-increasing technologies (chemical weed control, fertilization, improved seed varieties, etc.) reforestation of depleted areas
Guinea and Woodland (+900 mm)	intensive management systems mixed farming/confined dairy systems intensive steer feeding/feedlots animal traction/tractorization "today's best technology" forest management

Source: Appendix A.

Net cash farm incomes in the southern Sudanian and Guinean zones would be increased through a closer integration of crop and livestock husbandry on small West African farms. The adoption of bovine traction would increase cash incomes through increases in production (yields/area cultivated), manure utilization, custom work and increase in the value of the oxen before sale. Cash farm incomes from the adoption of intensive cattle feeding on small farms would be increased through the conversion of crop residues into cash and manure utilization. Expansion of both activities would contribute to increased demand for immatures from herds in

the north, thereby encouraging destocking of northern rangelands (Appendix A). Finally, these activities would increase the supply of red beef for consumption in inland rural areas of the southern Sudanian and Guinean zones.

This paper will examine the feasibility of the role these two activities may play in the regional stratification approach by attempting to determine the extent to which bovine traction and small unit feeding may: increase net cash farm incomes; increase the demand for immatures from northern ranges; and increase the supply of red carcass meat.

It will first be necessary to examine the current economic importance of ox-plowing and the factors which have contributed to its expansion within selected "pockets" of West Africa.

CHAPTER II

THE LOCATION AND IMPORTANCE OF BOVINE TRACTION IN WEST AFRICA

Despite long cultural contact with the Mediterrean area, where animal-drawn plowing has existed for centuries, the ox-drawn plow has generally remained absent in West African agriculture. The cultural diffusion of ideas therefore cannot explain this absence (138, p. 237; 105). Ox-drawn plowing was introduced on pilot farms in the major groundnut and cotton production areas of Central West Africa (Senegambia, central Mali, northern Nigeria and northern Cameroon) by colonial governments in the early part of the twentieth century. However, the expansion of bovine traction has been slow and to date it is a technology enjoyed by only a small minority of farmers in selected "pockets" of West Africa.[1]

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[1] E.g., in the northern Nigerian mixed farming program, considered to be one of the most important (and certainly the earliest) developments of bovine traction in West Africa, the number of farmers utilizing ox power increased by about seventeen per cent per annum from 1949 (5,763) to 1954 (12,761). However, about a third of the number of farmers who started in the program had dropped out by the end of the year (137, pp. 90-91). By 1966, only one per cent (50,000) of northern Nigeria's five million farmers had adopted the ox-drawn plow (150, p. 49).

Location of Bovine Traction

The major areas of bovine traction activities have evolved primarily within the Sudanian Eco-Climatic Zone (Figure 1).[1] This zone is very roughly demarcated by the 650 mm isohyet in the north and the 900-1,200 mm isohyets in the south (Appendices B and C). There is very little bovine traction activity in the Sahelian Zone (north of the 650 mm isohyet), except in seasonally flooded areas along the Niger River in Mali and Niger, and possibly along the Senegal River in southeastern Mauritania and eastern Mali. The only notable area of bovine traction activity (utilizing smaller, trypano-tolerant cattle) below the 900-1,200 mm isohyets has been the Kankan region of Guinea Conakry (6), although it presently appears to be expanding in the Casamance region of Senegal (162), the Korhogo region of northern Ivory Coast (145) and southern Mali (18).

Number of Working Oxen and Number of Older Oxen Slaughtered

There are perhaps a half million working oxen in West Africa, comprising less than two per cent of the region's thirty million cattle (Appendix J). The number of bovines put into draft work may have increased by seven to eight per cent per year from 1965 to 1974 (Appendix I). As a rough

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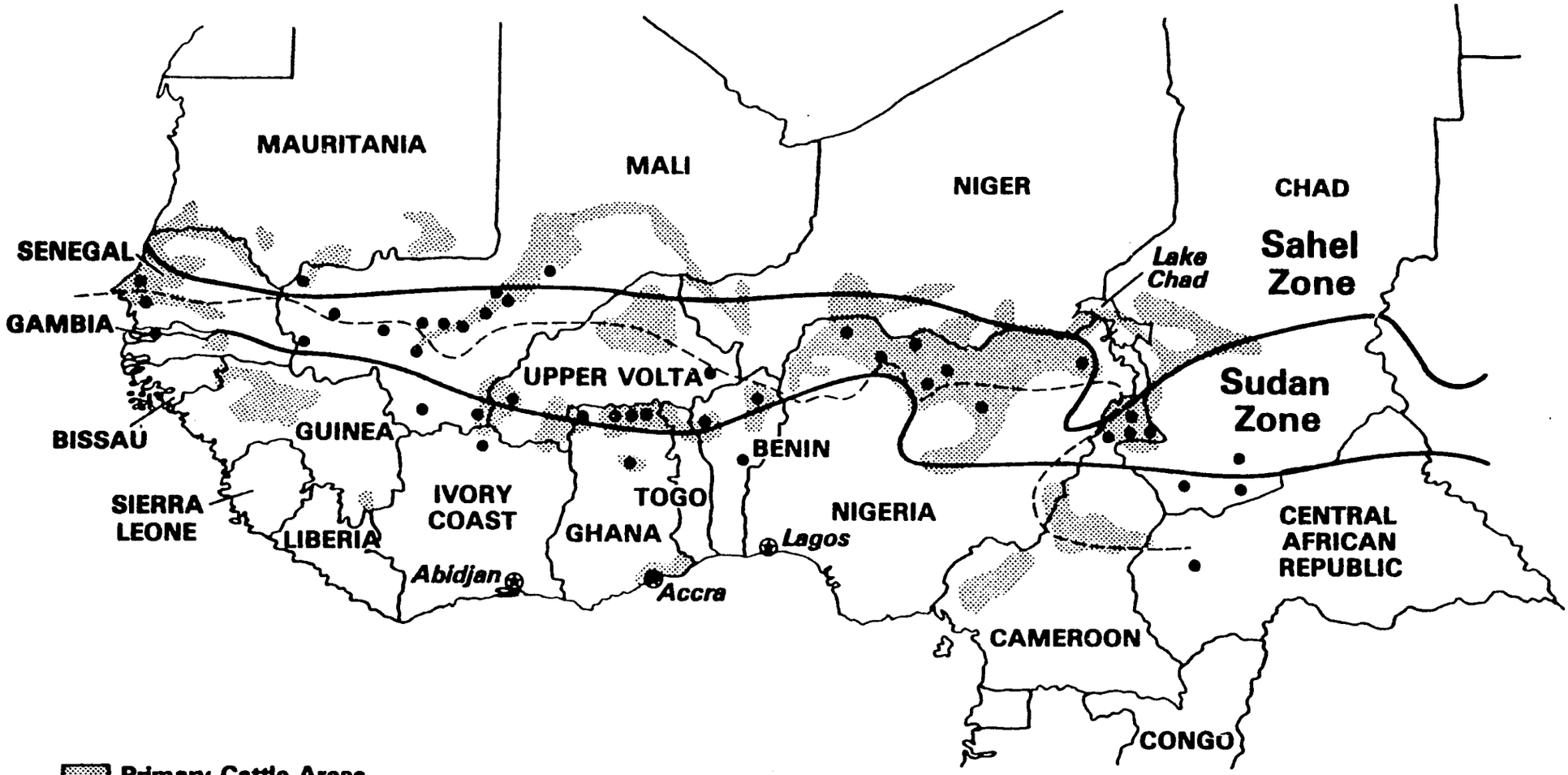
[1]Major project areas represented in Figure 1, major project entities, approximate dates of project implementation, and appropriate numbers of working oxen in each country are listed in Appendix I.

WEST AFRICA: ANIMAL TRACTION CENTERS IN RELATION TO CLIMATIC ZONES



Primary Cattle Areas

--- Approximate Northern Limit of Tsetse

• Centers of Animal Traction Activities

Production Zones After R.G. Harrison Church, 1966
Vegetation Zones After Matlock and Cockrun, 1974
Map by J. Sleeper, University of Maryland, 1977

approximation, possibly four per cent of all cattle marketed for slaughter in 1974 may have been older oxen.[1]

Number of Ox-Powered Farmers

Farmers who adopt bovine traction may be sedentary crop-dependent farmers, or sedentary, "semi-sedentary," or "semi-migratory" livestock-dependent farmers.[2] There may be a crop and livestock-dependent farmer population on the order of 50 million in West Africa.[3] Assuming that the average farm unit is comprised of five to ten persons, then there may be anywhere from five to ten million individual farms in the region. Of these, possibly 250,000, or only two to five per cent of all farmers, utilize oxen.

Level of Investment

Although the number of ox-powered farms in West Africa is extremely small, the approximate magnitude of farm investment in ox-drawn equipment and oxen is relatively substantial when compared to estimated investment in tractors in the region.

Approximate average investment during 1974-1976 in ox-drawn equipment and team might be on the order of $400 per

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[1]See pp. 67-70 below.

[2]Livestock and crop production are often practiced separately by different groups and according to eco-climatic zone (Appendix D). For a discussion of livestock-dependent farmers, see: 57; 168; 169.

[3]This estimate excludes the Gambia, Ghana, Togo and Benin (47, Appendix Table 2).

farm (Appendix P). This is a considerable amount compared to average per capita G.N.P. in the region of about $220 in 1974.[1] Assuming there are 250,000 farms, total investment might be on the order of $100 million. Assuming an average C.I.F. price for a tractor in a West African port is $10,000, then the 13,600 tractors in service in 1973 in West Africa might represent a level of investment of $136 million.[2]

Factors Contributing to the Expansion of Bovine Traction within the Sudanian Eco-Climatic Zone

There have been physical, economic and institutional factors which have favored the expansion of bovine traction within the Sudanian Zone.

Physical factors

Vegetation.--The Sudanian Zone is suitable for the animal-drawn plow because it has large expanses of flat dryland savannah with light bush and relatively few trees (1, p. 253). Complete destumping of the land (an extremely arduous task) is easier than in more humid zones.

Soils.--The friable (light) sandy to coarse loamy soils common throughout the Sudanian Zone are easier to plow than heavier clay soils, and are thus suited to a poor

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[1]Average of thirteen countries drawn from: 74, p. 12.

[2](42, I, p. 255). Average value of tractor imports in 1965 in several African countries was about $8,000 (99, Table I.6, p. 2-16).

power source.[1] Furthermore, deep tillage on these soils is traditionally avoided (125, p. 512). As outlined above, minimum tillage with the animal-drawn plow may improve soil water retention and soil porousity, permitting higher yields. Finally, because they are better drained and thus less apt to provide rainy season habitats for parasites, sandy soils may be more conducive to cattle husbandry (57, p. 67n).

Climate.--The short rainy season (three to five months) creates seasonal labor peaks and requires that cultural operations be rapid and timely to take advantage of the first rains. The dry climate also limits tse-tse infestation, permitting husbandry of trypano-susceptible (Zebu) or intermediate types of cattle. Because of their larger size, they are better suited for draft than the smaller, trypano-tolerant types.

Crops.--The major crops of the Sudanian Zone (cereals and groundnuts) are generally drought tolerant crops with short growing seasons and do relatively well in sandy soils. As field crops they lend themselves more readily to mechanized cultivation than to tree or root crops in the forest zone (1, p. 253).[2]

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[1]Although more than two oxen may be utilized to plow heavier clay soils, as on the floodlands in the Mopti region of Mali (125, p. 512).

[2]Although farmers have utilized the ox-drawn plow in yam cultivation in northern Benin (39, p. 98).

Economic factors

Supply of suitable cattle.--The physical proximity to a cattle production area has been cited as an important condition permitting the expansion of bovine traction in northern Nigeria (25, p. 18). It appears that the major areas of bovine traction activities have in fact evolved in or near major areas of cattle production within the Sudanian Zone (Figure 1).

Ownership of "wealth"[1]--A close examination of the literature suggests that many farmers who have adopted ox-cultivation make up a relatively wealthy minority--perhaps the top ten to fifteen per cent of farmers.[2] This appears to be due to four factors:

1) previous cattle ownership--Many farmers who have adopted bovine traction already owned or had easy access to cattle through kin or reciprocal relationships (32, I, p. 205 and II, p. 305; 58, p. 3; 176, p. 243 and 249). Farmers who own cattle may be considered to be wealthier than those who do not.[3] Furthermore, many programs do not offer credit for the purchase of cattle because the potential for fraud is

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[1]"Wealth" is defined here as the possession of productive resources (land, labor, capital).

[2]58, p. 45; 70, p. 152 and pp. 154-55; 108; 176, pp. 243, 253 and 262; 178; 180, p. 12.

[3]For many settled agriculturalists in West Africa, cattle serve the important economic function of storing wealth--something like a bank account (32, I, pp. 55-56). It would not be too much of an over-simplification to state that farmers who own cattle have bank accounts.

judged to be too great.[1] Whether previously owned or bought on credit, the evidence does suggest that the proportion of farmers owning cattle in areas of bovine traction activities (possibly one third) is higher than elsewhere in West Africa (Appendix K).[2]

2) larger land holdings.--Farmers with larger holdings have higher debt carrying capacities and lower feeding costs for oxen. Furthermore, small or fragmented holdings prevent efficient use of a team.[3]

3) larger labor force.--Under manual cultivation, the size of holding is generally a function of the family (or wage) labor force available at seasonal labor peaks (land preparation, planting, weeding, harvesting). As the plow has simply transferred the labor peak from land preparation to weeding, size of holding is dependent on the available family labor to weed the crops by hand (as it is under manual cultivation).[4]

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[1]Problems with fraud (and subsequent refusal of credit for the purchase of oxen) have been cited for programs in northern Cameroon (51, pp. 16-17), northern Nigeria (82, Annex 7, p. 2); central Mali (32, II, p. 316); and northern Ghana (76, Annex 2, p. 20).

[2]It is estimated that only about ten per cent of farmers in the Sudanian and Sahelian Zones depend upon livestock as their primary means of subsistence (47, Appendix Table 2). The number of crop-dependent farmers who own cattle is not known, but is believed to be small (Ibid., p. 19).

[3]It was found in northern Nigeria that ox-drawn wheeled tool bars are inefficient on fields of a length less than eighty-seven meters (99, p. 2-371). See also p.57n below and Appendix M.

[4]See p. 25 below.

4) "model farmer" approaches.--Donor and national agencies tend to concentrate their extension and support efforts on those farmers who already are more progressive and more willing to adopt innovations. These farmers tend to be more wealthy (149, pp. 33-35).

Cash crop production.--Animal traction programs have often been tied to the production of groundnuts or cotton. The cultivation of cash crops increases the farmer's cash revenues and permits him to pay off his loan more rapidly. Failure to tie animal traction to cash crop production has been cited as a primary factor for poor credit repayment (39, p. 54).[1] Also, subsistence farmers are more willing to adopt innovations for cash rather than food crops (119, p. 310; 147, pp. 344-45).

Institutional factors (support services)

Extension support.--Extension and training programs (plowing schools) have been extremely important to train farmers in the proper use and care of equipment and animals.[2] This is particularly true for farmers who lack experience in cattle husbandry (see: 21; 27; 145). However, the high cost of extension and other related support activities has limited

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[1]However, the over-emphasis on cash crop production technology to the detriment of food crops in the C.F.D.T. (French Company for Textile Development) programs in Mali and Cameroon has created other problems (32, II, pp. 332-33; 51, p. 23). Rather, the approach should encompass all crops.

[2]The Michigan State University mechanization survey of animal traction in tropical Africa also found this to be true (99, p. 1-12).

their benefits to only a few farmers, and these in cash crop zones. Closely related to training programs are community-oriented activities which reinforce the techniques learned in training, such as plowing schools.[1]

Veterinary support.--Veterinary support is extremely important because of the special health hazards associated with keeping the animals on the farm year around. Veterinary support has also been extremely important to aid farmers who lack experience in cattle husbandry.[2]

Availability of credit.--Farmers need (medium-term) institutional credit for the purchase of oxen and equipment, an extremely high capital investment in relation to their low cash resources.[3]

Research and design.--It is only since 1950 that implements have been designed for West African conditions (166, p. 113).[4] Most of the animal traction programs that have

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[1]These were important in northern Benin (39, p. 102). In Uganda, where ox-plowing has been well-developed, plowing matches were seen as very important in maintaining high standards of technical performance among farmers (89, p. 287).

[2]See p. 55n below. An Ivory Coast survey recommended that veterinary posts be located within at least thirty kilometers of bovine traction areas (8, p. 51).

[3]Because West African systems of land tenure prevent farmers from using their land as equity (61), credit programs often require "in-kind" commitments from farmers, such as provision of one ox, yoke and harness, etc.

[4]E.g., multi-purpose tool bars, reversible plows, groundnut lifters, light weight cultivators and light weight ridging plows for one ox (see: 99, Chapter III). Ox-drawn equipment in West Africa must be: lightweight, to fit smaller oxen; sturdy, because farmers are often poorly trained and soils are often not completely cleared; simple, to permit easy operation as well as repair by local village blacksmiths; and inexpensive, because West African farmers have few cash resources (100, p. 18).

not succeeded in West Africa have not been solidly supported by local research and development on the full range of animal equipment (40, p. 25n; see also: 39, p. 99; 149, p. 15).

Equipment repair.--Village level maintenance and repair capabilities have been judged as an important factor in permitting the expansion of animal traction in some areas.[1]

Supply of inputs and marketing of outputs.--One of the stated reasons for the success of ox-cultivation of cotton in Mali is that the C.F.D.T. markets equipment and supplies to the farmer and markets cotton from him (32, II, pp. 331-32). Related to assured markets for production increases are pricing policies.[2]

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[1]An F.A.O. expert in Upper Volta has noted that any area where there are fifty plows within a twenty mile radius can support a local blacksmith operation (180, p. 20). For an excellent description of village-level blacksmiths in Upper Volta and Niger, see: 148.

[2]Government policies of announcing official buying prices before the growing season has been cited as favorable to the expansion of ox-cultivation in Benin and the Gambia (39, p. 103; 176, p. 246).

CHAPTER III

INCREASE IN CASH FARM INCOME FROM THE ADOPTION OF BOVINE TRACTION

Review of Available Farm Management Data

Yield increases

Yield increases from cultivation effects and/or more timely cultural operations realized by farmers adopting bovine traction may be as high as twenty-five per cent for groundnuts and thirty per cent for millet and sorghum in some areas (Table 1). However, elsewhere yield increases have not been significant. Failure to realize yield improvements seem to be due primarily to the inability of the farmer to overcome the weeding constraint, either because of the lack of proper weeding attachments, lack of training of the animals, lack of skill on the part of the farmer, or insufficient on-farm labor to weed the crops by hand. The quality of land preparation may also be mediocre because the animals are in poor condition after dry season grazing or because the land is inadequately de-stumped. Failure to plant on time may also depress yields.[1]

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[1] It has also been indicated that soils with more than eighteen per cent clay content may not permit yield responses to plowing (14, p. 225).

TABLE 1

ESTIMATED YIELD AND AREA INCREASES PER UNIT FARMER FROM ADOPTION OF ANIMAL TRACTION[a]

Region	Date Surveyed	Number Farmers Surveyed	Crop[b]	Index of Area Cultivated[c]	Index of yields[c]	Cultural Operation	Source
Atakora	1974	--	rice	--	145-180	land preparation	(g)
Gambia	1966	--	m/s	142	106	land preparation	(h)
			g'nuts	124	95	land preparation	
	1959-1975	--	all	200	102	land preparation	(i)
S. Mali	1974	--	m/s	--	130	land preparation	(j)
			g'nuts	--	120	seeding	
N. Nigeria[d]	--	--	m/s	--	127	land preparation	(k)
			g'nuts	--	142	land preparation	
			cotton	--	221	land preparation	
Sine Saloum	1971	260	g'nuts	--	133	land preparation	(l)
			millet	--	133	land preparation	
			sorghum	--	168	land preparation	
Kaolack	1959-1964	50	all	124	--	seeding and/or land preparation[e]	(m)
Fada N'Gourma	1976	12	g'nuts	100	150	land preparation[f]	(n)
			sorghum	100	125		
			maize	100	125		
			millet	100	125		
			rice	100	120		

Selected Averages:

Index of Area Cultivated (Gambia, 1959-1975 and Kaolack, 1959-1964); 104/year
Index of Yields (excluding northern Nigeria): groundnuts: 125
millet/sorghum: 130

TABLE 1 (Continued)

a) Some reports do not specify whether farmers who adopted animal traction also increased their utilization of improved cultural practices (thinning), more frequent weeding), improved seed varieties or mineral fertilization.

b) m/s = millet and sorghum.

c) Unplowed = 100.

d) Yield effects are due to both manure application as well as plowing on farms adopting bovine traction.

e) Horse- or ox-drawn.

f) Donkey or ox-drawn.

g) (Benin) C. K. Eicher, et al., An Analysis of the Eastern O.R.D. Rural Development Project in Upper Volta: Report of the M.S.U. Mission, Working Paper No. 9, African Rural Economy Program, Department of Agricultural Economics, Michigan State University (East Lansing, 1976), p. 98.

h) J. M. Peacock, Report of the Gambia Ox-Plowing Survey, Wye College (Wye, 1966), as cited in: C. K. Kline et al., Agricultural Mechanization in Equatorial Africa, Institute of International Agriculture, Michigan State University (East Lansing, 1969), p. 2-87.

i) E. R. Morss, Strategies for Small Farmer Development: An Empirical Study of Rural Development Projects, (II Vols.; Boulder Colorado: Westview Press, 1976), 246 and II, 32-37.

j) I.R.A.T. observations in the O.A.C.V. project area, as cited in: I.B.R.D., Appraisal of Integrated Rural Development Project, Mali, Report No. 340a-M.L.I. (Wash., D.C., May 13, 1974), Annex 3, p. 5.

k) J. G. M. King, "Mixed Farming in Northern Nigeria," Empire Journal of Experimental Agriculture, VII, No. 27 (1939), p. 274.

l) (Senegal) M. Sargent, I.R.A.T.: Research on Cereal Production Technology in Senegal and Upper Volta, U.S.A.I.D. mimeographed report (Wash., D.C., September 24, 1974), p. 31.

m) (Senegal) M. Garin, "Bilan Economique de la Culture Attelee dans Quatre Villages du Laghem Oriental," Oleagineux, XXI, No. 6 (1966), Fig. 3, p. 367. Area increases computed from Fig. 3 can only be approximations.

n) (Upper Volta) T. Zalla, A Proposed Structure for the Medium-Term Credit Program in the Eastern O.R.D. of Upper Volta, Working Paper No. 10, African Rural Economy Program. Department of Agricultural Economics, Michigan State University (East Lansing, February, 1976), pp. 9-12.

There is little evidence that farmers have adopted the practice of plowing under, because the opportunity cost of land and/or labor devoted to the production of a non-edible crop may be too high (34, p. 30; 149, p. 13), and because this activity requires a prohibitive level of tractive power.[1]

Increase in area cultivated

It is extremely difficult to arrive at any typical rate of increase in area cultivated on farms adopting bovine traction. It appears that bovine traction has transferred the labor demand peak from land preparation to weeding in some regions (99, p. 2-362).[2] Thus, as under manual cultivation, the area farmed under bovine traction depends upon the amount of on-farm family (or wage) labor available to the farmer for weeding (108).[3] For this reason, static comparisons of farm size, such as the Wye College survey in the Gambia (Table 1), simply suggest that farmers who adopted bovine traction had larger families and already cultivated larger holdings than manual farmers (176, p. 253). Farms in Mali (comprised of about ten persons) increased the size of their sorghum fields by about twenty per cent before the manual weeding constraint was reached (93, p. 287 and 302).[4] However, no

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[1]See p. 52 below.

[2]Another study found that it is transferred to the harvesting period (5).

[3]This is in spite of evidence which indicates that the plow has been adopted by family production units experiencing a shortage of labor (6, p. 73; 21, p. 7; 57, p. 44n; 176, p. 244).

[4]Of the dozen farmers interviewed who adopted animal traction in Upper Volta (Table 1), only one had increased his

time period over which this increase occurred was indicated. The twice-fold increase on farms in the Gambia from 1959 to 1975 and the twenty-four per cent increase on farms in Kaolack, Senegal, from 1959 to 1964 (Table 1) work out to an average rate of increase in total farm size of about four per cent per year.[1] However, there is no indication that this rate of increase is any different from annual increases in area cultivated on manual holdings.[2]

Another factor which may lower the labor saved (and subsequent increase in area cultivated) is that it usually takes two to three persons to handle a pair of oxen (32, I, p. 112; 180, p. 3; 102, p. 246). This is a result of poor training on the part of both farmers and animals. Also, animals may only be able to work a few hours a day and offer limited tractive power because of poor health, poor dry season nutrition, improper harnessing, etc.

Increased relative population density and "communal" systems of land tenure which promote fragmented and dispersed holdings may also limit the farmer's ability to expand (contiguous) area under cultivation (61). Finally, expansion of

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hectarage in the last ten years and had accompanying changes in family size (180, p. 9).

[1]An examination of the S.A.T.E.C. (Society for Technical Aid and Cooperation) project review in de Wilde et al., suggests that farmers with donkey-drawn cultivators may have increased area under cultivation by fifteen to twenty per cent over a three year period, or an annual rate of four to six per cent (32, II, pp. 383-84).

[2]The Kaolack study (Table 1) indicated that manual farmers also increased the size of their (smaller) holdings by about the same annual rate (53, Fig. 3, p. 367).

area cultivated by the plow is dependent upon the ability of the farmer to adequately clear or destump his land.[1]

Manure production and utilization

The stall-production of manure has not been generally adopted by ox-powered farms in West Africa because of the dry season feeding constraint (32, II, p. 320; 108; 163).[2] Consequently, little manure is stall-produced over a seven to nine month period. In northern Nigeria, a pair of mature male Zebus on a bedding of cereal straw, weeds and coarse bush grass was estimated to produce five metric tons of manure per year (98, p. 274).[3] This is estimated to be just sufficient to allow continuous cropping of up to one hectare sorghum without the usual three-year fallow (30, pp. 131-134; see also: 125, p. 513). It is also difficult to keep oxen in stables or enclosed areas when available pasture is far from cropping areas (21, p. 9). Furthermore, as under the traditional system of paddocking cattle, manure spread on

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[1]In Senegal, it requires 160 days for one man to clear one hectare of bush ("jujubier") (123, I, p. 12), while complete de-stumping requires 200-300 days (14, p. 222).

[2]See pp. 56-62 below.

[3]Other reports from northern Nigeria and Upper Volta indicate that a pair of mature animals produces about five metric tons per year (4, p. 130; 26). This low amount is likely due to the requirement that animals be grazed for some part of the year away from the farm. In Senegal, I.R.A.T. indicates that two 500 kg. animals produce about five metric tons of manure (with bedding) over five months inclusive of the rainy season (66, p. 603). Elsewhere, they indicate that two 400 kg. animals kept in stalls year around produce about fourteen tons excrement free of bedding (135, p. 837). In the US, a pair of 400 kg. finishing steers produces about the same amount (41, p. 487).

the fields loses some of its value from oxidation, distribution by termites, and dispersion of the fine, dried particles by the wind (66, p. 595; 602; 104; 109).[1] Finally, there is increased danger from parasitic infection when the animals are penned in stalls over the wet season (32, II, p. 320).

For these reasons, it appears that farmers perceive the cost of the considerable labor devoted to construction of a manure pit and collection and distribution of manure in the fields to be greater than additional output from its application (32, II, pp. 319-22; 92, p. 311).[2]

Custom or rental services

Custom services or rental of equipment and animals for land preparation, mechanical seeding, groundnut lifting and carting provide extremely important cash revenues to ox-powered farms who do not have sufficient on-farm resources to feed their team (102, p. 256)[3] or who cannot expand area cultivated on their own farms because of the weeding constraint (156, p. 445).

However, it is very important to note that increased

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[1]There are no reports indicating that manure is plowed under after application in an attempt to preserve its value.

[2]It was also indicated that farmers in Sukumaland, Tanzania, believed that the additional output from manure utilization did not justify the additional labor required to produce and apply it (32, II, pp. 425-426).

[3]E.g., it was noted in northern Nigeria that few of the ox-powered farmers in a village near Katsina (receiving about 700-725 mm rainfall) could afford plows without hiring them out because of the need to buy feed for working oxen during the cropping season (69, p. 307).

custom cultivation by a farmer who depends upon it as a primary source of revenue appears to be limited by the requirement for timely cultural operations. A farmer who rents his own plow and team or a farmer who must rent or borrow a team often cannot take the best advantage of the first rains.[1] Evidently, the general expansion of custom services is limited by the number of manual farmers demanding them and the number of other ox-powered farmers supplying them in any particular region.

The evidence indicates that the demand for ox-carts is high in areas where bovine traction is well-developed (11, p. 338; 32, II, pp. 314-15; 44, p. 202; 99, p. xii; 103, p. 36). However, it may be that the cart is valued more for its ability to earn extra cash revenues for the farmer than for hauling manure to the fields.[2]

On-farm beef production

Few ox-powered farms appear to practice the on-farm raising of cattle because of the dry season feeding constraint. However, working oxen generally receive a high level of feed-

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[1]E.g., in the C.F.D.T. program in Mali, it was observed that farmers who obtained oxen through kinship ties did so at the expensive of early planting of the cotton (32, I, p. 206). Plow-owners in northern Cameroon were observed to plant their rice too late because they were renting out their plows to other farmers (21, p. 9). This problem has also been mentioned for farmers who share or hire oxen in northern India (68, pp. 220-221).

[2]The C.F.D.T. in Mali only sold carts to those families who had constructed manure pits. Some families constructed manure pits to obtain a cart, then abandoned them (92, p. 311).

ing and management than slaughter cattle.[1] Some farmers "feed out" older oxen, although there is little data as to numbers.[2] The evidence clearly indicates that working oxen are in high demand by local butchers and small unit feeders.[3] This is likely due to their greater size and weight in comparison to slaughter cattle.[4]

It would thus appear that the beef production side of bovine traction is an important source of capital regeneration for the ox-powered farmer.[5] Oxen appreciate in value as slaughter beef until full maturity (anywhere from five to eight years, depending upon breed). At that point their value slowly declines. It appears that many farmers retain their animals beyond maturity before replacing them (Table 2). This may indicate that revenues from animal-powered cultiva-

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[1]Some ox-powered farmers in northern Benin were able to maintain their animals over the dry season without the usual twenty-five per cent weight loss. Consequently, the animals were 50-100 kg heavier and visibly healthier than traditionally herded animals (39, p. 100).

[2]See p.76 n below.

[3]In northern Cameroon, local butchers were reported to "covet" working oxen (57, p. 23; see also: 62, p. 317). Reports from northern Nigeria indicate that selling older oxen is quite profitable (60, p. 170; 150, p. 48).

[4]The structure of demand for cattle and consumer preferences would also explain why they are in high demand. See Chapter V.

[5]It has been noted that capital generated from the sale of oxen in northern Nigeria was one reason why fewer ox-powered farmers in that country had to depend upon credit for replacement of oxen, plows and other equipment (102, p. 238).

In areas of Zaire where sandy soils and lack of tse-tse permitted the development of ox-cultivation, farmers had only to amortize equipment since oxen retained their value as slaughter beef (96, p. 340).

TABLE 2

ESTIMATED NUMBER OF YEARS WORKED AND INCREASE IN VALUE OF OXEN

Country	Region	No. Years Worked	Age Sold	Increase in Value[a]	Source
Benin	Atakora	2-3	6	200	(b)
Ivory Coast	Korhogo	4-5	6-7	-	(c)
Senegal	S. Saloum	4-5	6-7	-	(d)
Upper Volta	E. ORD	6-8	10-12	125	(e)
Mali	Koulikoro	5	8	-	(f)
Chad	Mandoul	5	8	100	(g)
Nigeria	Northern	6	10	167	(h)
	(average range)	4-5	7-8		

a) Purchase price = 100.

b) C. K. Eicher et al., An Analysis of the Eastern O.R.D. Rural Development Project in Upper Volta: Report of the M.S.U. Mission, Working Paper No. 9, African Rural Economy Program, Department of Agricultural Economics, Michigan State University (East Lansing, 1976), p. 100. Some farmers work a team for only two years and sell them at a net profit of $85 (C. Uzureau, "Animal Draft in West Africa," World Crops, XXVI, No. 3 (1974), p. 113).

c) Personal communication from J. Staatz to D. S. Ferguson.

d) I.R.A.T., Synthese des Activites et Resultats, 1970, au Senegal et sur la Rive Mauritanienne, (Bambey, Senegal, October, 1971), p. 131. Farmers netted FCFA 15-20,000 ($60-80) pair at sale.

e) T. Zalla, A Proposed Structure for the Medium-Term Credit Program in the Eastern O.R.D. of Upper Volta, Working Paper No. 10, African Rural Economy Program, Michigan State

Table 2 (Continued)

University (East Lansing, February, 1976), p. 13; and C. Malcoiffe, "Note sur la Gestion et l'Evolution des Troupeaux Bovins des Stations I.R.A.T. de Haute-Volta (1963-1971)," Agronomie Tropicale, XXVII, no. 5 (1972), p. 610.

f) Based upon a census of 3,563 working oxen by the O.A.C.V., which found 81 per cent of the animals aged four to eight years and 15 per cent aged nine to 15 years. The remaining four per cent were three year olds. Monsieur Cisse, "Note sur le Sous Projet Elevage de L'O.A.C.V. (Campagne 1975/1976)," Operation Arachide et Cultures Vivrieres, Sous Projet Elevage, Koulikoro, Government of Mali mimeographed report (May, 1976), 6 p.

g) G. Tacher et al., "Les Bovins de Culture Attelee au Tchad," Machinisme Agricole Tropicale, no. 29 (Janvier-Mars, 1970, pp. 16-18.

h) C. K. Laurent, "The Use of Bullocks for Power on Farms in Northern Nigeria," Bulletin of Rural Economics and Sociology, III, No. 2 (1968), p. 238.

tion (which depend a great deal upon how well the animals are trained) are greater than the potential revenues from sale of the oxen at maturity.[1] This is likely due to high replacement costs, i.e., training and marketing. Farmers may have difficulties in acquiring younger replacements suitable for draft, training them (and keeping them trained), and marketing them in a timely manner.[2] Unwillingness to turn over teams more rapidly would also suggest that there is a shortage of supply of young replacements suitable for draft.

Indicative Increase in Net Cash Income--The Example of Senegal

It is evident that bovine traction can increase cash farm incomes, but data from actual farm surveys as to the extent to which it does is generally inadequate. A *pro forma* cash-flow budget for a farmer in the Sine-Saloum region of Senegal gives an idea of the magnitude of increase in cash revenues from the adoption of bovine traction. The cash-flow format was used because it permits examination of the incidence of cash costs and cash revenues over the working period of a team of oxen on the farm. An examination of the timing of cash revenues (profit and depreciation) was considered necessary since the

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[1]In the Eastern O.R.D. project in Upper Volta, it was noted that few ox-powered farms would sell a trained ox at maturity, even though at this point its market value is the highest. However, there were marketing problems for older oxen in the region (180, pp. 7-8).

[2]In northern Benin, it appears that an effective extension program which emphasized the training of animals by the farmers themselves and a marketing program for older oxen enabled farmers to replace their animals every two or three years (Table 2). There, farmers were able to sell their animals at double their purchase price (39, pp. 99-101).

timing of increases in income is an important factor in farmers' decisions whether or not to adopt innovations. Certain assumptions (increases in yields and area cultivated, etc.) were based upon the above review of farm management data, although an I.B.R.D. (World Bank) budget has been used as a rough guideline (79, Annex 16, Tables 1-6).[1]

Introduction to the Sine-Saloum Region

Bovine traction has long been promoted by the French in Senegal. Most of the mechanized farmers and most of the country's working oxen are located in the Sine-Saloum Region, which produces about half of the country's groundnuts. Annual rainfall is 750-900 mm over a three to four month period. Soils are generally sandy to coarse loamy (14, p. 410).

Assumptions for an indicative budget

Yields.--The indicative budget in Table 3 is an attempt to compare annual cash costs and revenues of a farm under manual and ox-powered cultivation. Assumed yields under manual cultivation (Year 0) are average yields for 1974 recorded in the F.A.O. Production Yearbook.[2] Assumed yield effects of plowing under ox-powered cultivation (Years 1-4) are based upon Table 1: twenty per cent for groundnuts and thirty per

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[1]The only data drawn directly from the I.B.R.D. budget are farmgate prices and input costs. Conclusions drawn are therefore the responsibility of the author. Other budget data are listed in Appendix P.

[2]The traditional average for the region is 800 kg/ha groundnuts and 400 kg/ha millet (79).

TABLE 3

INDICATIVE ANNUAL CASH REVENUES AND CASH COSTS FOR A FARM ADOPTING BOVINE TRACTION[a]

Crop / Year	0	1	2	3	4
Groundnuts	3.0	3.15	3.31	3.48	3.65
Millet	3.0	3.15	3.31	3.48	3.65
(total)	6.0	6.30	6.62	6.96	7.30
(fallow)	(7.0)	(6.70)			
Value of Production[b]		(Francs C.F.A.)			
Groundnuts	105,825	133,340	140,112	147,308	154,505
Millet	45,000	61,425	64,545	67,860	71,175
Custom-carting revenues	--	10,390	10,390	10,390	10,390
Custom-seeding revenues	--	1,842	1,842	1,842	1,842
Sale of oxen fourth year[c]	--	--	--	--	88,440
(total)	150,825	206,997	216,889	227,400	326,452
Value of Subsistence and Taxes[d]	68,003	68,003	68,003	68,003	68,003
Gross Cash Revenues	82,822	138,994	148,886	159,397	258,349
Production Costs					
Downpayment (25% value of investment)[e]	--	31,740	--	--	--
Debt service (3 yrs @ 7.5% p.a.)	--	38,882	36,501	34,121	--
Repairs (10%)	--	7,936	7,936	7,936	7,936
Hand tools	1,000	1,000	1,000	1,000	1,000
Millet seeds (6 kg/ha)	540	567	596	627	657
Groundnut seeds (100 kg/ha)	12,450	13,073	13,737	14,442	15,148
Oxen work ration[f]	--	800	800	800	800
Veterinary drugs	--	150	150	150	150

Purchase of oxen fourth year[c] (total)	--	--	--	--	47,600
	13,990	94,148	60,720	59,076	73,291
Net Cash Revenues (profit and depreciation)	68,832	44,846	88,166	100,321	185,058
U.S. $ (rounded)[g]	($275)	($179)	($353)	($401)	($740)
Index of Cash Revenues (Year 0 = 100)	100	65	128	146	269

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a) Estimated farmgate prices, taxes and input costs (except value of investment) are drawn from: I.B.R.D., Appraisal of Sine-Saloum Agricultural Development Project, Senegal, Report No. 661a-S.E. (Wash., D.C., May 5, 1975). Credit terms and value of investment are drawn from: M. Sargent, I.R.A.T.: Research on Cereal Production Technology in Senegal and Upper Volta, U.S.A.I.D. mimeographed report (Wash., D.C., September 24, 1974). Custom revenues are based on estimates in: M. Garin, "Bilan Economique de la Culture Attelee dans Quatre Villages du Laghem Orientale," Oleagineaux, XXI, No. 6 (1966), pp. 365-70. Yields in Year 0 are drawn from the F.A.O. Production Yearbook for 1974.

b) Crop yields and prices:

	Year 0 yields kg/ha	Years 1-4 yields kg/ha	Index of yields	1974 estimated farmgate prices FCFA/kg
Groundnuts	850	1,020	120	41.5
Millet	500	650	130	30.0

c) Purchase of oxen fourth year: 238 kg @ FCFA 100 X 2
Sale of oxen fourth year: 402 kg @ FCFA 110 X 2

d) Value of subsistence and taxes (FCFA):

Family consumption (9 persons)	
Millet (220 kg/person)	59,400
Groundnuts (15 kg/person)	5,603
Taxes (FCFA 500/working adult)	3,000
	68,003

e) Value of investment (FCFA):

"Arara" tool bar	25,000	
hoe	7,700	
two one-row seeders	24,860	
yoke	1,800	
cart (without sides)	20,000	
(sub-total)	79,360	($317)
oxen	47,600	($190)
(total)	126,960	($507)

f) Oxen work ration: 100 g/day protein/mineral concentrate for 200 days @ FCFA 40/kg.

g) FCFA 1 = $0.004.

cent for millet.[1] No yield effects from either manure application or mineral fertilization were assumed. Plowing under does not appear to be widely practiced. Although improved varieties of groundnuts (28-206) and millet (Souna II) appear to be widely utilized in the region, their full yield potential is only realized with mineral fertilization (149, pp. 5-8).

Area under cultivation and crop mix.--Area under cultivation in Year 0 is six hectares, and is assumed to increase at five per cent per year during Years 1-4.[2] This would correspond to an approximate twenty per cent increase in total area cultivated over four years.

The recommended crop mix is an equal amount of land in cereals and groundnuts, which permits a rotation of groundnuts-cereals-groundnuts-cereals.[3]

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[1]For the purpose of this exercise, it is assumed that these yield increases are maintained for a period of four years. However, this would not likely to possible without manure or fertilizer utilization, and because total holding size (thirteen hectares) does not permit three-year fallows. Even if full fallowing were possible, it is unlikely that the thirteen hectares are completely destumped (149, p. 20).

[2]S.O.D.E.V.A. has determined that an ox-powered farm should have at least eight to twelve hectares, of which six are cultivated yearly (149, p. 27; see also: 123). Assumed total farm size is thirteen hectares.

[3]I.R.A.T. has proposed that groundnuts should be followed by cereals rather than another year of groundnuts because of risks of soil erosion and pest attacks (149, p. 32; 79). Currently, the ratio of groundnuts to cereals is about 1.5:1 (79). This crop mix would increase annual value of production by about seven per cent more than indicated in Table 3.

Custom/rental services.--Cash revenues from custom carting and seeding are based upon actual average revenues received by farms in the southern Kaolack region.[1]

Value of investment.--Many farms in the region already own a pair of bulls and already utilize horse-drawn seeders and cultivators (Ibid., p. 28). However, in order to obtain a comparison between traditional and ox-powered cultivation, it was assumed that the farmer adopting bovine traction purchases his oxen (as well as equipment) on medium-term credit and splits his team to use them individually for seeding and weeding.[2] Total cash cost of oxen and equipment ($507) is slightly less than the typical investment requirement for oxen and the complete line of equipment ($600) in the region (165, p. A-26).

Production costs.--Following the I.B.R.D. budget, repairs and maintenance were charged at ten per cent of equipment cost. Costs for normal maintenance of the oxen (crop residues, etc.) were not available. Depreciation and mortality risk were not charged since these are expense items without associated expenditure.

Value of subsistence.--A typical farm adopting bovine

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[1]FCFA 6,000 from custom carting in 1960 and FCFA 1,150 from seeder rental in 1962. To represent 1974 price levels, these figures have been increased by four per cent per annum, which is the approximate average annual increase in the Consumer Price Index for the period 1962-1974 (86).

[2]This is in fact suggested by Sargent (p. 16) in order to reduce the capital investment requirement for farmers adopting ox-powered cultivation who would otherwise utilize a horse for these operations.

traction in the region might have nine persons (149, p. 28). Annual family consumption as charged at 220 kilograms millet and fifteen kilograms groundnuts per family member.[1]

Purchase and sale of oxen.--It is assumed that the team is put to work at age three (thirty-six months) and sold at age seven (eighty-four months).[2] Average annual liveweight gains are about forty kilograms.[3] Approximate 1974 prices per kilogram for purchase and sale of team represent a price differential of only about ten per cent and an increase in total value of the team of about eighty-five per cent (compare with Table 2).[4]

Discussion

Magnitude and incidence of increase in net cash revenues.--Under best estimates of average yield and area increases from the adoption of ox-cultivation, a $500 package for oxen and equipment with a three-year pay-back period does not sub-

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[1]At about 3,400 Calories per kg millet and 3,800 Calories per kg groundnuts, this represents an equivalent of about 2,200 Calories per day, which was the approximate daily per capita consumption in Senegal during the period 1964-1966 (43, pp. 480-85; 90, Table 6-9, p. 160). In order to represent annual subsistence consumption in small farm budgets in West Africa, the I.B.R.D. generally charges 180-250 kg cereal per family member.

[2]Required weight (and therefore cost) of the team is somewhat under-estimated.

[3]This compares to annual gains of sixty to eighty kilograms of working oxen on pilot farms in the region as reported by S.O.D.E.V.A. (cited in 79, Annex 5, p. 2). Annual liveweights for the team are drawn from Table 7, p. 89.

[4]See Chapter V.

stantially increase cash revenues until the third or fourth year of adoption.[1] These findings are consistent with the literature: most animal traction programs in West Africa take three years to show reasonable returns to farmers (149, p. 56).

	0	1	2	3	4[a]
Value of production	$603	$827	$867	$909	952
Subsistence and taxes	272	272	272	272	272
Gross cash revenues	331	555	595	637	680
Production costs					
downpayment	-	127	-	-	-
debt service	-	156	146	136	-
other	56	93	96	100	103
	56	376	242	236	103
Net cash revenues[b]	$275	$179	$353	$401	$577
Cash returns/cash outlay[c]	5.9	0.7	1.4	1.7	7.4

a) Year 4 excludes cash revenues ($354) and cash costs ($191) from replacement of the team.

b) Gross revenues less production costs.

c) Incremental gross cash revenues divided by incremental production costs.

Failure to substantially increase production the first few years is in part due to the weeding constraint:[2]

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[1] It is widely held that expected increases in income from the adoption of innovations must be conspicuous, immediate and certain before they will be widely adopted by small peasant farmers in Africa and elsewhere (32, I, pp. 60-64; 147, p. 346 and p. 349; 174). One study of smallholder improvement programs in eastern Nigeria has indicated that farmers must expect an incremental cash revenue/cash outlay ratio of at least 2:1 (50, p. 582 and p. 587).

[2] It often takes at least three years for a farmer to learn how to correctly use animals and equipment for weeding, as well as other operations (32, II, p. 383).

area cultivated	net cash revenues 0	1	2	3	4[a]
5% p.a. increase	$275	$179	$353	$404	$577
10% p.a. increase	275	214	426	518	748
20% p.a. increase	$275	$283	$585	$793	$1,440

a) Year 4 excludes net cash revenues from sale of the oxen ($163).

Removal of the weeding constraint requires better farmer training in the correct use of equipment, as well as confidence and skill in operation of his team. This requires increased extension and training support services. It also requires a high level of management and training of the animals, which depends a great deal upon removal of the animal health and dry season feeding constraints (discussed in the next chapter).

Failure to increase production would also suggest that other yield-increasing technologies (mineral fertilization, chemical plant protection, etc.) should be promoted along with bovine traction (see: 103, p. 38). Further farm management research into the problem of why farmers refuse to adopt the stall production and utilization of manure is also needed. Inadequate manure production and inability to perform plowing under are also related to the animal health and dry season feeding constraints.

Magnitude of investment required.--Failure to substantially increase cash revenues the first few years is also related to the very high initial investment requirements for equipment and team (103, p. 37; 176, p. 247). Down payment

for equipment and team ($127) is equal to more than forty per cent of the manual farmer's net cash revenues ($275), while total cost of the investment ($507) is almost double net cash revenues.[1] This would indicate that longer-term credit arrangements would be required for those farmers who do not own oxen.[2]

Importance of increase in value of the team.--Potential for income generation from sale of the oxen becomes evident when gross value-added in Year 1 and Year 4 is computed (below). It becomes immediately apparent why some farmers do not hesitate to sell off their oxen when output from ox-powered cultivation (increases in yields and area) is not as

	Year 1		Year 4	
Gross value of production from yields/area cultivated under manual cultivation:	$603	73%	$603	46%
Value-added from increase in yields/area cultivated:	$175	21%	300	23%
Value-added from custom revenues:	$ 49	6%	49	4%
Value-added from sale of oxen:	$ -	-	353	27%
(total)	$827	100%	$1,305	100%

[1]Obviously, the convention of charging consumption expenditure (value of subsistence) used in the budget does not accurately estimate net cash farm revenues or debt carrying capacity under manual cultivation. U.S.A.I.D. estimates actual net annual cash income for a typical farm in the groundnut basin with six hectares and four working adults to be about $28 (FCFA 7,000) (165, p. A-26).

[2]Previous ownership of a pair of bulls would increase net cash revenues in Year 1 by $177, increasing the cash returns/cash outlay ratio from 0.7 to 1.1.

great as anticipated.[1] Gross value-added from increases in yields and area under cultivation in Year 4 ($300) is less than value-added from sale of the oxen ($353).

Ox-powered farmers who have access to major markets may obtain higher price differentials for their oxen then that assumed in the indicative budget. Stall-finishing the animals could put them in even higher weight and value categories.[2]

Importance of custom revenues.--Evidence from elsewhere in West Africa indicates that the proportion of custom revenues (four to six per cent) in the ox-powered farmer's gross revenues may very well be underestimated.[3] Higher revenues from custom work would make increases in net cash revenues higher than the indicative budget would indicate.

Adoption may be due to other factors.--Finally, if adoption of bovine traction does not substantially increase

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[1]The "premature" selling of oxen before realizing full production increases from the adoption of ox-cultivation has been cited as a problem in Cameroon (51, pp. 23-24) and Senegal (85, p. 264; 135, p. 850; 154).

[2]See Chapter V. For example, if the Senegalese ox-powered farmer could obtain a price differential of thirty per cent (and thus selling his team at FCFA 130/kg), profit net of the replacement team would be $228 instead of $163. Farmers may very well have access to strong markets, as one Senegalese expert has recently complained that "farmers do not use their teams for work" but sell them "because cattle-feeding is more profitable (85, p. 121)."

[3]E.g., a survey (102) in 1968 in the Gusau region of northern Nigeria estimated that one farmer with a pair of oxen could ridge ten 1.6 hectare (four acre) farms, or a total of sixteen hectares within a permitted six week period. They charged two Nigerian Pounds ($5.60) per 0.4 hectare (one acre). Thus, theoretically, an ox-powered farmer could earn over $200 from custom revenues alone. See also: 69, pp. 307-308.

net farm cash revenues from production increases, then adoption may be due instead to: social gains, such as prestige, relief from drudgery of manual labor with the hoe, or increase in leisure time;[1] or increase in off-farm or other income from labor freed by animal-powered cultivation.

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[1]Studies in East Africa have suggested that the adoption of bovine traction is not due to the gain in higher revenues but to relieve the farmer of drudgery of manual labor or other social gains (147, p. 342; 54, p. 30). The evidence suggests that this may be the case with some groups in West Africa who do not have strong "traditions" of agricultural labor and who have been characterized as "reluctant agriculturalists." Examples are the semi-migratory Fulani of Mali (57, p. 66) and Malinke entrepreneurs in Northern Ivory Coast (27, pp. 43-44).

CHAPTER IV

SELECTED CONSTRAINTS TO THE GENERAL EXPANSION OF BOVINE TRACTION IN WEST AFRICA

Livestock production has been divided into five major aspects, or phases: breeding; health; nutrition; marketing; and management (118, p. 9). Management relates to the daily care of animals and is closely tied to the four remaining aspects. These may be considered as constraints to the optimal utilization of the power source: limitations of the local animal breeds; poor animal health; poor feeding and nutrition; and difficulty of obtaining and marketing oxen. The supply of oxen will be considered under the marketing section.

Animal Breeds

Cattle breeds[1] are particularly important in any discussion of bovine traction, because the tractive power of an animal is basically a function of its weight and conformation. West African cattle breeds have been divided into three general ecological types according to their tolerance of trypanosomiasis (117).[2] The distribution of West African

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[1]For a review of West African cattle breed types, see: 35; 94; 112.

[2]Tolerance to trypanosomiasis depends upon acquired immunity, as well as the general state of health of the animal.

cattle types is shown in Figure 2. About eighty-five per cent of all West African cattle are trypano-susceptible and intermediate breed types raised in areas along or above the 1,000 to 1,200 mm isohyets (Appendix J).[1] Although there is little data as to the breed type composition of working oxen, it is likely that the majority of them are also trypano-susceptible and intermediate types.

Trypano-susceptible types

These are humped Zebu (bos indicus) breeds, generally found in the Sahelian and northern Sudanian Zones. Because of their larger size, they are the most suited for draft purposes. Susceptibility to trypanosomiasis has been the chief limiting factor to their wider utilization below the 1,000 mm isohyet. It appears that all Zebu breeds have been successfully utilized for traction by farmers or government stations, with two exceptions: the M'bororo (Red Fulani) of northern Nigeria and the Kuri of Lake Chad.[2] Notable triple purpose breeds (milk, meat, draft) are the white, lyre-horned Zebus of Senegal (Gobra) and Nigeria (White Fulani).

High levels of nutrition and management enable the animals to better resist trypanosomiasis in areas of strong tse-tse challenge. However, healthy working animals will succumb to the disease without drug treatment (139, p. 247). Stress

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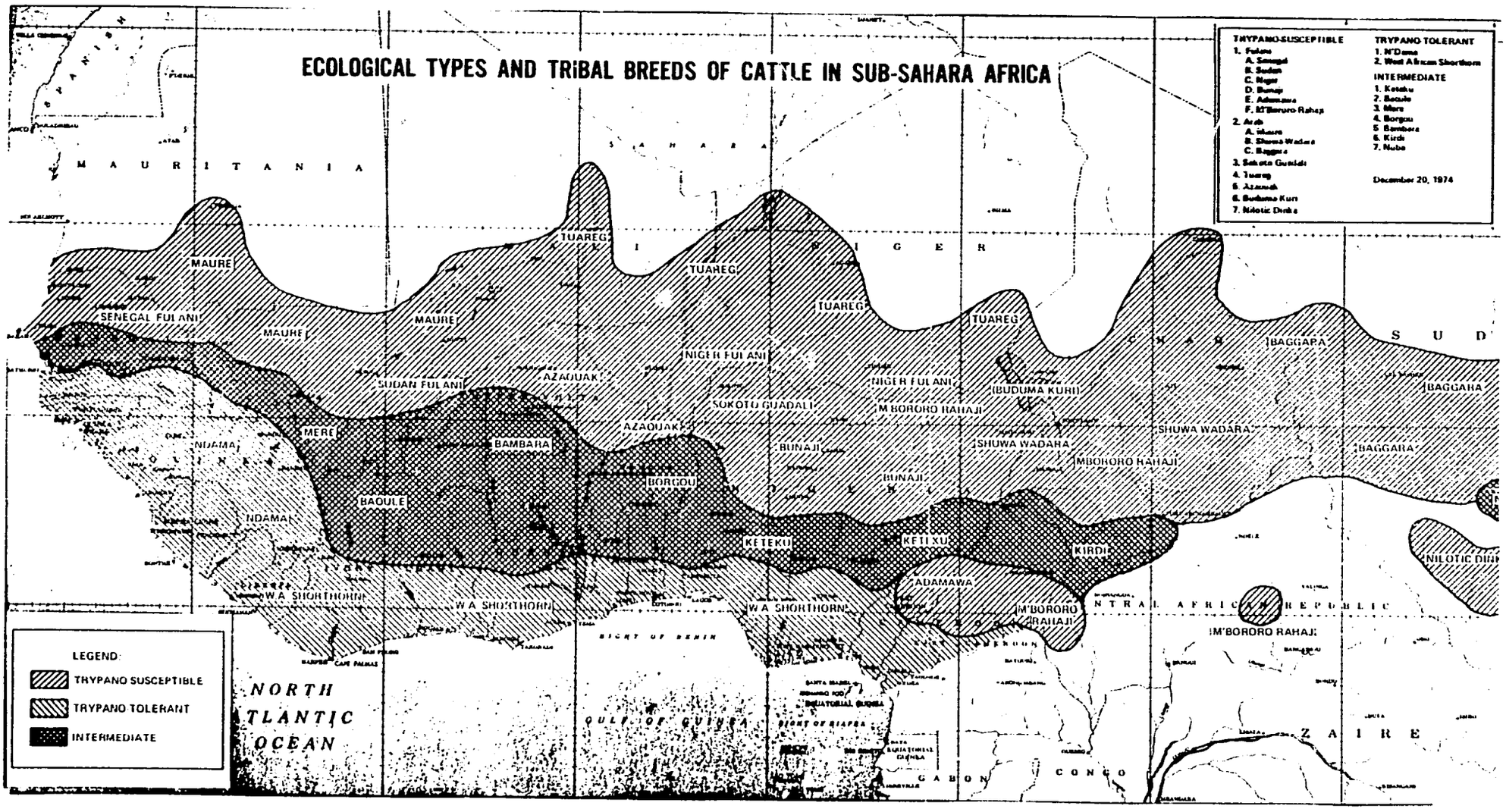
[1]It is possible that the northern limit of tse-tse infestation in Figure 1 is dated.

[2]Although the latter are not considered a Zebu breed (94, pp. 111-17 and 139-45).



(Source: G. B. McLeroy, December, 1974)

caused by poor diet or overwork can lead to breakdown in drug protection or any immunity acquired during earlier infections (179).

Trypano-tolerant types

These are smaller, humpless taurine (bos taurus) breeds which show a premunition to trypanosomiasis. There are two main groups: the larger, long-horned N'dama generally found in the southern Sudanian and Guinean Zones; and the smaller West African Shorthorn (W.A.S.) located generally in the Woodland zone (Figure 2). There are also N'dama X W.A.S. crosses.

N'dama.[1]--The N'dama has been recognized to be better than the West African Shorthorn for draft purposes, primarily because of their larger size. They are reputed to be able to survive poor conditions of husbandry but will succumb to trypanosomiasis if worked hard and fed poorly. Studies in Nigeria have concluded that N'dama cattle have more qualities of potential practical value than W.A.S. types and should be used to a greater extent in livestock development programs in tse-tse infested areas.[2]

West African Shorthorn (W.A.S.).--The thickset W.A.S. (Muturu, Kirdi, "Dwarf Pagan") are generally too small for

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[1]For a recent review of the N'dama in the Ivory Coast, see: 23.

[2]These suggest that the N'dama better withstand exposure to new antigenic types of trypanosomes without drug treatment, and are less susceptible to streptothricosis (lumpy skin disease), digital necrosis (footroot) and various tick-born diseases than either Zebu or W.A.S. cattle (146, II). A comparison of two surveys indicating rates of morbidity of working oxen in northern Ivory Coast (8) and southern Chad (158) might suggest that N'dama cattle are better suited to semi-humid production areas.

draft purposes, although it appears that they have been used with specially designed lightweight equipment in Ghana (99, pp. 2-84-85 and pp. 2-175-76). Larger N'dama X W.A.S. (Baoule) are utilized in northern Ivory Coast and the Central African Empire.[1]

Intermediate types

These are crosses between trypano-susceptible and trypano-tolerant types, i.e., N'dama X Zebu or W.A.S. X Zebu. It appears that N'dama X Zebu crosses are ideal work animals in areas of medium fly challenge.[2] They have been quite successfully used for draft in Sine Saloum (Djakore), southern Mali (Bambara), eastern Upper Volta (Azaouak X N'dama) and eastern Central African Empire (B'bororo X N'dama). Larger W.A.S. X Zebu (Borou, Keteku) are utilized in Nigeria and northern Benin.

Tractive power and minimum required weight

Most experts estimate that the available tractive (draft) power during an approximate three to five hour period is equal to about ten per cent of an animal's weight (123, p. 4n; 145, p. 35; 149 p. 46).[3] It is believed that with correct

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[1]For a review of attempts to introduce Baoule stock in the Central African Empire, see: 31.

[2]In northern Ivory Coast, it was found that N'dama and their crosses were better suited for draft than W.A.S. X Zebu or W.A.S. X N'dama cattle because of their better conformation, size, weight and hardiness (8, p. 50).

[3]Measured by a dynometer mounted between equipment and team (see: 123).

feeding and management, this can be increased to twenty per cent of team weight (123, p. 4n; see also: 110, p. 610). The minimum required amount of draft power for the performance of all cultural operations is 100 kilograms (149, p. 46; 135 p. 826).[1] Assuming that an animal can pull ten per cent of its weight, 100 kilograms of tractive power would require two 500 kilogram animals. However, many Zebu and most intermediate types of cattle rarely attain this weight at maturity under conventional management.

Breed type	Typical mature[a] bull liveweights	Available tractive power from two animals (@ 10% team weight
	(kgs)	(kgs)
Zebu	325-650	65-130
Intermediate	300- 475	60-95
N'dama	300-350	60-70
WAS	200-260	40-52

[a]Mature liveweights for Zebu reached at about ages six to eight years, and for N'dama about five to six years.

Source: Appendix L.

Results of experiments[2] would indicate that two 500

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[1]The required amount of tractive power depends upon the particular cultural operation (especially depth), and varies with soil conditions (soil structure, clay content and moisture) and type of equipment used. The available amount of tractive power depends upon the size of the animal, as well as its state of health, management and training, harness and yoke design, age put to work and age of castration. Smaller animals often are not castrated to retain spirited temperament.

[2]These trials were performed in Bambey (Senegal) in 1963, with a medium-weight tool-bar ("unite moyenne") on soils having

kilogram animals pulling ten per cent of their weight cannot provide enough tractive effort to plow under dense fallow (required effort: 156 kg) and may just possibly provide enough power for plowing under green sorghum 70-80 cm high (required effort: 71-112 kg). Building up ridges 30-40 cm high for groundnuts requires about 75 kg power.

The required amount of tractive power for minimum operations such as the seeding of millet and groundnuts with a two-row seeder (45 kg), superficial land preparation (scarification) and inter-row cultivation (weeding) at 3-4 cm depth (60-70 kg), and the lifting of groundnuts of the "bunch" variety (40-50 kg) would require two animals weighing each 350 kilograms. If a higher level of feeding and management permitted the animals to pull twelve per cent of their weight, then two 300 kilogram animals might suffice for these operations in sandy to coarse loamy soils. However, it appears questionable whether they could adequately perform the operations of ridging, deep plowing or plowing under (see: 104, 1967).

Breeding requirements for future bovine traction activities

The areas of greatest potential development of bovine traction are located below the 1,000 mm isohyet. These include: the Casamance in Senegal; southern Mali; and northern Ivory Coast. Several factors limit the introduction of Zebu stock into these areas: the high cost of tse-tse eradication

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a 2-7.6 per cent clay content and "good" soil moisture conditions (123, I, Tableaux III, VI, VII, XIII, and XIV; and II, Tableaux XVIII, XIX and XX.

and control programs; the possibility of the development of new antigenic types of trypanosomes resistant to drugs; and the greater prevalance of vector-borne and parasitic diseases in the more humid areas (see: 117; 146). Therefore, trypanotolerant cattle could play a crucial role in future breed expansion activities. The breed of choice appears to be the N'dama for crossing with female Zebu stock to produce large intermediate types which retain some premunition against trypanosomiasis as well as to upgrade W.A.S. stock in size and conformation. Because of the advantages of using trypanotolerant cattle or their crosses, the expansion of bovine traction within the current tse-tse belt will not substantially increase the demand for immatures from the northern rangelands for use in traction programs.

Animal Health

The poor health of oxen severely limits bovine traction activities, particularly in areas where farmers lack experience in cattle husbandry (e.g., see: 11, p. 178; see also: 8; 158).

A full range of diseases remain endemic in West Africa: contagious bovine pleuro-pneumonia, bovine brucellosis and tuberculosis, anthrax, blackquarter, pasteurellosis (septicaemia) and foot-and-mouth disease. Common parasitic diseases of the blood are tick-born (rickettsia, or heart-water; piroplasmosis, similar to Texas fever) as well as fly-born (trypanosomiasis). Helminthiasis is very wide-spread: nematodes (roundworms), trematodes (liver flukes) and cestatodes (tapeworms). It is

often associated with coccidiosis. Widespread epidermal diseases are cutaneous streptothricosis (Dermatophilus congolensis) and digital necrosis.[1]

General state of health

The general state of health of working oxen in West Africa is poor and due primarily to polyparasitism.[2] Other diseases, meager diet and stress from dry season grazing also play a part.

In West Africa, parasitism (especially helminthiasis) is more prevalent in sedentary and semi-sedentary than in migratory herds (7; 55; 171). Sedentary herds may be more affected because of higher local stocking rates and the fact that the animals stay longer in the same infected area.[3] In the Sahelian and northern Sudanian zones, mortality among sedentary herds during the drought of 1972-73 was far higher than that among migratory herds and may have exceeded fifty per cent (48, p. 56).

Mortality

Average annual (age-specific) rates of mortality in areas

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[1]Based upon a review of reports and articles in the following journals for the years 1969-1975: Bulletin of Epizootic Diseases of Africa (Kikuyu): Ghana Journal of Agricultural Science (Accra); Revue d'Elevage et de Medecin Veterinaire des Pays Tropicaux (I.E.M.V.T., Paris); and Tropical Animal Health and Production (Edinburgh).

[2]Polyparasitism is the attack by several species.

[3]There is a "vicious circle" relationship between gastrointestinal parasitism and level of nutrition. Low levels of nutrition increase susceptibility to challenge by parasites, while infestation may depress fodder intake up to ten per cent (171, p. 231).

of bovine traction activities appear to vary from one to ten per cent or even higher.[1] Prominent causes of mortality are: trypanosomiasis; over-work, under-feeding and mistreatment (especially of immatures); streptothricosis; rickettsia; and snake-bites and other accidents during unsupervised grazing.[2] Often the cause of death is unknown because many deaths are not reported to the veterinary services until the bodies are severely decomposed.

Problems of the veterinary services

The importance of access to veterinary services cannot be over emphasized.[3] However, the West African veterinary departments are generally under-staffed and under-equipped. Furthermore, the services readily available to the ox-powered farmer are often limited to annual large-scale vaccination campaigns which overlook teams of oxen or small herds kept near farms. The veterinary needs of farmers with oxen are

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[1]In northern Nigeria, estimates of mortality range from seven to fifteen per cent in the first year of work (at three to four years of age) and five to fifteen per cent over the next five years, or seven to thirty per cent over six working years (102, p. 240). This is an average annual age-specific rate of one to six per cent. Average annual mortality in the Eastern O.R.D. program in Upper Volta may be anywhere from ten to as high as twenty-five per cent (180, p. 13 and p. 16).

[2]Based upon a review of: 8; 102; 158; 180.

[3]A twelve-month survey in the Korhogo region of the Ivory Coast revealed that in a village located close to the veterinary service, eight per cent (four) of fifty working oxen died, while in an outlying pilot village, twenty-five per cent (eleven) of forty-five died. Increase of guidance from the veterinary service in the pilot village brought an immediate stop to high mortality (8). Six (12.5 per cent) of the deaths in a group of oxen distributed in the Eastern O.R.D. project could have been prevented by an improved animal care program (180, p. 16).

different from those of herders, since the most serious disease problem for oxen (polyparasitism) requires regular prophylaxis or treatment (158). Ox-powered farms require more individual attention for which the veterinary services are not properly equipped or staffed to provide. This problem has been partially overcome in the Benin program, where animal traction associations initiated by the farmers themselves facilitate farmer training in the need for preventive and regular treatment and stock their own medicine (39, p. 75).

Health requirements for future bovine traction activities

Losses from parasitism in sedentary herds can be overcome by relatively simple and inexpensive anti-helminthic treatments (12, 171). It also appears that vaccination against the full range of endemic diseases is justified (most important are: rinderpest, anthrax, blackquarter and septicaemia). However, medication alone cannot substitute for good nutrition and management.

Feeding and Nutrition

Most sedentary farmers in the Sudanian zone do not have enough on-farm resources (crop residues, fallow grazing and water) to provide maintenance[1] for a team of oxen on their holdings year around and provide an additional concentrated

[1]"Maintenance" is a purely theoretical term which nonetheless has practical applications. An animal is in a state of maintenance when its body composition remains constant, when it gives rise to no product such as milk and when it performs no work on its surroundings (114, p. 261). Maintenance allowance for a 360 kg bull in northern Nigeria is estimated to be about 2.2 kg T.D.N. and 0.180 kg D.P. (Appendix M).

ration for the work period. Although climate, crop mix and locally available grazing resources may differ from region to region, the available evidence would indicate that ox-powered farms with holdings under five to eight hectares in size must depend upon extensive off-farm grazing for all or part of the seven to nine month dry season to maintain their animals.[1] Upon their return to the villages at the end of the dry season, the cattle are in poor physical condition and are unsuited for the heavy work of land preparation.

Weight loss during dry season grazing

The limitations of natural grasses in the tropics are

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[1]In northern Nigeria, it has been estimated that at least eight hectares is required to support a team year around (108; see also: 60, p. 170; 4, p. 132). A survey in the Zaria province found that ox-powered farms with six hectare holdings had to depend upon a considerable amount of bush grazing to maintain their team (125, p. 513; see also: 108). This is supported by an examination of the total amount of available crop residues on a "typical" four hectare farm in the Zaria province (Appendix M). Results suggest that under the assumptions of average yields, a slightly modified crop mix and complete utilization of all farm crop residues and fallow, it is doubtful that the farm could provide sufficient maintenance for the oxen year around. It may be noted that in 1960, only the top nine per cent of all farmers in northern Nigeria cultivated holdings of four hectares and over (139, p. 270).

Elsewhere, it is estimated that the minimum holding size in southern Chad is five hectares (36), while in Senegal it is six (123, II). For the whole of West Africa, it has been suggested that eight hectares is the minimum holding size to justify a team of oxen and equipment (37, p. 134). Although these estimates likely refer to a farm size (cultivated area) large enough to justify investment requirements in oxen and a full line of equipment, the evidence from northern Nigeria cited above suggests that feeding costs are also lower for larger farms. Many smaller farms can justify a team of oxen by earning considerable external income from custom plowing, although (as it has already been pointed out) the general expansion of custom plowing beyond a certain point in a particular region is not possible.

well-documented.[1] Their quantity and quality exceed maintenance allowance of stock during the first few months of the rainy season when their crude protein content may be high. But protein content declines rapidly towards the beginning of the dry season as the grasses mature, and it may decline to three per cent or less in the late dry season (115, p. 78). Digestibility also declines as the grasses lignify over the hot dry season.

Cattle on natural grasses without supplemental feeding in Central West Africa may lose ten to thirty-three per cent of their weight by the end of the dry season (see: 13; 29; 106).[2] Within four to six weeks on the young grass of the rainy season, the animals may rapidly recover their weight during a period of "compensatory growth."[3] However, the set-back retards over-all growth, sexual maturity, milk yields

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[1]One expert has noted that no farmers with good working draft animals keep their livestock for any extensive period of the year on natural tropical grasslands where there is a marked dry season (177, p. 4).

[2]The following is an example of growth and loss of weight over a two year period:

	(kgs)
Liveweight of animal at end of first dry season	250
following rainy season	350
end of second dry season	255
following rainy season	382
end of third dry season	307

Source: Mittendorf (1963) cited in 139, p. 228. See also Figure 3.

[3]Compensatory growth is a short period of very rapid daily gain in weight which may occur after the appearance of rainy season grasses (or when presented with a growth ration high in mineral salts and nitrogen) and which may be a storing-up period for ballast, mineral salts and nitrogen (85, p. 56).

and reproductive efficiency (28). Protein is the most deficient nutrient in dry season pasture causing seasonal weight loss (122, p. 35).

Additional feeding requirements for working oxen

To perform at full potential, oxen require one to two kilograms of cereal or concentrate per head for feeding-up three weeks before the rains begin and during the period of heavy work (see: 88; 135; 143; 161). However, only farmers who have achieved high levels of productivity can be expected to spare cereal grains or legumes for livestock.[1] The requirement for feeding grain to oxen comes at the end of the dry season when the farmer's granaries are almost empty and his cash resources are the lowest (132, p. 9).[2]

Conventional grazing strategies

The sedentary farmer generally grazes his animals in two ways: either by contract management with Fulani herders, or by allowing the animals to scavenge in the village environs with little or no supervision.[3]

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[1]It has been estimated in the Gambia that not until farmers have doubled their subsistence production will they find it worthwhile to spare grain for livestock (19, pp. 60-65).

[2]Rather than feed their animals scarce cereal grains at the end of the dry season, Gambian farmers either worked their animals less (losing higher yields from timely cultivation) or purchased additional oxen (176, p. 248).

[3]Semi-migratory or semi-sedentary Fulani who have adopted the plow may manage their oxen themselves.

Contract grazing.--Contract management takes advantage of Fulani herders' traditionally superior management ability and knowledge of available water and forage resources of the Sudanian Zone. Herders may be paid in cash or in kind for their services.

Other reasons for entrusting the animals to the Fulani are: to protect against theft of cattle kept in small groups near villages; to either move them out of areas with increased tse-tse infestation during the rainy season or keep them out of infested areas while grazing over the dry season; to keep them out of the crops during the growing season; and to find better grazing outside over-grazed village perimeters.[1] Finally, sedentary farmers may not have adequate labor resources on the farm to manage the animals themselves.[2]

Allowing Fulani herders to assume management of oxen has been cited as a problem in bovine traction programs in northern Cameroon, northern Nigeria, Senegal, Chad and Mali.[3] Problems

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[1]It is possible that use of animal-drawn equipment is contributing to increased local grazing pressure by increasing the area under cultivation per unit farm. In the Sine Saloum region, it was noted that animal-drawn seeders and cultivators had increased total area planted to groundnuts and millet among the Serere, decreasing local fallow and pasture lands. As a result, more of their cattle were sent on transhumance (140, pp. 402 - 404). In Tanzania, the expansion of ox-drawn cotton cultivation in Sukumaland reduced local grazing such that one expert noted, "It is paradoxical that the oxen should have to draw the plow which is reducing their pasture ground (173, p. 80n)".

[2]It was believed that cattle-owners in a village of northern Nigeria hired more non-family labor than other farmers not only because their holdings were larger, but because of the considerable time spent looking after their cattle (134, p. 11). Polly Hill (69, p. 217) has noted that farmers in another village in the region board out their animals to "save labor."

[3](21, p. 9; 32, I, p. 112 and II, pp. 316, 320 and 358;

cited have been: the inability to retrieve work animals when needed; losses due to malnutrition, disease, accidents; and most important, loss of training.[1]

Local village grazing.--Often sedentary farmers may permit their animals to graze at will in the village perimeters over the dry season, either watched by a younger member of the family or not at all (e.g., see: 153). There is no evidence indicating that sedentary farmers use family or village labor (other than children) to graze their animals. This method of management may be more unsatisfactory than contract management.[2]

44, p. 222; 51, p. 17; 62, p. 217; 67; 99, p. 1-40; and 135, p. 828 and 834).

[1]Loss of training over the dry season is an extremely important problem. In many areas, the animals are utilized for only a short period during the cropping season (one to three months) and remain inactive for the rest of the year (138, pp. 236-37). However, the practice of pulling a dead weight to keep the animals trained has no evident purpose to peasant farmers and is never practiced as much as it should be (124, p. 7). Cart usage maintains training year around, but requires that farmers have adequate feed and water resources on or near the farm so the animals are accessible. It is interesting to note that pilot farms at Imperial College, Trinidad, found that the cultivation of short-cycle crops on 1.2 ha (three acres) was not enough to keep the animals trained and created a vicious circle--the less the animals worked, the less able they were to do more work. Consequently, neither oxen nor farmers gained any competence at inter-row cultivation (91, pp. 266-77).

[2]Children may be inexperienced graziers (63). When grazing in the village perimeters, oxen must compete with the other village livestock (67). An aerial survey in the Adamaoua region of northern Cameroon has attested to the fact that village perimeters are severely overgrazed (73). In the Doukolomba region of central Mali, oxen belonging to (sedentary) Bambara farmers were allowed to graze freely in the village perimeters over the dry season. These animals were in distinctly poorer health than the oxen taken on short transhumance by Fulani herders (56).

Selected alternatives to conventional grazing strategies

The few remaining alternatives to conventional dry season grazing strategies for ox-powered farmers will be briefly examined here.

Concentrated supplements.--Concentrated protein and mineral supplements can substantially reduce dry season weight losses (13; 52). Mineral/salt licks are generally too expensive for the average farmer. However, local "bush salt" (high in sodium bicarbonate) is fed in some areas.[1]

Agro-industrial by-products provide excellent sources of concentrated protein. Many and diverse agro-industrial products are produced in the region. However, their prices are high, many are exported (cottonseed, groundnut cake, fishmeal), and most are rarely available to the average farmer.[2]

Better utilization of crop residues.--Crop residues are higher in crude protein than natural grasses (121, III). They are a valuable food source for livestock. Most popular are the grain legume hays.[3] Like natural grasses, the protein content of crop residues falls off rapidly when left in the fields. Great care must be taken in handling and storing them to prevent leaf-shattering.

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[1]The intake of low-quality grasses can be increased by increasing the nitrogen content of the diet.

[2]Prices of agro-industrial by-products were especially high due to lowered yields after the droughts of 1972-1973. For a review of available agro-industrial feeds, see: 85.

[3]In northern Nigeria, some farmers store grain legume hays ("harawa") in their family granaries for dry season use of horses, sheep and goats (69, p. 36. See also: 71).

Haymaking.--It has been suggested that natural grasses be cut before they lignify and stored for later use (99, p. 1-40; 136). However, in northern Nigeria it was found that optimum cutting dates of many natural and cultivated grasses coincided with high atmospheric humidity so that hay-making conditions were not favorable (120). Results of digestibility trials have also indicated higher digestibility and rates of intake of natural grasses eaten by grazing animals than cut grass eaten by stall-fed animals.[1] Furthermore, many cultivated grasses grown on soils of low fertility have low digestibility and protein content (121, I, p. 167). The hay-making of cultivated legumes (soy, velvet beans, cowpeas) appears to present more of a possibility (120).

Ensilage.--Pit silos for conservation of natural grasses and other materials have been utilized in Chad, Cameroon and Mali. Some reports claim that they have been successfully received by farmers in Mali (142) and Cameroon (62, p. 309). However, like hay-making, the nutritive value of the final product reflects the quality of the original material.[2] Cereal/legume mixtures (maize/cowpea or sorghum/velvet bean) have proven to be better material for ensilage than natural and cultivated grasses (159; 121, II).

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[1]This was due to their greater selectivity while grazing. Stall-fed animals brought grass cut from the same grazing area had lower rates of intake and gained less weight (120; see also: 181).

[2]Digestibility trials in northern Nigeria have shown that the ensilage of many natural and cultivated grasses grown under normal West African levels of fertility will not provide maintenance requirements and may not justify the work involved (121, II).

Cultivated forage production and controlled grazing.--The more complete utilization of crop residues may only be a partial solution to the problem of dry season feeding. Agro-industrial by-products are expensive and not available to the average farmer, while the nutritive value of the final product in haymaking and ensilage reflects the quality of the original material. However, allowing the animals to harvest forage themselves in the conventional manner, but on cultivated pastures, either in crop rotations or in a controlled system of grazing on oversown rangelands, may a viable means of breaking the dry season feeding constraint.

A grass ley system of controlled grazing utilizing a native perrenial, Andropogon gayanus, has been proposed (10; 138). Research stations in Upper Volta, Ivory Coast and Nigeria have successfully utilized the legume, Stylosanthes gracilis, in crop rotations as well as oversown rangeland.[1] It has also been recommended that mixtures of grasses and legumes be utilized instead of single species, since mixtures may increase the quantity of forage and may be more nutritious.[2]

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[1] E.g., studies have been made at the Shika research station in northern Nigeria (about 1,100 mm rainfall over four to five months). They suggest that the oversowing of small areas with Stylosanthes at strategic points within areas of unimproved savannah grassland in a system of controlled grazing may prevent dry season weight loss. White Fulani cattle were grazed on unimproved savannah by day and paddocked at night on savannah grassland oversown with Stylosanthes seed. Liveweight gains during the dry season were equivalent to those of animals receiving 0.82 kg/head/day of whole cottonseed (64).

[2] A recent report on grassland research in northern Nigeria states that cultivated grass and legume mixtures should soon result in year-round grazing in the Sudanian rangelands (2, p. 166).

Little evidence to date indicates that farmers have adopted the practice of growing forage crops, or have set aside land for range improvement and controlled grazing.[1] Farmers may not wish to incur increased costs (increased labor input and forfeited crop yields) of growing forages on arable land where food or cash crops can be grown.[2] A fundamental constraint to controlled grazing may be the system of land tenure.[3] This discourages both the cultivation of grasses on fallow land and the oversowing of rangeland, in that limitation of stocking rates is not possible.[4]

Feeding requirements for future bovine traction activities.--In the future, other yield-increasing technologies (mineral fertilization) may increase the quantity of crop residues and quality of natural or cultivated grasses and forages for haymaking or ensilage. However, it appears that forage cultivation and range land improvement in a system of selective grazing must develop before a closer integration of crop and animal husbandry can be realized.

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[1]There is recent evidence indicating that some farmers in southern Mali have adopted the practice of growing cowpeas for forage, ostensibly for pit ensilage (18).

[2]Esther Boserup (p. 37n) cites farm management studies in India indicating that the labor cost to farmers of keeping oxen fed on common grazing are far lower than oxen fed on produced forage.

[3]Although cultivated land is de facto property of the individual in West Africa, volunteer vegetation on fallow and rangeland is considered to be common property and a gift from Allah (47, p. 27).

[4]It has also been suggested that communal grazing arrangements, or a collective system of animal supervision, be organized by ox-powered farmers (3; 36). To date, there is little available evidence on the success of these arrangements.

Supply and Marketing of Oxen

For bovine traction to be feasible, the farmer must be able to buy large immatures and sell older oxen rapidly and efficiently. Some programs have conducted buying activities to assist farmers in obtaining healthy, working-size animals (these may be important for farmers located far from cattle trails). In some areas, marketing activities have also been set up to enable farmers to realize the cash value of older oxen.

Supply of young oxen

Predictions for a serious "shortage" of animals suitable for draft have been recently made for Senegal, northern Benin, eastern Upper Volta and southern Chad (36; 39, pp. 75-76; 149, p. 17). Shortage of supply of working-size draft animals may be due to: the modest size of resident herds in most agricultural areas; the generally low fertility, high calf mortality and high morbidity of West African herds; and the rising demand for beef, which prices large steers suitable for draft out of the range of many small farmers.

Estimating the supply of male immatures.--Although shortages have been predicted, theoretically there should be enough animals for a wider expansion of bovine traction activities. It is possible to roughly estimate the potential supply of immatures and the demand for young oxen in West Africa. However, certain simplifying assumptions must be made.

The effective rate of growth of numbers of working oxen is assumed to be eight per cent per year. Average annual mortality is estimated to be three per cent.[1] It may further be assumed that animals are added to the traction herd at three years (thirty-six months), trained and worked on the farm for five years (sixty months) and sold at age eight (ninety-six months).[2] Although in some areas cows may be utilized for work, for the purpose of simplification it is assumed that only males are utilized. Based upon a total population of a half million oxen, the number of working oxen by age category and number of eight year olds marketed in 1974 would be:

age class	number working oxen	number oxen marketed
8	-	72,300
7	80,300	
6	89,100	
5	98,900	
4	109,800	
3	121,900	
(total)	500,000	

Thus, there may have been 120,000 three year olds entering the traction herd in 1974.

The total cattle population in West Africa is estimated at about thirty million. Age/sex composition of local herds may vary according to season and locality. Several estimates

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[1]See p. 55n above. This is the median value of the estimate for annual mortality in northern Nigeria.

[2]Based upon Table 2.

of Zebu age/sex composition would indicate that about five per cent (1.5 million) of the national herds might be male three year olds. Total available male three year olds for both slaughter and draft is a function of the rate of (age-specific) off-take (sales). This may vary between ten and fifty per cent of all male three year olds (Appendix N). If the age-specific off-take rate for male three year olds varies between thirty and forty per cent (giving 450-600,000 marketed animals), then the 120,000 animals entering the traction herd represent about twenty to twenty-five per cent of the available marketed three year olds. Thus, theoretically, there is room to expand bovine traction activities, since current activities only draw off about one fifth to one quarter of the marketed 450-600,000 three year olds, and only about eight per cent of the total available 1.5 million three year olds.

However, an estimate of the supply of immatures for draft would also depend upon the quality (size, conformation and health) of the available (marketed) animals. There are no accurate per centage estimates of the over-all condition and health of animals available to the farmer for draft.[1] If it is assumed that only the top two thirds of the 450-600,000 available marketed animals are suitable for draft, then there would have been 300-400,000 available animals to meet the demand for 120,000 oxen. Thus, it may be that thirty to forty

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[1]Culling rates for animals already purchased and in training are estimated to be ten per cent in the Ivory Coast (8, p. 50) and twenty per cent in Senegal (79, Annex 7, Table 3).

per cent of the marketed three year olds suitable for draft are already being used in some areas.

Contribution to reduction in herd numbers.--It appears that if the demand for working oxen continues to increase at eight per cent per year, bovine traction activities will continue to contribute little to reducing Sahelian and Sudanian herds. Whereas the number of three year olds extracted for draft represent only eight per cent of all 1.5 million three year olds in 1974, the number of animals entering the traction herd in 1990 (400,000) would represent only sixteen per cent of the 2.4 million three year olds at that time.[1] This would represent a reduction in total herd size in 1990 (forty-eight million) of less than one per cent.

Furthermore, the areas of potential expansion of bovine traction generally lie below the 1,000 mm isohyet. Future activities would thus require intermediate and trypano-tolerant breed types of cattle rather than Sudanian and Sahelian zone Zebus (which comprise over half of the regional cattle population).

Marketing of older oxen

The number of older oxen marketed for slaughter is not sufficient to depress local rural meat prices. Assuming that total off-take from the national herds is six per cent, the

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[1]This is based upon the assumption that total herd size (as well as the number of three year olds) increases by three per cent per year. It is estimated that the national herds in West African countries are increasing anywhere from two to five per cent per year (164, pp. 19-20).

number of older oxen marketed in 1974 (72,000) represents only some four per cent of the 1.8 million head marketed for slaughter.

It may be difficult for farmers to get full market value for their animals if they are located in areas distant from major markets. Such areas are southern Chad (36; 158) and eastern Upper Volta (180, pp. 7-8). Support of marketing activities in northern Benin and southwestern Upper Volta appears to have successfully enabled farmers to realize maximum cash value for older oxen (39, p. 100 and p. 76).[1]

Supply and marketing requirements for future bovine traction activities

As outlined above, there may be a substantial number of marketed three year olds suitable for draft already being drawn off for traction. If the effective demand for working oxen continues to increase by eight per cent per year, then the supply limit of marketed animals may soon be reached.[2] Increasing the marketed supply of large, healthy animals suitable for traction would require interventions (aimed at

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[1]Similar marketing programs to accompany the stall-feeding of older oxen have been recommended for southern Mali (46, p. 210).

[2]Assuming that the numbers of marketed three year olds suitable for draft in 1974 (300-400,000) increases by three per cent per year, there would be 500-600,000 available animals in 1993. Assuming that the number of working oxen increases by eight per cent per year, there would be a demand for 500,000 three year olds for traction in 1993, or 80-100 per cent of the marketed animals suitable for draft.

As indicated earlier, the fact that most farmers retain their oxen longer than it is economic to do so might imply a supply constraint.

improving health and nutrition) which confront the slow rates of maturity and high morbidity in conventionally managed herds. Finally, breeding programs would be required to increase the number of trypano-tolerant and intermediate types of cattle for traction suitable to the more humid zones.

To lower replacement costs for ox-powered farmers, there may be a need for marketing activities to assist the farmer located far from cattle trails in buying suitable animals. More important, however, is the need to assist him in obtaining access to major markets for his older animals.

CHAPTER V

INCREASE IN CASH FARM INCOME FROM THE ADOPTION OF SMALL UNIT FEEDING

Introduction to Selected Aspects of Supply and Demand for Cattle in West Africa[1]

West African consumer preferences

Consumers of beef in West Africa are low income persons for whom American concepts of quality (marbling) have little meaning. Meat is generally boiled to provide a sauce to garnish the local starchy staple food. The non-red meat parts (edible offal and even the hide) are also eaten and command selling prices slightly less than those for red meat. Demand for prime quality meat is small and limited to persons in higher income brackets in the large urban markets.

Prices at consumption centers

Consumer preferences are reflected in prices paid for slaughter cattle.[2] Highest prices are paid for large, well-

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[1]Unless otherwise indicated, the discussion in this section is based upon: 47, pp. 65-66.

[2]Liveweight prices in West Africa have been historically low, in many cases kept low by local governments. They began to rise in 1969, but were temporarily stopped by the droughts of 1972 and 1973, which caused producers to sell off many animals (85, p. 245). They have since begun to rise again with the constriction of supply caused by the drought and post-drought recovery of incomes.

fleshed animals at or near full mature bone structure and weight (Appendix O). The small demand for prime beef in the urban markets is supplied by the occasional range or stall-fed animal with a superior finish, by the few commercial ranches or feedlots, and by meat importations.

Prices in production zones

Again, highest prices are paid for large, range-grown animals[1] which can be marketed to the coast (on the hoof, by truck or rail) with minimal shrinkage and mortality. Farm-gate price differentials (difference between selling price and purchase price/kg) are very small or even negative for "fattened" cattle in the production zones. Unless rail or truck transport is available, they lose more weight in transit to the coast than range animals.

Seasonal price fluxuations

Prices paid to producers for their cattle vary according to local patterns of transhumance. Liveweight prices per kilogram are lowest towards the end of the rainy season and beginning of the dry season, when herders are near agricultural areas, but when average liveweight slaughtered is highest because their animals are gaining rapidly on rainy season grasses. At the end of the dry season and beginning of the

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[1]In the United States, younger animals of lower weight bring higher prices/lb than older animals. In West Africa, older (and heavier) animals bring higher prices/lb than younger animals (85, p. 244). Thus, range cattle may quadruple in total value while only doubling in weight from age two to six years. See Appendix O.

rainy season, liveweight prices per kilogram begin to peak while herders are absent from agricultural areas in search of better grazing and water for their animals. However, average liveweight slaughtered is the lowest, as available slaughter animals are thin from meager dry season grazing. A somewhat over-stated but nonetheless typical example of this relationship is graphically presented in Figure 3.

Location and Characteristics of Small Unit Feeding

There is very little published information about actual numbers of cattle fed out by small scale enterprises. There seems to be two general types of small unit feeding currently practiced in West Africa:

1) The feeding of cattle in stalls, at the stake or in enclosed areas. This activity may or may not produce "fattened" cattle. Often it may only amount to the maintenance of weight over the dry season to take advantage of seasonal price fluxuations.[1]

2) the fattening of cattle in pits ("boeufs de case") for religious purposes in the Margui-Wandala area of northern Cameroon.

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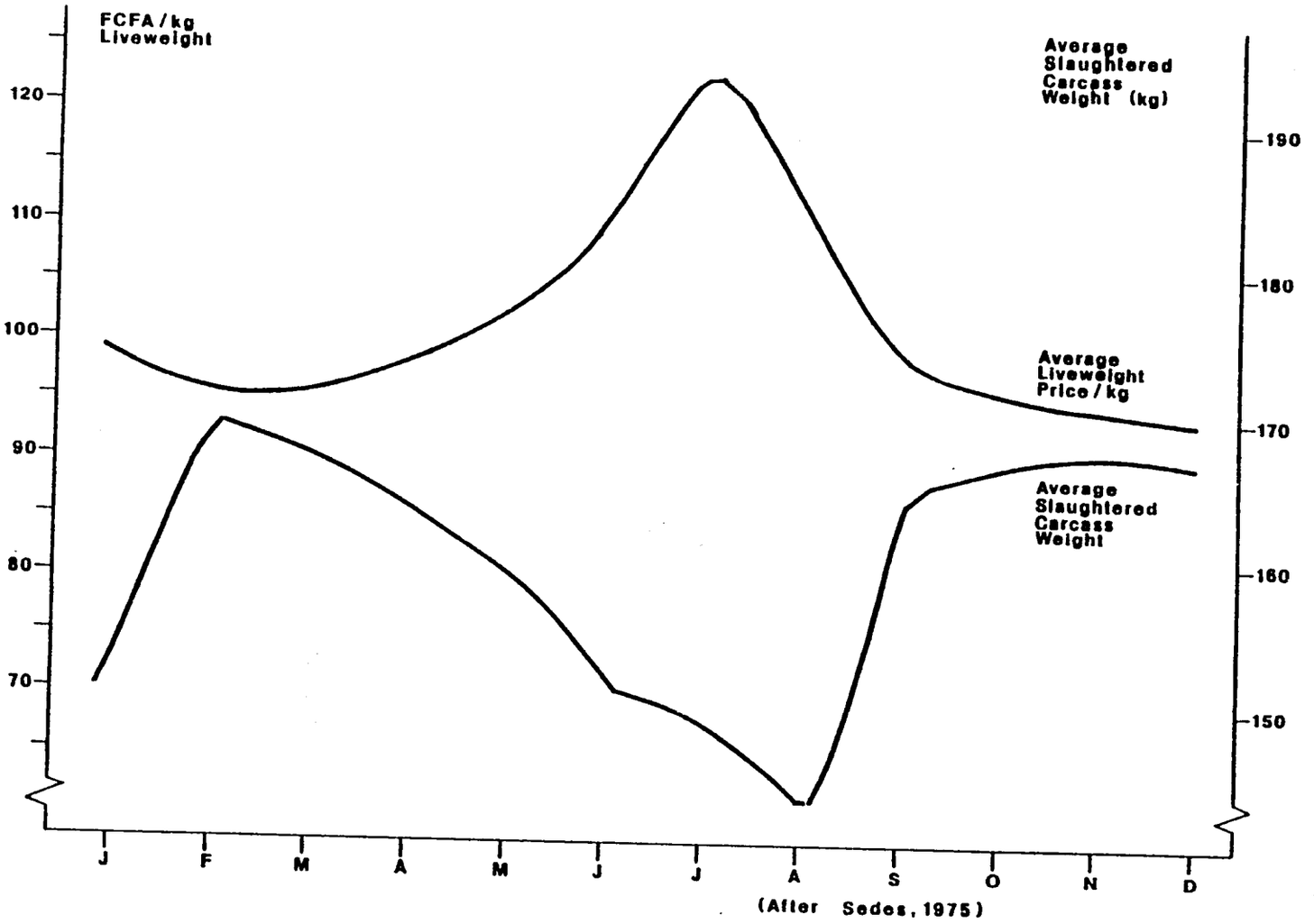
[1]It is for this reason that the term "feeding" ("embouche") rather than "fattening" ("engraissement") of cattle is used here. As in the United States, the goal of cattle-feeding in West Africa is to put animals in higher weight and value categories. However, in West Africa the degree of finish (growth of intra-muscular fat) is much less important in determining the feeding margin (except, of course, in urban centers where there is some demand for prime beef).

COMPARISON OF AVERAGE SLAUGHTERED CARCASS WEIGHT AND AVERAGE LIVEWEIGHT PRICE PER KILOGRAM BY MONTH

(Kaedi, Mauritania, 1971)



(After Sedes, 1975)

FIGURE 3

Location of small unit feeding

The former type of activity occurs at points between cattle production zones and either transportation terminals, large cattle markets or urban centers. It appears to be especially important where there are available supplies of dry season grazing (lowland, or "borgou" grasses). It also occurs where farmers have adopted bovine traction.[1] It is practiced by butchers, entrepreneurs and farmers.

The evidence indicates that small unit feeding is practiced in the following areas: 1) in Niger along the Niger River (85, pp. 305-310); 2) throughout northern Nigeria (101); 3) throughout northern Cameroon, especially in the Adamaoua region (85, pp. 297-300); 4) in central and southern Senegal above the Gambia (46, p. 91); 5) in the cotton zone of southern Chad, as well as near N'djamena (Ibid., p. 91; 32, p. 343); 6) in the Interior Delta as well as the southern region of Mali (18; 46, p. 90; 80); and in northern Ghana around the Kumasi cattle market (70, p. 129).

Review of available farm management data[2]

Feeding cattle to take advantage of price fluxuations.--Cash crop farmers located near production zones "save" thin range animals (sterile cows, orphaned males) which otherwise

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[1]In 1962, it was noted that mixed (ox-powered) farmers in northern Nigeria were the only cattle-owners to stall-feed cattle in that country (108). Several early reports from the Agricultural Department of Northern Nigeria indicate that mixed farmers made substantial profits from ox-feeding (130).

[2]Unless otherwise indicated, data in this section has been based upon a review of: 85, pp. 297-310; 101.

have little value to pastoralists. Animals are fed crop residues (cowpea and groundnut hay, cereal stover, as well as cereal bran in a good year) and available forage. They may be fed in enclosed areas (especially where lowland grass is available), but may be permitted to graze crop residues in the fields. The animals are sold when these are exhausted or before local herders return from the transhumance. However, where lowland grasses are available year around (as along the Niger River), several animals may be successfully fed out per year.

Compensatory weight gains can be substantial: farmers in the Boubon region of Niger specialize in feeding thin, sterile Djelli cows aged ten years and weighing about 250 kilograms at the beginning of the dry season. Reported daily gains were one kilogram and over on lowland grass and millet bran.[1]

Larger entrepreneurs near transportation terminals or urban markets exhibit considerable sophistication in their feeding practices. In addition to pack or work oxen, some feed younger bulls. These may be castrated and de-parasitized. Some entrepreneurs may feed as many as a dozen animals at a time for a period of three months to a few years. They may utilize farm by-products, but also buy cereal bran on the market. They pay great attention to the palatability of their feeds. Animals on pasture may receive salt and natron

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[1]Results of feeding trials in northern Nigeria which have attempted to simulate small unit feeding conditions are contained within Appendix H.

(sodium bicarbonate) supplements. It appears that entrepreneurs located near urban markets or transportation terminals can get good prices for fattened cattle and produce high quality carcasses for export to the urban areas.

Pit-fattening in northern Cameroon.--Young bulls weighing 150-200 kilograms are put into pit-type enclosures for one and sometimes several years. They are fed green Pennisetum, cereal bran, dried brewer's grains and leftovers. Legume hay is also fed over the dry season. Three year olds weighing 250 kilograms reportedly gain 500 grams per day. The animals are slaughtered for the Feast of the Bull. Some villages have commercialized this operation (116, pp. 14-15). It is estimated that perhaps ten per cent of total slaughtering in the Margui-Wandala area is comprised of animals fed in this manner. These animals are highly valued by local butchers. After one or two years of feeding, animals are sold for twice or more of purchase price.

Importance of the price differential (feeding margin).--Profitability of small unit feeding depends upon the price differential, or feeding margin (difference between sale price and purchase price per kilogram liveweight), as well as the cost of feed, gain efficiency and other factors. Price differentials depend upon seasonal fluxuations in supply and may vary considerably from market to market. It appears that they are lowest in production zones and highest in terminal urban markets. Actual price differentials in terminal urban markets ranging from twenty to thirty per cent for forty to fifty kilogram net weight differences are presented in Table 4.

TABLE 4

TYPICAL LIVEWEIGHT PRICE DIFFERENTIALS IN SELECTED CITIES

City	Date	Initial Weight kg	Final Weight kg	Net Differences kg	Purchase Price/kg	Sale Price/kg	Index of Price[a]	Source
Gusau, Kano	1962	318	396	78	13.3d (16.0¢)	17.6d (21.0¢)	131	(b)
Kaduna	1965	318	408	90	15.5d (18.6¢)	19.9d (24.0¢)	129	(c)
Dakar	1973	310	360	50	70FCFA (25.2¢)	90FCFA(32.4¢)	129	(d)
Bamako	1973	320	360	40	65FCFA (23.4¢)	80FCFA(28.8¢)	123	(d)
Abidjan	1973	320	360	50	100FCFA (36.0¢)	120FCFA(43.2¢)	120	(d)

NOTE: 1d (pence) = U.S. $0.012; FCFA 1 = U.S. $0.0036

a) Purchase price = 100.

b) Average of actual prices paid and received by small unit feeders for 177 Zebu cattle in nine areas of northern Nigeria. Most of the animals were sold in Gusau and Kano. L. L. Larson and U. Ndanko, Report on Nine Cattle Fattening Trials in the Provinces of Sokoto, Katsina, Kano, Bauchi and Bornu of Northern Nigeria, U.S.A.I.D. Report No. a-13 (Lagos, June, 1962).

c) D. S. Ferguson, The Nigerian Beef Industry, Cornell International Agricultural Development Bulletin No. 9, Cornell University (Ithaca, 1967), p. 50.

d) J. Sarniguet, "Economie de l'Embouche Intensive," I.E.M.V.T., L'Embouche Intensive des Bovins en Pays Tropicaux, Actes du Colloque, Dakar, 4-8 Decembre (Maisons-Alfort, 1973). pp. 243-246.

Few available budgets for small unit feeding take account of the spread between purchase and sale price per kilogram, primarily because local market conditions are so variable and actual prices paid to the producer are so difficult to obtain. The evidence does suggest that small unit feeders in production zones cannot obtain profitable feeding margins unless they are located near transportation terminals to link them to the stronger urban markets (101).

Indicative Budgets for Niger, Senegal and Nigeria

Indicative budgets for small unit feeding have been constructed for Niger, Senegal and Nigeria (Table 5). Daily gains (600 grams per day for yearlings in Niger and 500 grams per day for older animals in Senegal and Nigeria) may be considered quite reasonable when compared to actual feeding trials in Appendix H. Assumed price differentials (ten to fifteen per cent for seventy-five to ninety kilogram net gains) may be considered conservative when compared to Table 4 and Appendix O.

It would appear at first glance that small unit feeding may only be marginally profitable.[1] At the assumed prices in Table 5, small unit feeders would have to feed out three or more head to cover the loss of one animal (see below).

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[1]It might also be noted that intensive cattle feeding is only marginally profitable in the U.S. (85, p. 283). Custom feeders in Texas only received a margin above cost of concentrate (corn and cottonseed) and interest (4.8%) of about $45 per 470 kg steer in the first quarter of 1976 (38, Table 3). At liveweight prices during that period, they would have to feed out five animals to cover the loss of one head. (When the cost of milc and alfalfa is included, their margin is reduced to -$60/head.)

TABLE 5

INDICATIVE MARGINS ABOVE CONCENTRATE AND INTEREST COSTS

FOR SMALL UNIT FEEDING (150 DAYS)

Location	E. Niger[a]	Senegal[b]	Nigeria[c]
Breed	Azaouak	Djakore	W. Fulani
Initial Wt. (kg)	170	238	360
Final Wt. (kg)	260	313	435
Net Gain (kg)[d]	90	75	75
Purchase Price/kg	65 FCFA	100 FCFA	0.496 Niara
Sale Price/kg	75 FCFA	110 FCFA	0.546 Niara
Index of Price[e]	115	110	110
Total Purchase Value	11,050 FCFA	23,800 FCFA	178.56 Niara
Total Sale Value	19,500 FCFA	34,430 FCFA	237.51 Niara
Increased Value	8,450 FCFA	10,630 FCFA	58.95 Niara
Costs[f]	5,453 FCFA	3,915 FCFA	35.03 Niara
Margin 1 Animal	2,997 FCFA	6,715 FCFA	23.92 Niara
Margin 3 Animals	8,991 FCFA	20,145 FCFA	71.76 Niara
Margin 5 Animals	14,985 FCFA	33,575 FCFA	119.60 Niara
Margin 1 Animal (with index of price = 130)	5,467 FCFA	12,975 FCFA	66.9 Niara

a) Niger: Based upon feeding trials at Toukounos Ranch (L. Adamou, "Embouche Intensive au Niger," I.E.M.V.T., Actes du Colloques, pp. 305-310). Animals consumed about 2 kg/day/head concentrate (47% rice farine, 35% millet, 15% groundnut cake, 3% mineral salts) @ FCFA 11/kg and high quality silage. Assumed interest charge (on total cost of one animal and concentrate) is 15%. Sale price in Niamey is net of transport and slaughter taxes.

TABLE 5 (Continued)

b) Senegal: Based upon data from: I.B.R.D., Appraisal of Sine Saloum Agricultural Development Project, Senegal, Report No. 661a-S.E. (Wash., D.C., May 5, 1975); and M. Sargent, I.R.A.T.: Research on Cereal Production Technology in Senegal and Upper Volta, U.S.A.I.D. mimeographed report (Wash., D.C., September 14, 1974), pp. 29-30. Under the S.O.D.E.V.A. project, animals are fed 50 g/day mineral supplement manufactured in Kaolack (45 per cent bone meal, 35 per cent salt, and 20 per cent fish meal) @ FCFA 40/kg, as well as groundnut stalks and cereal stover. Reported gains were 500 g/day. Assumed interest charge is 15 per cent. Farmgate prices in Kaolack are net of marketing costs.

c) Nigeria: Based upon a budget for small unit feeders in: I.B.R.D., Appraisal of a Livestock Development Project, Nigeria, Report No. 127a-U.N.I. (Wash., D.C., October 9, 1974) Annex 10, p. 2. Animals would be fed one kg/day concentrate (cottonseed, rice bran/middlings, groundnut cake) @ ₦ 0.110/kg and groundnut stalks. Interest under the project is charged at 9.5 per cent. (Cattle insurance was charged at ₦ 0.0176/kg. This would increase costs by ₦ 8.6/head). Liveweight prices in northern Nigeria were estimated to range from ₦ 160-180/head for 318-363 kg animals.

d) Compare with feeding trials cited in Appendix H.

e) Purchase price/kg = 100.

f) Concentrate and interest.

	E. Niger	Senegal	Nigeria
purchase value	$44	$ 95	$271
sale value	78	138	360
net increase in value	34	43	89
costs	22	16	53
margin one animal	12	27	36
margin three animals	36	81	108
margin five animals	$60	$135	$180
margin one animal (@ 30% price differential)	$22	$ 52	$102

Source: Table 5. FCFA 1 = $0.004; Niara 1 = $1.52.

However, when asked why they feed out cattle, small unit feeders in northern Nigeria responded that cattle-feeding is a means of saving money (i.e., holding operating capital together over the dry season) and is a valuable source of manure (101).

Furthermore, small unit feeders with access to urban markets can obtain larger feeding margins for their animals. The small price differentials assumed in Table 5 might be representative for feeders located within production zones. If it were assumed instead, for example, that the feeder in northern Nigeria could obtain a price differential of thirty per cent (as in terminal urban markets), then revenues above concentrate and interest would be about $100.[1]

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[1]This may be considered to be a substantial profit for the feeding of one animal when compared to average farm income (including value of subsistence) of about $220 in the Gusau region (82, p. 24).

Constraints to Future Expansion

The constraints to the expansion of small unit feeding are similar to those for bovine traction (feeding and nutrition during the dry season, health problems of settled management, availability of institutional credit, etc.) However, it would appear that the two most important constraints to the expansion of small unit feeding are: seasonal shortages of feedstuffs, especially agro-industrial by-products; and the inability of the farmer to obtain a good feeding margin for his finished animals.

The first constraint would appear to limit small unit feeding activities near irrigated schemes or lowland areas (where there is year around availability of forage) or near agro-industrial processing plants (rice mills, sugar refineries or cotton gins). Otherwise, expansion of small unit feeding would appear to depend upon the ability or willingness of the farmer to grow and store forage crops (85, p. 245).

The second constraint appears to limit small unit feeding activities to areas with access to the better developed urban markets.

CHAPTER VI

IMPACT OF BOVINE TRACTION AND SMALL UNIT FEEDING UPON THE AVAILABLE SUPPLY OF RED CARCASS MEAT

This chapter will examine the question whether or not bovine traction and small unit feeding (separately or combined) may increase the supply of red beef in a region. The question whether or not the utilization of young animals for several years of draft work may subtract from the available supply of red carcass meat (because of delayed marketing) will also be examined.

The Example of Senegal

In 1974, the F.A.O. estimated that there were 2.296 million cattle in Senegal (42, I). Almost half (1.042 million) are estimated to be of the trypano-tolerant (humpless) and intermediate (Zebu X humpless) cattle types. About half of these animals (604,600) are located in the Sine Saloum and Senegal Oriental (Eastern Senegal) regions. Possibly four per cent of these animals were male three year olds and perhaps thirty per cent were marketed for slaughter. Based upon these assumptions, there may have been 7,300 male three year olds available for slaughter in the Sine-Saloum region in 1974. Since the Djakore (Zebu Gobra X N'dama) intermediate type cattle appear to be very numerous in the Sine-Saloum and

Senegal Oriental regions, it will also be assumed that the 7,300 available three year olds are Djakore cattle.[1]

There were estimated to be about 16,400 working oxen in Senegal in 1974 (149, p. 29). Most of these are located within the Sine Saloum region, and many of these are Djakore cattle (135, p. 827). For the purposes of this exercise, it will be assumed that all the working oxen were also Djakore cattle.

It will also be assumed that the average annual mortality of working oxen is four per cent, that their effective numbers grow by eight per cent per year, and that all draft animals are males and are extracted from local herds at age three.

Systems of Rotation

Two systems of rotation (replacement) of the oxen may be examined:

1) Rapid rotation, or the "ideal" system, where the animals are purchased and put to work at age three, worked for three years, and sold at age six.

2) Slow rotation, or the most widely practiced system now, where the animals are purchased and put to work at age

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[1]Estimates of population of breed types by region, per centage male three year olds and per centage off-take are drawn from: 152, Tableaux 2.214 (b) and (c), pp. 26-28; and Appendix N. S.E.D.E.S. estimates that perhaps ninety-seven per cent of the cattle in Sine-Saloum and ninety-four per cent in Senegal Oriental (Eastern Senegal) are trypano-tolerant or intermediate cattle. Many of these are Djakore cattle (75; 112, p. 15). The Djakore are considered ideal work cattle because, to a certain extent, they retain the size of the Gobra and the trypano-tolerance of the N'dama. Mason (Ibid.) states that they exhibit a certain hybrid vigor and are valued as beef animals. Doutresoulle (35, p. 94) reports that bulls commonly weigh 400 kgs.

three, worked for six years, and sold at age nine.

The age distribution and total animals marketed under the two systems would be that shown in Table 6.

TABLE 6

HYPOTHETICAL AGE CLASS AND OFF-TAKE OF CATTLE UNDER RAPID AND SLOW SYSTEMS OF OXEN ROTATION

		Rapid Rotation		Slow Rotation	
Age Class	Total Available	Oxen	Total Marketed	Oxen	Total Marketed
10					
9					1,800
8				2,000	
7				2,300	
6			4,300	2,500	
5		4,900		2,800	
4		5,400		3,200	
3	7,300	6,100	1,200	3,600	3,700
		16,400	5,500	16,400	5,500

Both systems utilize the same number of oxen. Under the rapid system, 6,100 out of a total available of 7,300 three year olds are purchased and put to work, leaving 1,200 to be marketed along with 4,300 six year olds. Under the slow system, 3,600 are purchased and put to work from the available 7,300 three year olds, leaving 3,700 three year olds to be marketed along with 1,800 nine year olds.

Weight Gains and K.O.P.

Some assumptions must now be made about the daily weight gains and K.O.P. (Killing-Out Percentage) under different systems of management. Annual liveweights for Djakore cattle as recorded at the Centre de Recherches Agronomiques at Bambey, Senegal, are presented in Table 7. Annual liveweights for other intermediate and trypano-tolerant types are also indicated.

Any attempts to accurately estimate average weight gains and K.O.P. for cattle in any system of management in West Africa may be misleading. For the purposes of this exercise, it will nonetheless be assumed that average liveweights, daily weight gains and K.O.P. for Djakore cattle under various systems of management will be those presented in Table 8. These may be considered to be conservative.

There are four different systems of management conceptualized in Table 8:

System 1) Three-year-olds raised in traditional herds and immediately marketed for slaughter.

System 2) Three year olds raised in traditional herds but stall-fed for 150 days before marketing.

System 3) Three year olds put to work under a rapid system of rotation. They are worked for three years, removed from work at age six and then stall-fed for 150 days before marketing.

System 4) Three year olds put to work under a slow system of rotation. They are worked for six years, removed from work

TABLE 7

MALE LIVEWEIGHTS OF TRYPANO-TOLERANT AND INTERMEDIATE CATTLE TYPES

(kgs)

Station	Type	Birth	1	2	3	4	5	6	7	8	9	10
Farako-Ba[a]	Azaouak X N'dama	19	171	271	345	400	450	495	-	-	-	-
Bambey[b]	Djakore	21	144	203	238	311	342	389	402	430	460	460
Musaia[c]	N'dama	-	136	220	-	-	363	-	-	-	-	-
Minankro[d]	N'dama	18	130	227	311	324	-	-	-	-	-	-
Upper Ogun[e]	N'dama X WAS	16	127	208	270	-	-	-	-	-	-	-

a) (Upper Volta) These weights are based upon only a few weighings of working oxen at the station and can only be considered indicative. C. Malcoiffe, "Note sur la Gestion et L'Evolution des Troupeaux Bovins des Stations I.R.A.T. de Haute-Volta (1963-1971)," Agronomie Tropicale, XXVII, No. 5 (1972), pp. 624-630 and Fig. 7, p. 627.

b) (Senegal) P. Nourissat, "La Traction bovine au Senegal," Agronomie Tropicale, XX, 9 (1965), Tableau V, p. 827.

c) (Sierra Leone) N. R. Joshi et al., Types and Breeds of West African Cattle, F.A.O. Agricultural Study No. 37 (Rome: F.A.O., 1957), Table 44, p. 124.

d) (Ivory Coast) Years 1,2 and 3 represent gains on permanent Stylosanthes pasture. The best five year old bulls rarely weigh more than 450 kg. J. Coulomb, "La Race N'dama: Quelques Caracteristiques Zootechniques," Revue de'Elevage et de Medecine Veterinaire des Pays Tropicaux, XXIX, No. 4 (1976), pp. 367-380. G. Renaut reports that six year old N'dama oxen may weigh 350-375 kg. "Contribution au Development de la Culture Attelee en Cote d'Ivoire," Machinisme Agricole Tropicale, No. 15 (July-Sept, 1966), p. 35.

e) (Nigeria) V. A. Oyenuga, Agriculture in Nigeria, (Rome: F.A.O., 1967), Table 10.4.

TABLE 8

INDICATIVE LIVEWEIGHTS, WEIGHT GAINS AND K.O.P. FOR INTERMEDIATE (DJAKORE) TYPE CATTLE UNDER DIFFERENT SYSTEMS OF MANAGEMENT

(kgs)

	Traditional	Finished at 3 years	Oxen Rapid Rotation	Oxen Slow Rotation
Liveweight at 3 years[a]	238.0	238.0	238.0	238.0
Daily gain 36-60 months[b]	--	--	0.138	0.138
Daily gain 60-72 months[b]	--	--	--	0.065
Weight before finishing[a]	--	238.0	389.0	460.0
Daily gain 150 days finishing[c]	--	0.500	0.400	--
Daily gain 60 days finishing[c]	--	--	--	0.350
Net gain after finishing	--	75.0	60.0	21.0
Final liveweight	238.0	313.0	449.0	481.0
KOP (Killing-Out Percentage)	50%	54%	52%	50%
Carcass weight	119.0	169.0	233.5	240.5

a) Liveweights for Djakore (Zebu X N'dama) at ages 3, 6 and 9 are drawn from Table 7.

TABLE 8 (Continued)

b) It is believed that these daily gains for stall-fed working oxen are conservative. S.O.D.E.V.A. has reported that stall-fed working oxen (fed groundnut tops, cereal hay and a mineral concentrate) gained 0.164-0.219 kg/day (60-80 kg/year). Cited in: I.B.R.D., Appraisal of Sine Saloum Agricultural Development Project, Senegal, Report No. 661a-S.E. (Wash., D.C., May 5, 1975), Annex 5, p. 2.

c) It is believed that these daily gains for stall-finishing are conservative. It was reported that stall-finished oxen in the S.O.D.E.V.A. program gained 0.500 kg/day (M. Sargent, I.R.A.T., Research on Cereal Production Technology in Senegal and Upper Volta, U.S.A.I.D. mimeographed report (Wash., D.C., September 24, 1974), p. 30).

d) See Appendix H for K.O.P. of controls in feeding trials with Djakore and N'dama cattle.

e) N. R.Joshi et al. (Types and Breeds of West African Cattle) report that "average" N'dama oxen yield 45-50 per cent while the "best" yield 54-55 per cent (p. 126). N'dama in Sierra Leone yield about 42 per cent, while Fulani (predominantly Zebu) trade cattle in Ghana yield about 48 per cent (R. W. Touchberry, A Study of the N'dama Cattle at the Musaia Animal Husbandry Station in Sierra Leone, University of Illinois Agricultural Experiment Station Bulletin No. 724, 1967, Table 16; and J. Kahoun, "Slaughter and Carcass Characteristics in Fulani Cattle," Acta Universitatis Agriculturae: Faculatas Agronomica (Brno), XXI., No. 3 (1973), p. 580.)

at age nine, then stall-fed for 60 days before marketing.[1]

Total Available Carcass Meat

Total available carcass meat from different combinations of systems of management (utilizing the same number of animals) is computed from Tables 6 and 8, and presented in Table 9. The seven situations represented in Table 9 are listed below, as are the conclusions which may be tentatively drawn from this analysis.

1) Traditional (no bovine traction or small unit feeding).--All available three year olds are marketed for slaughter in the conventional system, which produces an available supply of red beef of 868,700 metrics tons.

2) All three year olds finished (no bovine traction).--Feeding out all the available three year olds for five months (at daily gains of 0.500 kilograms per day) can increase the available supply of red carcass meat by forty per cent.

3) and 4) Rapid systems of rotation.--A rapid system of rotation (where marketing of oxen is delayed the least) can increase the available supply of carcass meat from three year olds by thirty to forty per cent, depending upon whether or not the remaining three year olds are fed out also.

5) and 6) Slow systems of rotation.--A slow system of rotation (where marketing of oxen is delayed the most) can maintain the available supply of carcass meat from three year olds

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[1]Trials (167) in Senegal indicate that the feeding of older Zebu Gobra oxen for periods longer than two to three months is not economic. It is assumed here that nine year old intermediate type cattle are also responsive to short periods of stall-feeding.

TABLE 9

TOTAL AVAILABLE CARCASS MEAT UNDER DIFFERENT SITUATIONS

Situation	Age	Total Animals Marketed	Carcass Weight (kgs)	Total Carcass Weight (kgs)	Index
1) Traditional (no bovine traction)	3	7,300	119.0	868,700	100
2) All 3 yr olds finished (no bovine traction)	3	7,300	169.0	1,233,700	142
3) Rapid Rotation (3 yr olds not finished)					
Traditional	3	1,200	119.0	142,800	
Oxen	6	4,300	233.5	1,004,050	132
				1,146,850	
4) Rapid Rotation (3 yr olds finished					
Traditional	3	1,200	169.0	202,800	
Oxen	6	4,300	233.5	1,004,050	140
				1,206,850	
5) Slow Rotation (3 yr olds not finished					
Traditional	3	3,700	119.0	440,300	
Oxen	9	1,800	240.5	432,900	101
				873,200	

TABLE 9 (Continued)

Situation	Age	Total Animals Marketed	Carcass Weight (kgs)	Total Carcass Weight (kgs)	Index
6) Slow Rotation (3 yr olds finished					
Traditional	3	3,700	169.0	625,300	
Oxen	9	1,800	240.5	432,900	122
				1,058,200	
7) Slow Rotation (neither 3 yr olds nor oxen are finished)					
Traditional	3	3,700	119.0	440,300	
Oxen	9	1,800	230.0	414,000	98
				854,300	

at the current level or increase it by twenty per cent, depending upon whether or not the remaining available three year olds are also fed out.

7) Slow system of rotation (neither oxen nor the remaining three year olds are fed out).--This system just about maintains the available supply of carcass meat from three year olds at the current levels.[1] It must be pointed out, however, that in this particular example, bovine traction would in fact decrease the meat supply at annual mortality rates above four per cent. It would increase the available supply of meat at rates below four per cent.

This analysis would indicate that bovine traction does not decrease the available supply of meat from delayed marketing, and can substantially increase the meat supply when combined with small unit feeding.

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[1]Assumed K.O.P. for oxen under situation 7) is 48% of final liveweight (based on estimate for Fulani trade cattle in 97).

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Potential benefits of bovine traction and small unit feeding

Data from research stations indicate that bovine traction (ox-plowing) in a system of mixed farming may increase production in the following ways: increases in yields from the cultivation effects and timeliness of plowing; increases in area cultivated by reducing per hectare labor requirements; and increases or maintenance of yields from the stall production and utilization of manure. Other benefits are additional revenues from custom work and the increase in value of the animals before sale.

Small unit feeding (stall-feeding of small numbers of cattle on small farms) may occur separately from or conjointly with bovine traction. Small unit feeding enables the farmer to convert farm by-products into cash, may be a source of manure for his crops, and, like ox-plowing, initiate on-farm beef production on sedentary farms. Data from research stations have shown that most West African breed types of cattle have good feeding qualities.

Through a closer association of crop and livestock husbandry, bovine traction and small unit feeding may play a role in

the regional stratification approach to West African livestock development by: increasing net cash farm incomes; increasing the demand for immatures from northern ranges; and increasing the regional supply of red beef carcass meat.

Location and importance of bovine traction

Despite its considerable benefits, bovine traction is a technology enjoyed by only a minority (less than five per cent) of West African farmers. There are possibly a half million working oxen in West Africa, comprising less than two per cent of the region's thirty million cattle. Older oxen might represent only four per cent of all cattle slaughtered in the region. Nonetheless, the magnitude of investment in oxen and equipment (possibly $100 million, or $400 per farmer) is comparable to overall investment in tractors. Furthermore, the number of cattle put into traction may be growing at seven to eight per cent per year.

Physical and economic factors have favored the development of bovine traction within the Sudanian Eco-Climatic Zone (650 mm to 900-1,200 mm isohyets). The former include: light vegetation (permitting easy clearing); sandy, friable soils (requiring less tractive power); and the dry climate (limiting tse-tse infestation). The latter include: proximity to a cattle production area (ensuring a supply of suitable animals); the ownership of "wealth" (i.e., productive resources); and cultivation of cash crops.

Relatively wealthy farmers tend to: already own cattle (meaning lower start-up costs); cultivate larger holdings

(meaning fewer problems of scale); manage a larger labor force (to perform weeding, which is too difficult with ox-cultivation); and receive more attention from extension and other support services (because of "model farmer" approaches). Cultivation of one of the major cash crops in the region (groundnuts or cotton) permits the farmer to more rapidly pay off his loan.

The presence of several institutional factors (support services) have also been necessary: extension support and training programs; veterinary services; institutional credit; research and design activities; village-level maintenance and repair facilities; and a dependable supply of inputs, as well as assured markets for production increases in some areas.

Increase in cash farm income from the adoption of bovine traction

Review of available farm management data.--A review of the available farm management data strongly suggests that bovine traction has had only limited success in the field. Although yield increases may be as high as twenty-five per cent for groundnuts and thirty per cent for cereals in some areas, elsewhere they have not been significant. Although farmers who have adopted ox-cultivation may have substantially increased area cultivated, the evidence available to data indicates that annual increases in area have only been on the order of four or five per cent per year. The primary constraint to increased yields and area cultivated is the inability of the farmer to perform ox-drawn weeding, either because of the lack of proper weeding attachments, lack of skill and training on the part of

the farmer, or lack of training or poor condition of the animals. These problems are in turn related to the strong need for support services (extension and training, veterinary, research and design) and the dry season feeding and health constraints (discussed below). The latter also appear to be very important constraints to year-round stall production of manure, which is not at all widely practiced.

It is therefore not surprising that custom or rental services provide extremely important cash revenues to farmers who have inadequate farm resources to feed their oxen or who cannot increase production because of the weeding constraint. However, it appears that the general expansion of custom work is limited by the requirement for timely cultural operations.

Similarly, revenues from sale of the oxen are considerable and are an important source of capital regeneration. This is because the animals have increased in weight and value. However, most farmers in West Africa work oxen on the farm beyond full maturity, at which point their rate of appreciation begins to decline. Failure to sell animals when it is most economic to do so is due to: difficulty of obtaining suitable working-size immatures, training them and keeping them trained (i.e., high replacement costs); and difficulty of obtaining full cash value of older animals because many farmers do not have access to stronger urban markets. Difficulty of training animals and keeping them trained implies the need for strong extension and training support services. But the inability to maintain a high level of animal training is also related to the dry season feeding constraint.

Indicative budget.--The limitations of ox-cultivation as a technology adapted to many West African farmers are further brought out by an indicative budget for a farm adopting bovine traction. Based upon the review of available farm management data, a pro forma budget in a cash-flow format gives an idea of magnitude and incidence of cash revenues and cash costs over the working period of a team of oxen on the farm. Results correspond well with generalizations made elsewhere in the literature about animal traction in West Africa.

Results indicate that the farmer adopting ox-cultivation does not substantially increase net cash farm revenues (profit and depreciation) until the third or fourth year of adoption. This is due to the considerable investment requirement for equipment and team at conventionally available medium-term credit ($500 with a downpayment of twenty-five per cent and three years repayment at seven per cent), in comparison to estimated cash farm revenues (net of subsistence) of $275. Failure to substantially increase net cash farm revenues the first few years is also due to inadequate net increases in production. Net increase in value of production from the adoption of ox-cultivation ranged from $175 the first year of adoption to $300 in the fourth year, in comparison to a $600 value of production under manual cultivation. The budget also shows the importance of custom revenues, which in the case of the budget might be fifty dollars a year, but elsewhere in West Africa might be substantially higher (possibly $200). Gross revenues from sale of the team at maturity (about $350) and net revenues (about $160) after costing the replacement team

clearly indicate that sale of the team is an important source of capital regeneration.

Failure to substantially increase cash farm revenues from the adoption of bovine traction suggests that adoption may not be due to increases in income but to social gains (prestige, increase in leisure time, relief from drudgery) or increase in other income from any labor saved by animal-powered cultivation.

Selected constraints to the general expansion of bovine traction

A primary constraint to the general expansion of ox-cultivation within and south of the Sudanian Zone is the lack of or inadequate institutional support services. However, certain constraints which continue to limit the expansion of ox-cultivation are also general constraints to settled livestock production in West Africa: the limitations of local breeds, poor health; inadequate feeding and nutrition; and difficulty of obtaining and marketing animals.

Breeds.--The breed types of West African cattle are (in order of heaviest weight and least resistance to trypanosomiasis): trypano-susceptible (Zebu); intermediate (Zebu X N'dama and Zebu X West African Shorthorn); and trypano-tolerant (N'dama and WAS). Required tractive power for different cultural operations and the most recent estimates of average cattle liveweights were examined. Most Zebu and intermediate, many N'dama but few WAS types can provide enough power for the minimum operations of scarification, seeding, weeding and groundnut lifting in the sandy to coarse loamy soils of West Africa. Few animals appear large enough to perform plowing under of

vegetative matter. However, the introduction and utilization of (heavier) Zebu stock into areas below the 1,000 mm isohyet is not feasible because of disease limitations. These areas hold the greatest potential for the future expansion of bovine traction.

Health.--Annual age-specific mortality rates in areas of bovine traction activities may vary from one to ten per cent or even higher. Trypanosomiasis, other diseases, as well as mismanagement of animals (overwork) are prominent causes of death. The general state of working oxen appears to be mediocre due to a combination of poor nutrition and polyparasitism. Because of the greater health problems associated with sedentary management and the general inexperience of settled agriculturalists, ox-powered farmers need more individual attention for which the West African veterinary services are under-equipped and under-staffed to provide.

Feeding and nutrition.--The dry season feeding problem is a primary constraint to the general expansion of bovine traction activities in West Africa. The lack of on-farm resources (water, crop residues and fallow grazing) to support a team year around requires that the animals be grazed extensively (away from the farm) for all or part of the dry season. The farmer usually contracts the management of oxen over the dry season to Fulani herders, or may permit the animals to graze in the village area with little or no supervision. Under either system, extensive grazing over the seven to nine month dry season on natural grasses causes a decline in animal weight (ten to thirty-three per cent) and animal health, as

well as a loss of manure and the inability to retrieve the oxen when needed for work. More important, extensive grazing away from the farm means that the animals are not accessible to the farmer for a period of several months, which prevents year around utilization (custom carting) and maintenance of a high level of domestication. Thus, not only are the animals in poor physical condition but they have lost a degree of training by the end of the dry season when the heaviest work (land preparation) is required of them. A feeding-up and work ration of cereal grain or bran is then required, but it is at this time when the average West African farmer's cash resources and family granaries are at their lowest.

There are relatively few alternative solutions to the problem of dry season feeding and nutrition other than traditional grazing strategies. Partial solutions are: a more complete utilization and storage of crop residues; making agro-industrial by-products more available to farmers; haymaking and ensilage of natural or cultivated forage. The remaining and only truly viable alternative is either forage production in crop rotations (legumes by themselves or in mixtures with grasses or cereals) or controlled grazing on improved (oversown) local range lands or village grazing reserves. Little evidence to date indicates that farmers have adopted the practice of growing forage crops in rotation. A fundamental constraint to both forage cultivation and controlled grazing is the system of land tenure.

Supply and marketing.--The evidence indicates that there is a growing shortage of young animals suitable for draft, which prices large, working-size steers out of the range of many farmers. Results of an attempt to approximate the supply of available male animals from the Sudanian and Sahelian range lands indicate that possibly 120,000 (only eight per cent of all male three year olds and twenty to thirty per cent of annually marketed three year olds) were drawn off for draft work. Thus, theoretically, there is no supply constraint. However, if it is assumed that only the top two thirds of the number of animals marketed annually are suitable for draft (size, conformation, health), then current bovine traction activities may be already utilizing thirty to forty per cent of marketed animals suitable for draft in some areas. Under this assumption and at current rates of increase in demand for working oxen (eight per cent) and population of total herd (three per cent), then the upper supply limit of marketed animals suitable for draft would be reached in less than a decade.

Possibly four per cent of all cattle marketed for slaughter in 1974 were older oxen. The evidence indicates that farmers have difficulty marketing older oxen rapidly and efficiently to obtain their full market value.

Increase in cash farm incomes from the adoption of small unit feeding

Selected aspects of supply and demand for cattle.--The structure of demand for beef in both consumption and production

zones in West Africa is such that highest market prices per kilogram liveweight are paid for large, well-fleshed animals at full maturity. Outside of the largest urban markets, "prime" (marbled) beef and thus "fat" animals do not command high prices, as they cannot be marketed from production zones in the conventional manner (trekking) without substantial weight loss.

Liveweight prices in crop production zones generally fluxuate with supply (local patterns of transhumance) and tend to be lowest towards the end of the rainy season and highest towards the end of the dry season. In an opposite fashion, animal liveweights fluxuate according to availability of feed and are high at the end of the rainy season and low at the end of the dry season. Thus, because the degree of finish is not as important a goal in West African cattle-feeding (as it is in the United States), and because well-fleshed animals may bring especially high prices during the dry season, cattle-feeding may be profitable even though it amounts to maintenance of the animal's weight over the dry season. However, entrepreneurs with access to strong urban markets (often by truck or rail) can get good premiums for finished animals.

Review of available farm management data.--There is very little published information about actual numbers of cattle fed out by small scale feeders, although locations of small unit feeding appear to be geographically widespread. There are two general types of small unit feeding currently practiced in West Africa: the feeding of cattle in stalls, at the stake or in enclosed areas to take advantage of local price fluxuations;

and the pit-fattening of cattle in northern Cameroon.

The former type of activity is more numerically important and is practiced by butchers, entrepreneurs and farmers at points anywhere between cattle production zones and transportation terminals, large cattle markets or urban areas. It occurs where there are available supplies of dry season grazing (lowland pastures), as well as in regions where farmers have adopted bovine traction. The pit-fattening of cattle is geographically limited to northern Cameroon and appears to be practiced primarily for religious purposes, although some villages have commercialized the operation.

Profitability of small unit feeding depends most upon the price differential, or feeding margin (difference between sale and purchase price per kilogram liveweight), as well as other factors. Actual price differentials in terminal urban markets may range from twenty to thirty per cent more than purchase price per kilogram for forty to fifty kilogram net liveweight differences.

Indicative budgets.--Indicative small unit feeding budgets for Niger, Senegal and Nigeria were constructed with only ten to fifteen per cent price differentials for seventy-five to ninety kilogram net gains (over a feeding period of 150 days). Margins above cost of concentrate and interest indicate that profit from small unit feeding in production zones may be quite small, but may range from $20 to $100 per head if the feeder has access to a strong market.

Constraints to future expansion.--It appears that the two most important constraints to the general expansion of small

unit feeding are: the absence of a year-round supply of feedstuffs; and the inability of the farmer to obtain a good feeding margin for his finished animals. The former will continue to limit feeding activities near irrigated schemes, lowland areas or agro-industrial processing plants, while the latter will continue to limit feeding activities to areas with access to urban markets.

Conclusions

Evaluation of the role of bovine traction and small unit feeding in the regional stratification approach

Under currently operating constraints, the adoption of bovine traction would not substantially increase cash farm incomes for many West African farmers.--The adoption of bovine traction would not substantially increase cash farm incomes for the majority of West African farmers. Many cultivate small and/or fragmented holdings which prevent profitable utilization of a team because of problems of scale (especially high feeding costs). Furthermore, required investment in team and equipment (about $500) is beyond the means of the average small farmer in a region of the world where average per capita incomes are very low ($200-250). Although liberalized credit repayment (longer than three years) or subsidy of equipment may lower the annual investment costs, increase in production may not be possible because of the inability of the farmer to overcome the two most important constraints: weeding and dry season feeding. These two constraints are closely related in that the latter con-

tributes to the former by causing loss in training and weight during extensive grazing away from the farm on natural grasses over the long dry season. Finally, the ability to earn considerable custom revenues does permit a farmer to adopt ox-cultivation even though his production is limited by the weeding constraint or his holding is too small to feed his power source. But the number of farms he can service is limited by the requirement for timely cultural operations, as well as by the number of manual and ox-powered farms in his area (i.e., local demand and supply of custom services). Finally, although income realized from the increase in weight and value of the team is considerable, beef production by itself cannot be a justification for the adoption of bovine traction.

Nonetheless, the fact that the number of working oxen is increasing by seven to eight per cent per year suggests that farmers are adopting ox-cultivation. The analysis indicates that the adoption of ox-cultivation can be profitable under most (but not necessarily all) of the following conditions:

1) the farmer already owns or has access to a pair of working-size bulls through kin or reciprocal relationships. This generally implies he also be located near a cattle production zone, ensuring a supply of working-size animals.

2) the farmer cultivates a large proportion of marketable cash crops in his crop mix (permitting him to pay off his loan more rapidly).

3) the farmer cultivates a relatively large holding (possibly five to eight hectares at a minimum). A large holding with a large proportion of contiguous land within it means

better efficiency (lower turn-around and transportation time between fields), lower feeding costs and a higher debt-carrying capacity. As size of holding is generally a function of available labor within the production unit, the farmer also must have access to a relatively large labor force (wage or family) to overcome the peak weeding constraint and to handle increases in area weeded. There may also be increased labor requirements for land-clearing (destumping), operation of the team (usually demanding three persons), as well as their daily care and management.

4) if condition 3) above is not met, then the farmer who adopts bovine traction must be able to earn a substantial amount of cash revenues from custom work.

5) the farmer has access to a strong urban market to realize maximum cash value of his older oxen.

6) he already utilizes some yield-increasing technologies.

7) he receives some support from extension, veterinary and other support services (including a dependable supply of inputs).

The analysis has indicated that those who have some of the above advantages likely comprise the top ten to fifteen per cent of farmers. Thus, the rate of increase in the number of working oxen would be expected to eventually decrease.[1] With increasing

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[1]A study in 1962 (108) predicted that because of the requirements of a relatively large land holding and labor force, ox-cultivation would not expand beyond the top ten per cent of farmers in Katsina Province, Nigeria (or beyond the top twenty-five per cent with a general expansion of custom work). For Nigeria as a whole, it appears that ox-cultivation has not expanded beyond one per cent of farmers in the Northern Region since 1966-70 (see pp. 11n and 57n, and Appendix I). More recent data as to the current number of ox-powered farms in Nigeria may confirm this assertion.

cattle ownership among settled agriculturalists, increasing beef prices, increased farmer training in weeding and increased availability of lower cost equipment packages designed for farmers with low cash resources, the current rate of expansion of ox-cultivation in West Africa may continue. However, with removal of the high start-up costs and increased farmer training in weeding, there would still remain the dry season feeding constraint. Ox-cultivation will remain an extremely important means of more closely integrating crop and livestock production on settled farms. But it will not become a truly viable farming system for many West African farmers until forage cultivation or controlled grazing evolve.

Therefore, the policy implication of this analysis is simply that bovine traction is not the universal answer to increased food and cash crop production in West Africa. Rather, the appropriate approach in integrated rural development projects is to promote other yield-increasing technologies (mineral fertilization, H.Y.V. seeds, chemical plant and seed protection) which may be more rapidly adopted by the mass of West African farmers, yet retain a bovine traction component for farmers who meet the above conditions.[1]

The adoption of small unit feeding may substantially increase cash farm incomes.--As indicated above, cattle-feeding can substantially increase cash farm incomes if feeders have access to major urban markets so as to obtain good feeing margins. A general expansion of this activity would be expected

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[1]This in fact appears to be the approach in some of the I.B.R.D. integrated rural development projects currently under way in West Africa.

with removal of the dry season feeding constraint and improved access to urban markets.

Bovine traction would not draw off a substantial number of immatures from northern rangelands.--Bovine traction activities may have drawn off only some eight per cent (120,000) of the 1.5 million three year olds in 1974, or less than a half per cent of the region's 30 million cattle. If bovine traction activities continued to increase at eight per cent per year and the national herds by three per cent, then by 1990 still less than one per cent of the national herds would be drawn off for traction. Furthermore, since over half of the regional herd is comprised for trypano-susceptible (Zebu) animals, future areas of potential expansion (which are below the tse-tse belt) would not substantially increase the demand for animals from the northern ranges. It is paradoxical that at the same time there may be a shortage of young animals suitable for draft, primarily because of the special requirements for draft work (size, conformation and health) and high morbidity and slow rates of maturity characteristic of most conventionally-managed animals.

Inadequate data for small unit feeding.--It appears that cattle-feeding activities present more potential for drawing off younger animals. However, there is very little evidence as to actual numbers of animals fed out.

Bovine traction and small unit feeding can increase the supply of red carcass meat.--In some areas, donor and national agencies actively promote bovine traction and small unit feeding together as beef production activities. Ideally, the

farmer would buy a pair of immatures, work them for two to three years, then market them after a few months of stall-feeding. For added income, the farmer would also be encouraged to feed immatures as a side activity.

However, the previous review of available farm management data indicated that because of high replacement costs and a possible supply constraint, most farmers in West Africa retain working oxen for several years. The question then arises whether or not the diversion of young animals into draft work is currently decreasing the available supply of red carcass meat because of delayed marketing.

A hypothetical model was utilized to explore this question as well as to compare the amount of beef carcass meat from a combined system of bovine traction and small unit feeding to the available amount of carcass meat from young animals which would otherwise be immediately marketed for slaughter.

Results indicate that at a low rate of annual mortality (four per cent) and average liveweight gains and K.O.P. (Killing-Out Percentage), ox-cultivation does not decrease the supply of available carcass meat because of delayed marketing. Combined with cattle-feeding, it can increase the supply of red carcass meat by as much as forty per cent.

Recommendations

Recommendations to increase the profitability and rate of expansion of bovine traction

Reduction of investment required.--To reduce the considerable investment required for ox-drawn equipment and team

(about $500), there is need for:

1) longer-term credit arrangements (longer than three years) or subsidy of equipment costs.

2) continued research and design of lower-cost, light-weight equipment packages which would be made available to farmers.

Increase in production.--To enable the farmer to realize full production increases (yields and area cultivated) from the adoption of bovine traction, the following are needed:

1) removal of the weeding constraint through improved farmer and animal training support activities, as well as increased availability of weeding and other equipment.

2) promotion of other yield-increasing technologies along with bovine traction (mineral fertilization, chemical plant protection, etc.).

3) removal of the animal breeding, animal health and dry season feeding and nutrition constraints to settled livestock production in West Africa. In particular, the health and feeding constraints contribute to poor animal performance and training, inadequate manure production and failure to adopt plowing under. The latter operation is also difficult to perform in semi-humid and humid zones because available breeds are too small.

Replacement of the team at maturity.--To permit farmers to replace their animals when it is most economic to do so requires:

1) lowering the cost of a trained pair of oxen by lowering training costs, by emphasizing that farmers train animals themselves and utilize them on the farm year around (custom carting).

2) removal of the supply and marketing constraints to settled livestock production as they apply to ox-powered farmers.

Recommendations for removal of livestock production constraints

Breeding.--Because the introduction and utilization of Zebu stock is not feasible in more humid zones, donor and national agencies must concentrate upon:

1) improved feeding and management of lighter breeds to enable them to provide more power.

2) organized breeding activities which would increase local supplies of trypano-tolerant and intermediate types of cattle (particularly N'dama X Zebu crosses).

Health.--Because of the greater health problems of settled management, the following are needed:

1) vaccinations against the full range of diseases which continue to remain endemic in West Africa.

2) simple anti-helminthic treatments made available to farmers.

3) increased attention from local veterinary services and/or organization of "self-help" societies to supply medicine and facilitate farmer training in their administration.

Feeding and nutrition.--Because forage cultivation and/or controlled grazing on improved rangelands is the only permanent means of breaking the dry season feeding constraint, there is immediate need for the following:

1) continued research into viable forage species for semi-humid and humid regions and their dissemination to farmers.

2) increased research into land tenure implications of controlled grazing schemes and/or village grazing reserves.

Supply and marketing.--Because the limited supply of working-size animals prices steers out of range of many farmers, the following interventions are necessary:

1) Health and nutrition programs for conventionally managed herds to increase the number of large, healthy animals suitable for draft.

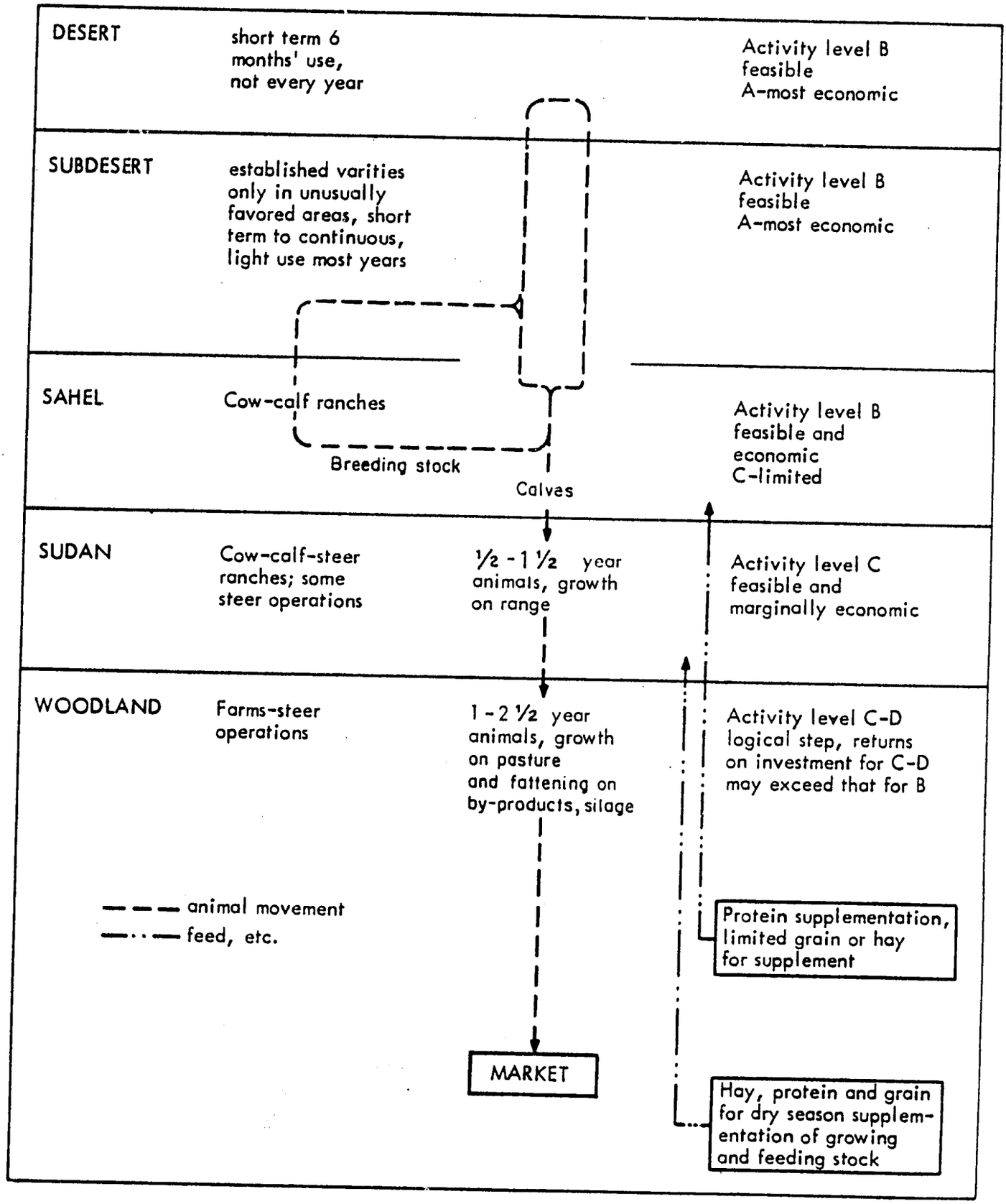
2) Breeding programs to increase the number of trypanotolerant and intermediate breeds for semi-humid and humid zones.

Because some ox-powered farms cannot get full cash value for older oxen, marketing interventions are needed to assist them in obtaining access to major markets.

Recommendations for increased expansion of small unit feeding

Because small unit feeders need a year-round supply of feed, removal of the dry season feeding constraint is required (as well as increased availability of agro-industrial by-products).

Because many feeders cannot obtain good feeding margins for finished animals, marketing interventions and/or improved transportation facilities are required for better access to the strong urban markets.



SCHEMATIC VIEW OF THE REGIONAL STRATIFICATION APPROACH

(Continued)

The following management systems are included in each activity level:

Level A (minimum activity)--fallow system of cultivation and extensive grazing of livestock within present capacity of environment.

Level B (extensive management activity)--improved hand tools; improvement of native seeds; water development (wells, catch basins, water spreading, etc.); fencing of cultivated areas; crop rotations; extensive management of livestock.

Level C (intensive management activity)--improved seeds introduced; some use of chemical fertilizer; chemical means of plant protection; animal traction; use of manure and green manure crops; forage cultivation and pasture rotation; reforestation in depleted areas; increased use of crop residues; some intensive feeding systems; improved breeding systems; milk production around cities; some commercialized poultry production.

Level D (widespread utilization of intensive agricultural systems, similar to those in developed countries)--full chemical fertilization and plant protection; introduction of exotic species and breeds; intensive pasture management; commercialized poultry production; environmental control systems for dairy animals; motorized irrigation; complete small and large scale mechanization, contract or corporate farming in irrigated areas; confined feeding systems; "today's best technology utilized."

Source: W. G. Matlock and E. L. Cockrum, A Framework for Evaluating Long-Term Strategies for the Development of the Sahel-Sudan Region. Vol. II. A Framework for Agricultural Development Planning. Center for Policy Alternatives. Massachusetts Institute of Technology (Cambridge, December 31, 1974), p. 159 and pp. 29-41.

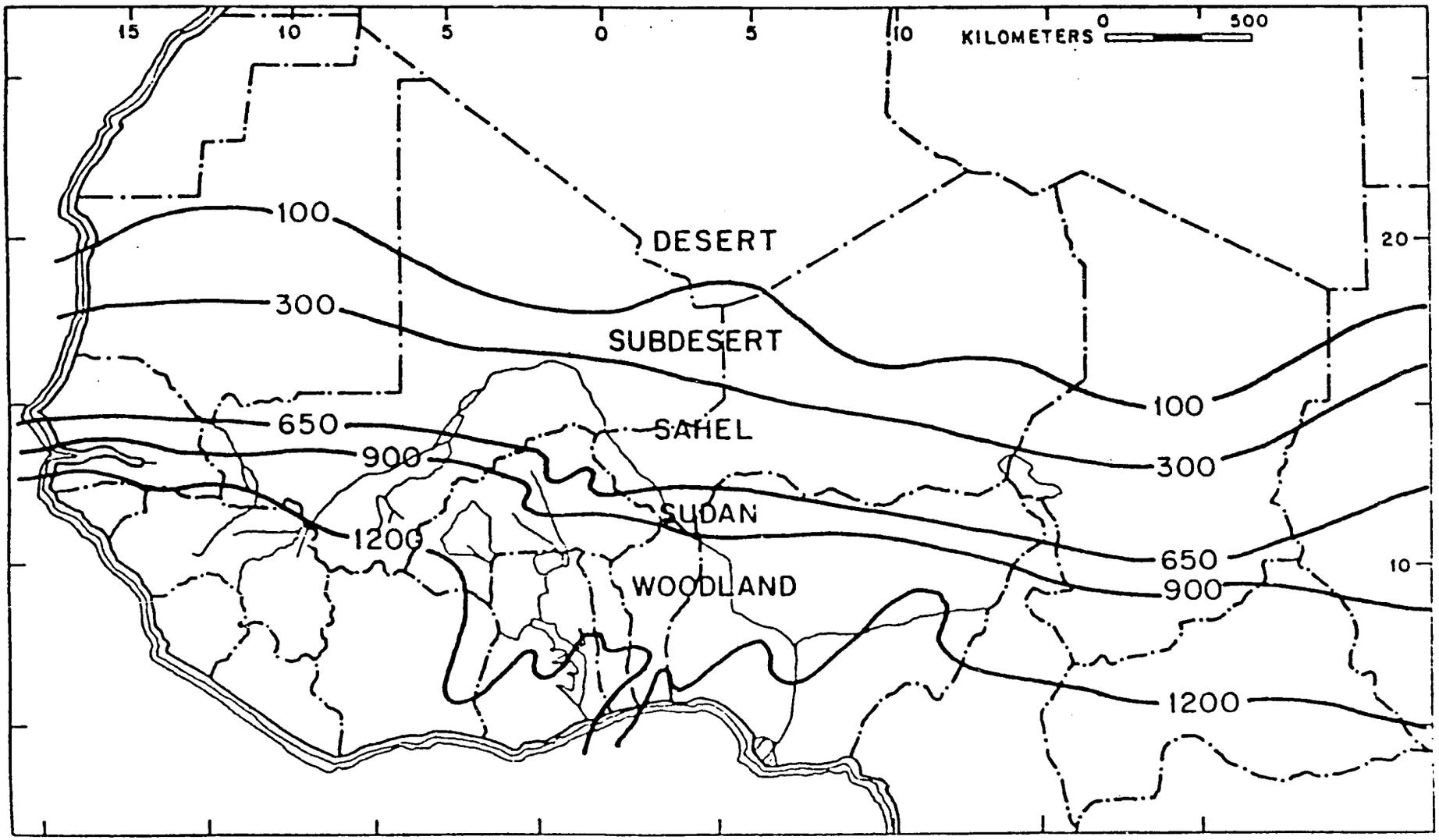


FIGURE 5

CLIMATIC ZONES OF WEST AFRICA

(Matlock and Cockrum, p. 74)

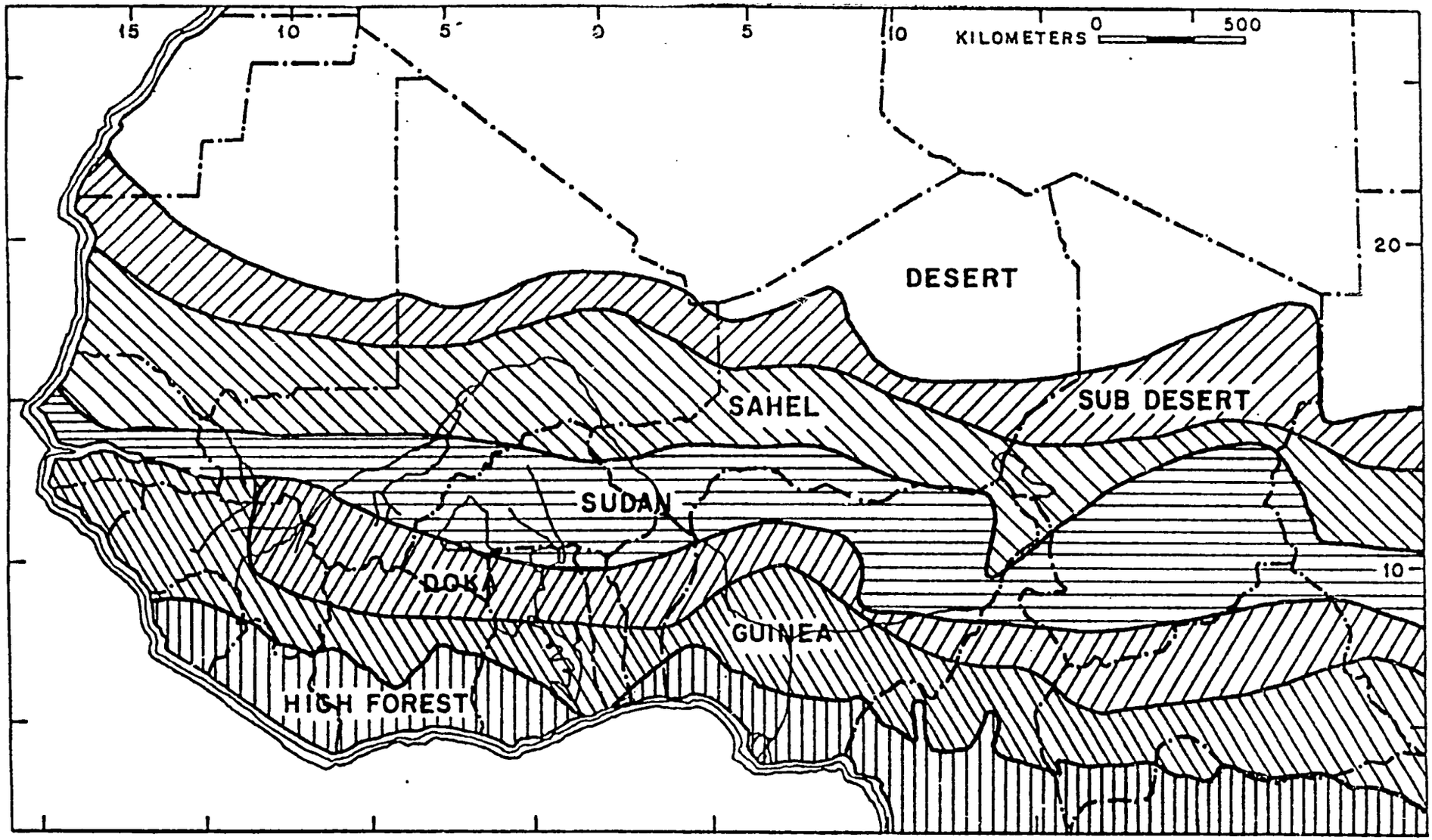


FIGURE 6

VEGETATION ZONES OF WEST AFRICA

(Matlock and Cockrum, p. 89)

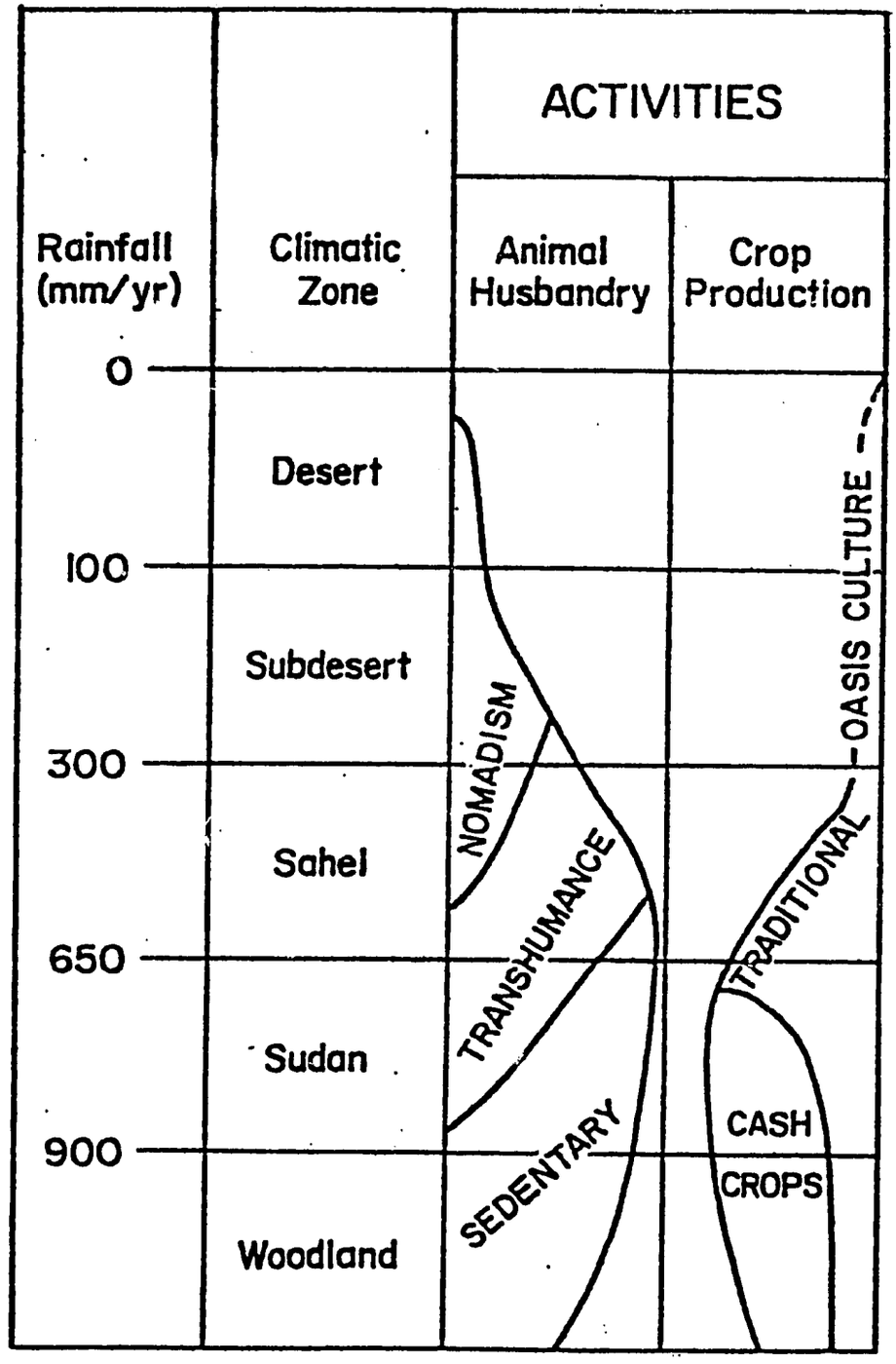


FIGURE 7.

DISTRIBUTION OF AGRICULTURAL ACTIVITIES BY CLIMATIC ZONE

(Matlock and Cockrum, p. 104.)

TABLE 10

I.R.A.T.[a] EXPERIMENTAL TRIALS 1950-1969: YIELD EFFECTS OF PLOWING ON SELECTED WEST AFRICAN CROPS

Crop	Number of Trials	Yield Unplowed Controls kg/ha	Yield on Plowed Fields kg/ha	Index[b] of Yield
Pearl Millet	21	1,245	1,501	121
Sorghum	39	1,874	2,410	129
Maize	6	2,093	2,661	127
Rainfed Rice (paddy)	11	966	2,481	257
Cotton	7	1,629	2,062	127
Groundnuts (unshelled)	27	1,412	1,686	119

a) Institut de Recherches Agronomiques Tropicales. Stations located in Senegal, Mauritania, Nigeria and Upper Volta. Tillage was performed on de-stumped land (sandy to coarse loamy soils) before and/or after the rainy season.

b) Unplowed = 100.

Source: C. Charreau and R. Nicou, "L'Amelioration du Profil Cultural dans les Sols Sableux et Sable-Argileux de la Zone Tropicale Seche Ouest-Africaine et ses Incidences Agronomiques," Agronomie Tropicale, XVI, No. 9 (1971), Table IV-18, p. 935.

TABLE 11

MALI: PER HECTARE LABOR REQUIREMENTS FOR GROUNDNUT AND CEREAL PRODUCTION UNDER MANUAL AND OX-POWERED CULTIVATION

Operation	Manual Cultivation	Ox-Drawn Cultivation	
	Man Days	Man Days	
Groundnuts			
Land preparation	12.50	13.00	
Planting	10.00	2.00	
2nd weeding	25.00	10.50	
3rd weeding	18.75	6.00	
Harvesting/Threshing	26.25	22.50	
Internal transport	12.00	5.75	% Reduction in Man Days
Total	104.5	59.75	57%
Sorghum/Millet			
Land preparation	12.05/8.50	10.00/6.50	
Planting	2.05	2.00	
1st weeding	12.00	6.00	
Ridging	6.25	2.00	
2nd weeding	12.00	6.00	
Internal transport	10.00/9.00	5.75	
Total	54.35/49.80	31.75/28.25	58/57%

Labor requirements for groundnuts are based upon 1,200 kg/ha yields. Requirements for the transport of cereals are based upon 900 kg/ha yield for sorghum and 725 kg/ha yield for millet. Ox-drawn equipment includes: multi-cultivator, seeder, groundnut

lifter, and cart. Where two figures are cited, the first refers to sorghum, the second to millet. I.R.A.T., Operation Arachide, as cited in: I.B.R.D., Appraisal of Integrated Rural Development Project, Mali, Report no. 340a-M.L.I. (Wash., D.C., May 13, 1974), Annex 3, Table 2.

TABLE 12

YIELD INCREASES FROM APPLICATION OF FARM YARD MANURE

IN SELECTED AREAS OF WEST AFRICA

Region	Crop	No. of Seasons	Unmanured Control Yield kg/ha	Manured Yield kg/ha	Index of Yield	Amount Applied m. tons/ha
Bouake[a]	rice	-	1,190	1,940	163	-
S. Saloum[b]	sorghum	1	540	1,167	216	10.0
Kano[c]	millet	10	689	1,000	145	6.7
	sorghum	10	437	1,067	244	6.7
	g'nuts	10	902	1,181	131	6.7
	A. gay.[d]	-	40,636	75,520	186	9.0
N. Ghana[e]	cereals	9	-	1,049	145	4.5-9.0
	g'nuts	5	-	717	114	4.5-9.0

a) (Ivory Coast) Yield for paddy rice is expressed in total dry matter. R. Hamon, "L'Habitat des Animaux et la Production d'un Fumier de Qualite en Zone Tropicale Seche," Agronomie Tropicale, XXVII, No. 5 (1972), p. 592.

b) (Senegal) Factorial analysis with sig. diff. (p=5%) of 336 kg. P. Vidal et al., "Influence des Fumures Organiques et Minerales sur la Production des Sorghos et la Qualite des Recoltes," Agronomie Tropicale XVII, No. 6 (1962), pp. 383-388.

c) (Nigeria) Average of yields in the northern Sudanian zone on five manured and unmanured plots. E. B. Dennison, "The Value of Farmyard Manure in Maintaining Fertility in Northern Nigeria," Empire Journal of Experimental Agriculture, XXIX, No. 116 (1961), pp. 330-336.

d) (Andropogon Gayanus) B. N. Bowden, "Studies on A. Gayanus Kunth. I. The Use of A. Gayanus in Agriculture," Empire Journal of Experimental Agriculture, XXXI, No. 123 (1963), pp. 267-73.

e) Factorial analysis where the average yield effects of manuring are expressed in percentages of mean plot yields in seven areas of the Guinea Savannah zone of northern Ghana. Average sig. diff. (p=5%) was 97 kg for cereals (millet,

sorghum, maize) and 38 kg for groundnuts. R. K. Djokoto and D. Stephens, "Thirty Long-Term Fertilizer Experiments under Continuous Cropping in Ghana. I. Crop Yields and Responses to Fertilizers and Manures," Empire Journal of Experimental Agriculture, XXIX, No. 114 (1961), pp. 181-195.

TABLE 13. WEST AFRICA: DAILY WEIGHT GAINS AND KILLING-OUT PERCENTAGES (KOP) FOR INTENSIVE FEEDING TRIALS

Group[a]/Location of Trials	Breed	Number	Initial Weight kg	Age Years	Length Trial days	Daily Gain kg	KOP %	KOP Control %	Source	Primary Feedstuff (Available Locally)
Zebu (long- or lyre-horned)										
Nigeria[b]/	W. Fulani	56	360	--	114	0.580	53	--	(e)	Groundnut cake, cotton seed, sorghum bran, groundnut tops, grass hay and/or grass silage.
Ivory Coast	S. Fulani	9	266	5-10	160	0.650	55	46	(f)	Improved permanent pasture (stylosanthes).
Senegal	Gobra	20	276	3-5	126	0.659	56	--	(g)	Molasses, groundnut shells, rice straw.
Senegal	Gobra	9	245	3-5	112	1.063	56	47	(h)	Cotton seed, molasses, groundnut shells.
Senegal	Cobra	15	367	7-9	84	0.800	58	53	(g)	Maize bran, rice farine, molasses, groundnut shells.
Zebu (short- or medium-horned)										
Niger	Azaouak	6	170	1+	150	0.720	54	--	(i)	Rice farine, millet, groundnut tops, grass silage.
Cameroon	Adamaoua	5	364	3-4	90	0.533[c]/	55	52	(j)	Cotton seed, grass hay, dry season pasture.
Cameroon	Adamaoua	36	346	4	48	1.028	52	--	(k)	Molasses, groundnut tops, grass (stylosanthes) hay.
Senegal	Maure	9	223	3-5	112	1.152	54	44	(h)	Cotton seed, molasses, groundnut shells.
Nigeria[b]/	Shuwa	50	300	--	104	0.629	--	--	(e)	Brewer's grains, groundnut cake, groundnut tops, grass hay or grass silage.
Nigeria[b]/	S. Gudale	19	331	--	117	0.749	--	--	(e)	Cotton seed, groundnut cake, groundnut tops, grass silage.
Zebu X Humpless										
Senegal	Djakore	--	--	2-3	60	1.000	--[d]/	--	(l)	Sorghum farine, groundnut tops.
Senegal	Djakore	9	236	3-5	112	0.938	55	45	(h)	Cotton seed, molasses, groundnut shells.
Humpless										
Ivory Coast	N'Dama	10	114	1	365	0.393	55	--	(m)	Improved permanent pasture (stylosanthes).
Ivory Coast	N'Dama	10	224	3-5	112	0.813	54	46	(h)	Cotton seed, molasses, groundnut shells.

(Continued)

NOTE: Veterinary treatment was administered in most trials: anti-parasitic drugs, antibiotics, vaccinations or prophylactic treatment against trypanosomiasis. K.O.P. (Killing-Out Percentage) or "rendement brut" is the hot carcass weight divided by live-weight before slaughter X 100. K.O.P. for control carcasses refers to animals raised in the traditional (extensive) manner and slaughtered before commencement of the trial for purposes of comparison. Only the main feedstuffs are listed (vitamins/minerals were fed in some cases and common salt in most cases). Except for older Gobra aged 7-9 years, most of the animals were not castrated (castration was generally found to adversely affect quantitative weight gains but improve carcass quality.) For rates of feed and water intake, feed conversion, feed composition and other data, see sources.

a) Breeds have been grouped according to the scheme presented in N. R. Joshi et al., Types and Breeds of African Cattle, F.A.O. Agricultural Studies No. 37 (Rome, 1957), pp. 6-7.

b) These are trials which have attempted to simulate small unit feeding conditions.

c) Control animals under traditional (extensive) management on dry season pasture experienced a net average daily loss of 0.311 kg during the period.

d) K.O.P. for three year olds raised on permanent stylosanthes pasture for one to three years (J. Coulomb, "Incidence de L'Age de Commercialization des Boeufs d'Attelage sur la Production de Viande," I.E.M.V.T. mimeographed report (1976), 5 p.

e) L. L. Larson and U. Ndanko, Report on Nine Cattle Fattening Trials in the Provinces of Sokoto, Katsina, Kano, Bauchi and Bornu of Northern Nigeria, U.S.A.I.D. Report No. A-13 (Lagos, June, 1962), 15 p.

f) J. Charray, "Embouche de Zebus Peuls sur Stylosanthes Gracilis," I.E.M.V.T., L'Embouche Intensive des Bovins en Pays Tropicaux, Actes du Colloque: Dakar, 4-8 December, 1973 (Maisons-Alfort, 1973), pp. 167-170.

g) J. Valenza et al., "Engraissement Intensif de Zebu Peul Senegalais (Gobra); II. Males Castres 7-10 Ans, Poids Moyens 330 Kg." Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux, XXIV, No. 1 (1971), pp. 111-124; and "III. Males Entiers ou Castres 3-5 Ans et Boeufs 7-9 Ans," No. 4 (1971), pp. 597-634.

h) P. L. Pugliese et H. Calvet, "Type d'Animal a Traiter en Embouche Intensive, Resultats de Quatre Annees d' Experiences au Senegal," I.E.M.V.T., Actes du Colloques, pp. 107-113.

i) L. Adamou, "Embouche Intensive au Niger," I.E.M.V.T., Actes du Colloques, pp. 305-310.

j) Ph. Lhoste, "Essai de Finition de Boeufs Zebus avec Utilisation Maximale de Melasse," I.E.M.V.T., Actes du Colloque, pp. 139-147.

k) Ph. Lhoste and R. Dumas, "Embouche Intensive des Zebus de L'Adamaoua. I. Comparison de Differents Systemes d'Alimentation," Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux, XXV No. 2 (1972), pp. 259-276.

l) H. Hamon, "Creation, Amelioration de Performances d'une Race de Bovins de Trait au C.N.R.A. de Bambey," Machinisme Agricole Tropcale, No. 29 (Janvier-Mars, 1970), pp. 19-21.

m) J. L. Jouve, "Etude, en Cote d'Ivoire, de la Croissance de Taurillons N'Dama Entretenus Suivants Divers Modes d'Embouche," Revue d'Elevage et de Medecine Veterinaire de Pays Tropicaux, XXV, No. 2 (1972), pp. 317-324.

TABLE 14. WEST AFRICA: AREAS OF BOVINE TRACTION ACTIVITIES AND GENERAL ESTIMATES OF OXEN POPULATION: 1965-1974

Locations Represented on Map	Primary Project Organization and Approx. Dates Project Implementation	Total Number Working Oxen 1965	1970	1972	1973	1974
(Sahelian Countries)						
Mali						
Markala, Kogoni	Office du Niger (1945)					
Bamako, Segou/Macina, Mopti	CFDT (1952)	130,000	180,000	190,000	200,000	(210,000)[a]
Bougouni, Sikasso, Kayes, Bafoulabe, Kita, Kolokani, Banamba, San, Kenieba	BDPA (1967), OACV (1973)					
Chad						
Moundou, Moissala, Koumra	CFDT/ONDR (1958)					
Bokoro/Kilbini (trials)[e]	BDPA (1962)	23,500	42,000	--	83,000	95,000
Senegal						
Djourbel, Kaolack	SATEC (1963), SODEVA (1968)	10,000	14,000	15,000	16,000	16,400[b]
Upper Volta						
Fada N'Gourma	Eastern ORD (1968)					
Bobo-Diolasso	Matourkou	2,000	--	--	7,000	9,400
Mauritania	--	3,500	5,500	5,500	3,000	(3,000)
Niger	--	1,000	1,370	2,000	1,000	(1,000)
	Sub-total	170,000	--	--	310,000	334,500
(Sub-Humid Countries)						
Nigeria						
Kano, Katsina, Bauchi, Bornu, Sokoto, Zaria, Gusau	(1930)	50,000	100,000	--	100,000	(100,000)
Cameroon						
Maroua/Mokolo, Garoua, Kaele, Yagoua	CFDT/SEMNORD (1954)	24,000	--	--	17,000	20,800[c]
Gambia						
Kwinella	MFC (1952)	--	--	--	--	12,000
	Sub-total	74,000	--	--	117,000	132,800
(Humid Countries)						
Ghana						
Bawku, Bolgantanga, Navrongo, Lawra/Wa/Tumu	CSC (1966)	5,000	(7,500)[d]	--	12,000	16,000
Ivory Coast						
Korhogo/Ferkessedougou (trials)	SATHACI/CEEMAT (1966)					
Bouake [e]	CIDR (1964)	200	--	--	2,000	(2,000)
Benin						
Atakora, Borgou and Zou Provinces (trials in Zou in 1971)	UNDP/FAO/CFDT (1963)	40	--	--	6,000	6,300
Central African Empire						
Grimari (trials)	CUMA (1963)					
Ouham [e]	BDPA (1967)	500	2,400	--	2,000	(2,000)
Togo [e/f]						
Northern region	--	300	500	--	500	(500)
	Sub-total	6,040	--	--	22,500	26,800
	Total	250,000	--	--	449,000	494,400

NOTE: The annualized rate of increase from 1965 to 1974 is about 7.8 per cent. Numbers of working oxen in parentheses are author's estimates. Unless otherwise indicated, all entries for numbers of working oxen have been drawn from: D. S. Ferguson, A Conceptual Framework for the Evaluation of Livestock Production Development Projects and Programs in Sub-Sahara West Africa, Center for Research on Economic Development, University of Michigan (Ann Arbor, October, 1977), mimeographed draft, Table 7. The latter is based primarily upon figures drawn from: S.E.D.E.S., Recueil Statistique de la Production Animale (Paris, 1975).

a) Another estimate for 1973 put Mali's total population of working oxen at 250,000 (J. D. Stryker, Livestock Production and Distribution in the Malian Economy, U.S.A.I.D. mimeographed report (Wash., D.C., August 20, 1973), p. 7.

b) Estimate refers to the Sine-Saloum Region. M. Sargent, I.R.A.T.: Research on Cereal Production Technology in Senegal and Upper Volta, U.S.A.I.D. mimeographed report (Wash., D.C., September 24, 1974), p. 29.

c) S.C.S., North Cameroon Resource Inventory (Exclusive of Adamaoua Division), U.S.A.I.D./U.S.D.A. Development Studies of the Sahel-Sudan Zone, Project Activity No. 625-11-955-907, mimeographed draft (Wash., D.C., February, 1976), p. 180.

d) Based on an estimate of 4,185 oxen farmers in 1968, in C. K. Kline et al., Agricultural Mechanization in Africa, Institute of International Agriculture, Research Report No. 6, Michigan State University, (East Lansing, December, 1969), p. 2-84.

e) Not represented on map.

f) Peace Corps, Togo Animal Traction, Mimeograph (Wash., D.C., 1976).

TABLE 15

WEST AFRICA: CATTLE POPULATIONS AND APPROXIMATE PER CENTAGE ZEBU AND INTERMEDIATE TYPES, 1974

(Sahelian Countries)	Number[a] Cattle 1974 (1000 head)	Approximate[b] % Zebu and Intermediate	Number[c] Working Oxen 1974 (1000 head)
Mali	4,500.0	94	210.0
Chad	2,800.0	99	95.0
Senegal	2,266.0	54[d]	16.4
Upper Volta	1,400.0	66	9.4
Niger	2,800.0	98	1.0
(Sub-Humid Countries)			
Nigeria	10,918.0	99	100.0
Cameroon	2,500.0	99	20.8
Gambia	292.0	10	12.0
(Humid Countries)			
Ghana	1,100.0	10	16.0
Ivory Coast	480.0	14	2.0
Benin	740.0	86	6.3
Central African Empire	460.0	99	2.0
Total	30,256.0	85%[e]	490.9

Notes and sources:

a) F.A.O. Production Yearbook, 1974.

b) S.E.D.E.S., Recueil Statistique de la Production Animale (Paris, 1975).

c) Appendix I.

d) This estimate excludes Intermediates.

e) Weighted average.

TABLE 16

ESTIMATED PERCENTAGE CATTLE OWNERSHIP IN SELECTED BOVINE TRACTION PROJECT AREAS

Region	Date	Approx. no. farms in project area	% farms owning cattle	Source
N. Bourgou, Benin	1972	31,500	50[a]	(b)
N. Cameroon	1976	--	15	(c)
W. Gambia	1976	2,200	10-20	(d)
N. Ghana	1976	125,000	34	(e)
S. Mali (groundnuts)	1974	200,000	50	(f)
S. Mali (cotton)	1965	--	50[a]	(g)
Sine-Saloum, Senegal	1975	70,000	50[a]	(h)
E. ORD, Upper Volta	1976	22,500	20-30	(i)
Gusau, Nigeria	1974	68,000	7	(j)
	(total)	519,000	31-34%[k]	

a) Author's estimates referring to project areas where it was stated that the "majority" of farmers owned or had easy access to cattle.

b) C. K. Eicher et al., An Analysis of the Eastern O.R.D. Rural Development Project in Upper Volta: Report of the M.S.U. Mission, African Rural Economy Program Working Paper No. 9, Michigan State University (East Lansing, 1976), p. 98; and I.B.R.D., Appraisal of the Zou-Bourgou Cotton Project, Dahomey, Report No. PA-99 (Wash., D.C., January 21, 1972), Annex 10, p. 2.

c) North Cameroon Resource Inventory (Exclusive of Adamaoua Division), U.S.D.A./U.S.A.I.D. Development Studies of the Sudan-Sahelian Zone, Project Activity No. 625-11-955-907, mimeographed draft (Wash., D.C., February, 1976), p. 233. Estimate of per centage livestock-dependent farmers drawn from: D. S. Ferguson and F. Vandemaele, Feasibility Study of Livestock Production in Arid Regions (S.O.L.A.R.); West African Sudano-Sahelian Countries. United Nations Environmental Program, Conference on Desertification, September, 1976, Table 2.

d) I.B.R.D., Appraisal of Rural Development Project, The Gambia, Report No. 1089a-GM (Wash., D.C., June 2, 1976), pp. 5, 18 and 31.

e) I.B.R.D., Appraisal of Upper Region Agricultural Development Project, Ghana, Report No. 1061a-GH (Wash., D.C., June 3, 1976), p. 7 and Annex 5, p. 2.

f) I.B.R.D., Appraisal of Integrated Rural Development Project, Mali, Report No. 340a-MLI (Wash., D.C., May 13, 1974), p. 7.

g) J. C. de Wilde, et al., Experiences with Agricultural Development in Tropical Africa (II vols.; Baltimore: The John Hopkins Press, 1965), II, p. 316.

h) I.B.R.D., Appraisal of Sine Saloum Agricultural Development Project, Senegal, Report No. 661a-SE (Wash., D.C., May 5, 1975), p. 7.

i) C. K. Eicher et al., op. cit., pp. 43-44 and p. 101.

j) C. K. Laurent, "The Use of Bullocks for Power on Farms in Northern Nigeria," Bulletin of Rural Economics and Sociology (Nigeria), III, No. 2 (1968), pp. 237-8; and I.B.R.D., Appraisal of Gusau Agricultural Development Project, Nigeria, Report No. 354a-UNI (Wash., D.C., September 6, 1974), p. 4. Estimate of per centages of livestock-dependent farmers drawn from: Ferguson and Vandermaele, op. cit. The Laurent study found in a survey of 290 farmers in the Gusau area in 1967 that only about four per cent of farmers owned teams of oxen (Table 1, p. 243).

k) Unweighted average.

TABLE 17

ESTIMATED MATURE LIVEWEIGHTS AND AVAILABLE DRAFT POWER FOR SELECTED TYPES AND BREEDS OF WEST AFRICAN CATTLE[a]

	kgs	Available[b] draft power kgs
Trypano-susceptible (Zebu)		
Short- or medium-horned		
Sokoto Gudale (Nigeria	508-660	102-132
Azaouak (Upper Volta)	350-500[c]	70-100
long- or lyre-horned		
White Fulani (Nigeria)	533-662	107-132
Gobra (Senegal)	415	83
Sudanese Fulani (Mali)	325	65
Trypano-tolerant (Humpless)		
N'dama	300-350	60-70
West African Shorthorn		
Ghana Shorthorn	260	52
Muturu (Nigeria)	230	46
Somba (Togo)	200	40
Intermediate (Zebu X Humpless)		
Azaouak X N'dama (Upper Volta)	490[d]	98
M'bororo X N'dama (C.A.E.)	350-400[e]	70-80
Djakore (Gobra X N'dama--Senegal)	360[f]	72
Borgawa (Zebu X Muturu--Nigeria	330	66
Bambara (S. Fulani X N'dama--Mali)	300	60

NOTE: Unless otherwise indicated, all data has been drawn from: J. Coulomb, "La Race N'dama. Quelques Characteristiques Zootechniques," Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux, XXIX, No. 4 (1976), pp, 367-380; N. R. Joshi, et al., Types and Breeds of West African Cattle, F.A.O. Agricultural Study No. 37 (Rome: F.A.O., 1957); I. L. Mason, The Classification of West African Livestock, Technical Communication No. 7, Commonwealth Bureau of Animal Breeding and Genetics (Edinburgh: Stough and Bucks, 1951); and V. A. Oyenuga, Agriculture in Nigeria (Rome: F.A.O., 1967).

a) Under conventional conditions, mature liveweights for Zebus are reached at about 6-8 years and for N'dama about 5-6 years.

b) At ten per cent of team weight.

c) Age four years and over.

d) C. Malcoiffe, "Note sur la Gestion et L'Evolution des Troupeaux Bovins des Sations I.R.A.T. de Haute-Volta," (1963-1971)," Agronomie Tropicale, XXVII, No. 5 (1972), pp. 624-630 and Fig. 7.

d) R. Morel, "Une Methode de Developpement Rurale: La Traction Animale dans la Prefecture de L'Ouaka (Republique Centrafricaine)," Machinisme Agricole Tropicale, No. 13 (Janvier-Mars, 1966), pp. 3-4.

f) P. Nourissat, "La Traction Bovine au Senegal," Agronomie Tropicale, XX, No. 9 (1965), Tableau V and Text, p. 827.

TABLE 18

TOTAL AVAILABLE CROP RESIDUES AND DAYS OF MAINTENANCE FOR TWO 360 KG OXEN ON A HYPOTHETICAL FARM (4 ha) IN NORTHERN NIGERIA

Dried Crop Residues	Yield[a] Edible Material kg/ha DM	TDN[b] %	DP[b] %	Area[c] ha (%)	Total Avail. Residues kg DM	Total Avail. kg TDN	Total Avail. kg DP
Sorghum stover	1,738	44.18	2.10	1.44 (36)	2,503	1,106	53
Groundnut hay	515	41.21	5.80	0.68 (17)	350	144	20
Cowpea hay	258	41.43	6.80	0.44 (11)	114	47	8
Cotton hay[d]	281	38.40	5.50	0.52 (13)	146	56	8
Sweet potato leaves	1,121	10.66	1.40	0.12 (3)	135	14	2
P. pedicallatum hay	1,345	17.80	1.10	0.80 (20)	1,076	192	12
Sorghum bran[e]	108	40.55	4.90	--	156	63	8
Totals				4.00 (100)	4,480	1,622	111

Days of Maintenance[b] (@ 2.2 kg TDN and 0.180 kg DP per 360 kg animal/day X 2)	369	308
Days of Maintenance[f] (@ 2-2.5 kg DM/day/100 kg liveweight)	249-311	

a) Yields per hectare of edible D.M.(dry matter) for sorghum, groundnut, cowpea and cotton are means drawn from: J. G. T. van Raay and P. N. de Leeuw, The Importance of Crop Residues as Fodder, Samaru Research Bulletin No. 139 (Ahmadu Bello University, Zaria, 1971), Table 5, p. 142. Yields for sweet potato, P. pedicullatum ("Kyasuwa") and sorghum bran ("Dusa") are drawn from: M. M. Alkali, "Mixed Farming in Northern Nigeria," Proceedings of the Joint Seminar on Problems and Approaches in Planning Development: 16 Oct-7 Nov, 1967, Berlin: Westkreuz-Druckerei, 1968), pp. 129-139.

b) Drawn from: T. A. Phillips, An Agricultural Notebook, with Special Reference to Nigeria (Longmans of Nigeria, 1966), pp. 160-66. Nutrient values were originally expressed in Starch Equivalents and were converted to T.D.N. (digestible nutrients) by multiplying by 1.0989.

c) Based upon estimates (adjusted to account for mixed cropping) on a four hectare farm in Zaria Province, northern Nigeria. D. W. Norman, Economic Analysis of Agricultural Production and Labor Utilization Among the Hausa of Northern Nigeria, Samaru Research Bulletin No. 191 (Ahmadu Bello University, Zaria, 1973), Table 13. Norman estimated the following proportions of land under different crops: 22% sorghum, 14% millet, 10% groundnuts, 10% cowpeas, 6% cotton, and 3% sweet potatoes. Another 20% of the holding (mostly upland) is under fallow. The remaining 15% of the land is primarily lowland, planted to sugarcane, maize and other crops.

It was assumed in the table that the proportion of land planted to millet in the Norman estimate was instead planted to sorghum, since farmers cannot collect (short-cycle) millet residues because they are engaged in other activities during the growing season, and cannot permit animals to graze them because of intercropping with sorghum (Van Raay and de Leeuw, p. 139). Since the amount of residues from the lowland crops was not available, it was further assumed that larger proportions of land were planted to groundnuts and cotton. P. pedicallatum ("Kyasuwa") is a widespread annual in the region frequently found on fallow land during the early years after cultivation (T. B. Miller and A. B. Rains, The Nutritive Value and Agronomic Aspects of Some Fodders in Northern Nigeria. I. Fresh Herbage, Samaru Research Bulletin No. 29 (Ahmadu Bello University, Zaria, 1963), p. 164).

d) Content of D.P. (digestible protein) is based upon an estimate of 8% crude protein for dried cotton hay (from van Raay and de Leeuw, Table 9, p. 145), multipled by a digestibility coefficient of 68.3. Digestibility coefficient and estimated content of T.D.N. drawn from: National Academy of Science, Atlas of Nutritional Data on U.S. and Canadian Feeds, (Wash., D.C., 1971), p. 279.

e) 18% of yield at 600 kg yield/ha (Alkali, p. 133).

f) This is the generally accepted daily dry matter requirement for cattle in West Africa (van Raay and de Leeuw, p. 144n).

TABLE 19

ESTIMATED PERCENTAGES OF MALE THREE YEAR OLDS IN SELECTED ZEBU (SAHELIAN AND SUDANIAN) NATIONAL HERDS

Region	Percentage Male 3 yr olds[a]	Percentage Age-Specific Off-Take	Percentage Age-Specific Mortality	Source
Bobo Diolasso, Upper Volta	4.36	20.0	5.6	(b)
Upper Volta (all)	4.60	--	--	(c)
N. Cameroon (excl. of Adamaoua)	5.06	47.0	6.0	(d)
Fifth Region, Mali	4.67	10.0	6.0	(e)
E. Senegal	5.40	11.0	3.5	(f)
E. Chad	6.40	--	--	(g)
(average)	5.08%			

a) This is the approximate percentage of male three year olds before age-specific off-take and mortality, i.e., at the beginning of the year. Except for sources (c) and (g), estimates are drawn from herd inventory models, where percentage of male three year olds equals the number of male three year olds at beginning of year divided by the total number of animals at beginning of year.

b) I.B.R.D., Appraisal of a Livestock Development Project, Upper Volta, Report No. 674a-UV (Wash., D.C., May 8, 1975.

c) S.E.D.E.S., Recueil Statistique de la Production Animale (Paris, 1975), Tableau 9, p. 130. Estimate for 1969/1970.

d) S.C.S., Northern Cameroon Resource Inventory (Exclusive of Adamaoua Division, U.S.A.I.D./U.S.D.A. Development Studies of the Sahel-Sudan Zone, Project Activity No. 625-11-955-907, mimeographed draft (Wash., D.C., February, 1976), Table 25, p. 249.

e) I.B.R.D., Appraisal of a Livestock Project, Mali, Report No. 538a-MLI (Wash., D.C., January 10, 1975), Annex 12, Table 1.

f) I.B.R.D., Appraisal of Eastern Senegal Livestock Development Project, Senegal, Report No. 988a-SE (Wash., D.C., May 3, 1976), Annex 15, Table 2.

g) F.E.D., Study of the Actual Situation of Livestock Breeding in the Country of the Sahel and Preventive Measures to be Reconsidered, U.S.A.I.D. mimeographed translation (Wash., D.C., February, 1974), p. 293.

TABLE 20

WEST AFRICA: HYPOTHETICAL WEIGHT AND VALUE OF SLAUGHTER STOCK BY AGE 1-6 YEARS, 1975

Age mo	Weight Live kgs	Value Per Kg. FCFA	Total Value FCFA
12	120	58	7,000
18	140	64	9,600
24	175	70	12,250
30	220	82	18,000
36	250	108	27,000
48	330	142	47,000
60	380	158	60,000
72	400	160	64,000

Table based on various estimates of growth rates for Zebu breed types under range conditions and current (mid-1975) price levels.

Source: D. S. Ferguson and F. Vandemaele, Feasibility Study: Stratification of Livestock Production in Arid Regions (S.O.L.A.R.). West African Sudano-Sahelian Countries, U.N. Environmental Program, Conference on Desertification, (September, 1976), Table 2, p. 67.

TABLE 21

WEST AFRICA: ESTIMATED FARMER COSTS FOR EQUIPMENT "PACKAGES" AND OXEN, 1974-1976

Date	Country		Cost[a]		$US (rounded)[b]
1974	Nigeria[c]	"Arara" tool bar	65		
		2 yokes (one large, one small)	21		
		harness, etc.	10		
			96	₦	
		2 four-year-olds	240		
			336	₦	$510
1974	Mali[d]	tool bar	30,000	FM	
		tyne	4,750		
		cart wheel set	32,800		
		seeder	18,500		
		groundnut lifter	6,075		
			92,125		
		2 300 kg oxen	60,000		
			152,125	FM	$300
1974	Senegal[e]	"Arara" tool bar	25,000	FCFA	
		hoe	7,700		
		2 one-row seeders	24,860		
		yoke	1,800		
		cart (without sides)	20,000		
			79,360		
		2 300 kg oxen	60,000		
			139,360	FCFA	$560
1976	Upper Volta[f]	plow	16,850	FCFA	
		harness & yoke	6,000		
			22,850		
		2 oxen	40,000		
			62,850	FCFA	$250
1976	Gambia[g]	tool bar, plow, cultivator, seeder, groundnut lifter, cart and 2 oxen	1,495	D	$790

(Continued)

Date	Country		Cost	$US (rounded)[b]
1976	Cameroon[h]	"Sine" tool bar	25,000 FCFA	
		yoke	1,500	
			26,500	
		2 oxen	50,000	
			76,500 FCFA	$300
1976	Ghana[i]	plow/ridger	122 ¢	
		cart	277	
			399	
		2 oxen	350	
			749 ¢	$650
			AVERAGE[j]	$480

a) NOTE: Equipment costs do not represent market prices, as equipment is partially subsidized in some cases.

b) 1 ₦ (Nigerian Niara) = U.S. $1.52
500 FM (Malian Francs) = $1.00
1 D (Gambian Dalasi) = $0.53
1 ¢ (Ghanian Cedi) = $0.8667
1 FCFA (Central African Franc) = $0.004

c) F. A. Nasir, "Evaluation of Ariana Equipment," Samaru Agricultural Newsletter, XVI, No. 3 (1974), pp. 88-97.

d) I.B.R.D., Appraisal of Integrated Rural Development Project, Mali, Report No. 340aM.L.I., Wash., D.C., May 13, 1974) Annex 11, Table 1; and Appraisal of a Livestock Project, Mali, Report No. 538a-M.L.I. (Wash., D.C., Jan. 10, 1975), p. 23.

e) M. Sargent, I.R.A.T.: Research on Cereal Production Technology in Senegal and Upper Volta, U.S.A.I.D. mimeograph (Wash., D.C., September, 1974) and I.B.R.D., Appraisal of Sine Saloum Agricultural Development Project, Senegal, Report No. 661a-SE (Wash., D.C., May 5, 1975) Annex 15, p. 2.

f) T. Zalla, A Proposed Structure for the Medium-Term Credit Program in the Eastern O.R.D. of Upper Volta, African Rural Economy Program, Working Paper No. 10, Michigan State University (East Lansing, February, 1976), p. 13.

g) I.B.R.D., Appraisal of Rural Development Project, Gambia, Report No. 1089a-G.M. (Wash., D.C., June 2, 1976), pg. 36.

h) S.C.S., North Cameroon Resource Inventory (Exclusive of Adamaoua Region), U.S.D.A./U.S.A.I.D. Development Studies of the Sahel-Sudanian Zone, Project Activity No. 625-11-955-907, mimeographed draft (Wash., D.C., February, 1976), p. 233.

i) I.B.R.D., Appraisal of Upper Region Agricultural Development Project, Ghana, Report No. 1061a-G.H. (Wash., D.C., June 3, 1976), Annex 6, Table 4.

j) Cattle and equipment prices, recommended (and available) equipment components, and cropping requirements differ from region to region. This figure is intended only to represent an approximate magnitude of required investment in team and equipment.

ACRONYMS USED IN THE TEXT

B.D.P.A.	Bureau pour la Production Agricole (Paris)
C.A.E.	Central African Empire
C.E.E.M.A.T.	Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropicale (Paris)
C.F.D.T.	Compagnie Francais pour le Developpment des Fibres Textiles (Paris)
C.I.D.R.	Compagnie Internationale de Developpment Rural (Paris, Abidjan)
C.N.R.A.	Centre National de Recherches Agronomiques (Senegal)
C.S.C.	Christian Services Committee (Upper Region, Ghana)
C.U.M.A.	Centre d'Utilisation de Material Agricole (C.A.E.)
D.M.	Dry matter
D.P.	Digestible protein
F.A.C.	Fonds d'Aide et de Cooperation (Paris)
F.A.O.	Food and Agriculture Organization (U.N.)
F.E.D.	Fonds Europeen de Developpment
I.B.R.D.	International Bank for Reconstruction and Development
I.E.M.V.T.	Institut de l'Elevage et de Medecin Veterinaire des Pays Tropicaux (Paris)
I.R.A.T.	Institut de Recherches d'Agronomie Tropicale (Paris)
K.O.P.	Killing-Out Percentage
M.F.C.	Mixed Farming Center (Gambia)
O.A.C.V.	Operation Arachide et Cultures Vivrieres (Mali)
O.N.D.R.	Office National du Developpement Rural (Chad)
O.R.D.	Organisme Regionale de Developpment (Upper Volta)

(Continued)

S.A.T.E.C.	Societe d'Aide Technique et de Cooperation (Paris)
S.A.T.M.A.C.I.	Societe d'Assistance Technique pour la Modernization Agricole de la Cote Ivoire (Ivory Coast)
S.C.S.	Soil Conservation Service (U.S.D.A.)
S.E.D.E.S.	Societe d'Etudes pour le Developpment Economique et Social (Paris)
S.E.M.N.O.R.D.	Secteur de la Modernization du Nord (Cameroon)
S.O.D.E.V.A.	Societe de Developpment et de Vulgarization Agricole (Senegal)
S.O.N.A.C.O.	Societe Nationale Agricole Pour le Coton (Benin)
T.D.N.	Total digestible nutrients (1 lb T.D.N. = 1.0989 lb Starch Equivalent).
U.N.D.P.	United Nations Development Program
U.S.A.I.D.	United States Agency for International Development
W.A.S.	West African Shorthorn

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