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ANIMAL TRACTION IN EASTERN UPPER VOLTA: A TECHNICAL, ECONOMIC AND INSTITUTIONAL ANALYSIS[1/]

by

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by

Vincent Barrett, Gregory Lassiter, David Wilcock,
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1. INTRODUCTION

1.1. Background

In the 1970s, there was a dramatic increase in development assistance to the West African Sahel, a contiguous belt of countries including Mauritania, Senegal, Mali, Upper Volta, Niger, Chad, Cape Verde Islands, and The Gambia. This increased assistance came largely in response to the severe 1969-1973 drought. Following the drought, Sahelian states, with the assistance of donors, launched a number of projects to increase food production and achieve regional self-sufficiency.

In 1975, the U.S. Agency for International Development (USAID) and several other donors helped the Government of Upper Volta launch a medium-term recovery project in the Eastern Region of Upper Volta, an area covering about 50,000 km^2 with a 1979 population of about 440,000 (Mehretu and Wilcock, 1979). The Integrated Rural Development Project had two major objectives.[1/] One was to help develop the institutional capacity of the regional rural development authority, the "Organisme Regional de Developpement de l'Est" (Eastern ORD or EORD). The second was to increase agricultural production and rural incomes in the region through the introduction of animal traction (ANTRAC) cultivation techniques, supported by EORD technical, extension, credit, and marketing services. The use of animal draft power was expected to improve farm productivity by alleviating labor constraints and by integrating crop and animal production. The project's strategy of developing the operational capacity of the Eastern ORD (EORD) and of introducing donkey and oxen cultivation technology followed a pattern used in other ORDs in Upper Volta.[2/]

The technical assistance component of the USAID project was provided through a contract with the Department of Agricultural Economics at Michigan State University (MSU) beginning in May, 1977. The MSU team provided technical assistance to the Eastern ORD, and also carried out farm production, marketing, and regional planning surveys over a three-year period, 1978-1980. During the project, the number of trained personnel employed by the EORD increased six-fold to over 400 persons throughout the region. The number of farmers using animal traction (ANTRAC) increased dramatically over the project period, from 180 in 1974 to approximately 1,740 in 1979/80.

[1/] See USAID (1974) for a description of the IRD Project.

[2/] See Eicher et al. (1976) for an early review of the IRD Project implementation strategy, and Mehretu and Wilcock (1979) for an introduction to the Eastern Region.

1.2. Objectives of the Report

This report analyzes the technical, economic, and institutional impact of the animal traction program, the major component of USAID assistance to the EORD Integrated Rural Development Project. The use of animal traction has been popular in West Africa since the 1930s, owing partly to apparently favorable experiment station research results, and partly to cases of successful adoption, e.g., in Senegal and Mali. However, as Sargent et al. (1981) found in a review of 125 projects involving ANTRAC in francophone West Africa, there is very little evidence on two questions: (1) the performance of ANTRAC under actual farmer conditions; and (2) the effect of ANTRAC independent of other elements of the technical package such as improved seeds, fertilizer, etc.

The specific objectives of this paper are to: (a) describe the 1975-81 EORD animal traction program with emphasis on its institutional features and historical context; (b) evaluate the farm level technical and economic impact of the ANTRAC program on the basis of empirical studies carried out in 1978 and 1979; and (c) recommend changes in content and approach which may improve future ANTRAC programs in the Eastern Region of Upper Volta and elsewhere in West Africa.

1.3. Supporting Data Used in This Report

Most empirical findings presented in this report are based on analysis of data from the 1978-79 farm survey conducted by the Bureau of Economic Analysis and Planning of the Eastern ORD in cooperation with the MSU contract team.[1/] During the period of May 1, 1978 to April 30, 1979, the economic activities of 480 farm households selected from 27 villages were monitored.[2/] The sample is stratified across 12 zones that were purposively selected in order to represent the broad agro-climatic variation found in the EORD. Within each zone, a sample of "traditional" agricultural households (those using currently available agricultural methods based almost entirely on hand hoe cultivation techniques) was randomly selected. In addition, a purposive sample of the relatively most successful animal traction farm households, as identified by local extension personnel, was selected in five zones in order to represent the "performance

---

[1/] This survey was carried out with support from contract AID/afc-C-1314 between USAID and Michigan State University.

[2/] For additional details on the objectives, structure, and methodology of the survey, see MSU Contract Team, "Six-Month Report: December 1977-May 1978," pp. 31-54.

frontier" or potential of this new technology.[1/] After attrition, the sample consisted of 355 hoe farming households and 125 ANTRAC households. The distribution of these 480 households across the 27 villages and 12 agro-climatic zones of the EORD is presented in Table 1.1. The analysis in this report focuses on the five ANTRAC zones--Piela, Diabo, Logobou, Diapangou, and Ougarou--whose location is indicated in Figure 1.1 by the circled capital letters "TA." Sample villages with no animal traction are indicated by triangles.

Farm families were interviewed on a wide range of farm, off-farm, and household activities. The survey employed the "cost route" method of data collection, based on recurrent weekly or monthly interviews to obtain information on household resource allocation. Labor use in all farm field activities was obtained through weekly interviews with one-third of both hoe and ANTRAC households.

Other information used in the report comes from forage, plowing, and fertilizer trials conducted by the livestock specialist. Observations and informal interviews conducted by all team members provide additional background for the analysis.

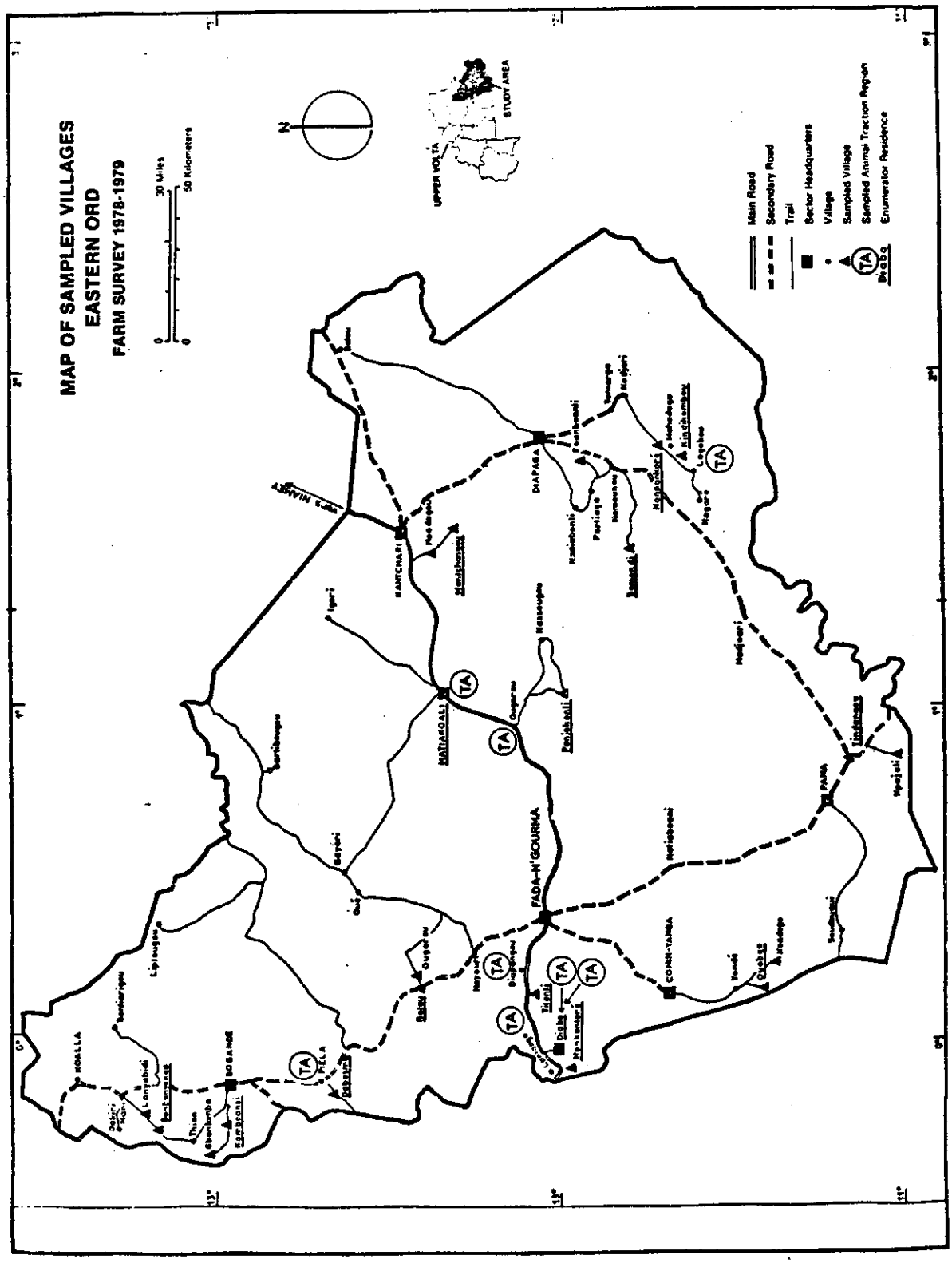
[1/] Because of the recency and geographical dispersion of the program, the majority of EORD ANTRAC users in 1978 were recent adopters who had hardly begun to use their ANTRAC equipment or experience any benefits from it. For this reason, a non-random sample was used to carry out a "most favorable case" evaluation of ANTRAC in order to provide an indication of ANTRAC potential under EORD conditions.

Table 1.1 DISTRIBUTION OF THE 480 FARM HOUSEHOLDS SURVEYED IN 1978-79 BY ZONE, VILLAGE, AND SUB-SAMPLE

Agroclimatic Zone	Village	Number of Sampled Households by Sub-Sample	
		Traditional (TRAD)	Animal Traction (ANTRAC)
1. Bogande	1. Balemba	18	-
	2. Komboassi	18	-
2. Mani	3. Lanyabidi	18*	-
	4. Bombonyenga	18	-
3. Piela	5. Dabesma	18	-
	6. Piela (ANTRAC)	-	18
4. Diabo	7. Mocontore	18	-
	8. Lantaogo (ANTRAC)	-	18
	26. Diabo I (ANTRAC)	-	17
	27. Diabo II (ANTRAC)	-	18
5. Logobou	9. Namponkore	18*	-
	10. Kindi Kombou	18*	-
	11. Logobou (ANTRAC)	-	18
6. Partiaga	12. Bomondi	18*	-
	13. Dupcaali	18	-
7. Yonde	14. Ouobgo	17	-
	15. Kondogo	18*	-
8. Diapangou	16. Tilonti	18	-
	17. Diapangou (ANTRAC)	-	18
9. Botou (N. de Fada)	18. Botou (N. de Fada)	18*	-
	19. Ougarou (N. de Fada)	19*	-
10. Kantchari	20. Mantchangou	17	-
	21. Mohadagou	18	-
11. Ougarou	22. Poniokondi	18	-
	23. Ougarou (ANTRAC)	-	18
12. Pama	24. Tindangou	16	-
	25. Kpcaali	16	-
TOTAL		355	125

*Indicates villages where the chief was purposively included in the sample in order to assure village support for the survey. Due to the non-random nature of the selection process for these seven village chiefs, they are excluded from the analyses in this report.

Figure 1.1 MAP OF THE 1978-79 EORD FARM SURVEY AREA



2. SMALLHOLDER FARMING SYSTEMS IN EASTERN UPPER VOLTA USING HOE, DONKEY, AND OXEN CULTIVATION

2.1. Overview of the Hoe Production System

Farming in the Eastern Region consists almost entirely of hoe agriculture and livestock production by small farmers. Virtually everyone farms and most people raise goats, sheep, or less frequently, cattle. The principal crops are sorghum and millet. Family labor is the key agricultural input. Even including the government and service sectors, there are few opportunities for full-time wage employment.[1/] Because both input and product markets are poorly developed, few economic transactions are monetized and most crop production is consumed by rural households. Despite the low productivity of existing agricultural technology, moderately fertile soils enable small agricultural surpluses to be produced in average years. Nonetheless, infrastructural and institutional constraints make it difficult for farmers to participate in the market economy.

The low productivity of hand hoe production systems is largely a function of the limited area that hoe farmers can cultivate within the relatively short span of the rainy season (550 mm. of rainfall spread over 3.5 months in the extreme northern part of the Eastern Region to 1,100 mm. of rainfall over 5.5 months in the south). An adult can plant and weed only about 1.25 hectares (see Table 2.1 at the end of this section). Because of high variability of rainfall and high evaporation rates at the beginning and end of the rainy season, effective rainfall is low and the timing of planting can be extremely critical. High mid-season rainfall stimulates the growth of weeds which can greatly reduce yields.

2.2. The Farming System with Animal Traction

In the literature on technical change, mechanization is considered to be labor-saving with little, if any, impact on yields (Bieri, de Janvry, and Schmitz, 1972; Binswanger and Ryan, 1977). Proponents of ANTRAC in West Africa have attributed much broader benefits to ANTRAC. By replacing hoe cultivation, ANTRAC potentially allows farmers to expand acreage and improve yields. Acreage expansion is possible through a reduction in labor time required per hectare. For example, animal weeding is three to four times faster than hand weeding for a given area. Higher yields result in the short run from better and more timely performance of tillage, and in the long run from improved soil fertility due to

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[1/] See Wilcock (1981) for a detailed description of rural small-scale enterprises in the Eastern Region.

incorporation of manure and crop residues.[1/] Savings in labor time due to ANTRAC may be devoted to other activities of value to the household. Use of animal-drawn carts can facilitate crop removal and marketing and provide a source of income from custom transport where the demand for that service exists.

Full adoption of ANTRAC entails several major changes in the traditional farming system: (1) learning to manage large animals; (2) using new implements and agronomic techniques; (3) intensifying land use and maintaining soil fertility; (4) changing the crop mix; and often (5) substantial borrowing to finance purchase of the ANTRAC package. ANTRAC adopters also become more dependent on outside institutions for input supply, repair and maintenance, animal health services, credit, and extension advice.

2.2.1. Managerial Requirements of Large Animals

Hoe farmers in the Eastern Region of Upper Volta and in most parts of the Sahelian region of West Africa have had limited experience with livestock other than goats, sheep, and poultry. A farmer adopting animal traction must be able to select the appropriate species, breed, and age of animal. He must learn to train and maintain these large animals on his farm. The necessary managerial skills are complex and thus take time to acquire. Training animals, especially oxen, is a new farm task which can be daunting for an inexperienced farmer. Animal feeding requires knowing how to conserve forage and how to formulate rations. The farmer must reallocate his labor force to provide forage and pasture for his animals. Lastly, he must learn how to maintain the health of his animals through good stabling techniques and the use of prophylactic and curative veterinary practices.

2.2.2. Use of New Implements and Agronomic Techniques

ANTRAC technology entails new tillage techniques, and hence a series of unfamiliar economic and agronomic decisions. The farmer must decide whether the returns from certain practices will be sufficient to justify investment in the necessary equipment and labor. For example, seedbed preparation is critically dependent upon the timing and the quantity of rain. If rains come late, the hoe farmer does not have the time to prepare all his fields even though he knows this is beneficial. A delay in planting will reduce yields. Plowing with a moldboard

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[1/] Maintenance of soil fertility on continuously cultivated land permits a transition from extensive bush fallow farming to intensive "sedentarized" farming, which is implicitly regarded as desirable by some ANTRAC advocates.

plow is quicker and easier but can still delay planting because a good, soaking rain is necessary before the sunbaked, hardened soil can be worked. Whereas a traditional farmer can plant immediately following the first rains with the daba (hand hoe), the traction farmer plows first before planting. There is thus a trade-off between the benefits of plowing and early planting. Irregularity of early rains and the probability of drought periods in May and June exacerbate this dilemma.

The farmer must also decide whether to carry out scarification, which does not provide the same agronomic benefits as plowing, but is quicker.[1/] In areas with low rainfall (600 mm.) and sandy soils, scarification may be the best method of seedbed prèparation for large fields because the rigid scarifier tines can enable the farmer to work the soil even before the first heavy rains. Other decisions involve whether to plow under green manure at the end of the rainy season, or to prepare the seedbed using a ridger to avoid water-logging.

Sowing techniques may also need changing. For example, weeding is a major constraint which can be overcome by animal-drawn weeders, but this requires the farmer to plant in lines by hand or with an animal-drawn seeder. If a farmer plants by hand, he must use a line tracer or a rope. Animal-drawn seeders can increase the speed at which fields are planted, providing the land has been destumped and derooted and the soil is moist.

Ridging, or basin-listing, increases infiltration and helps prevent lodging during the latter part of the season. Ridging can be performed with either a ridger or a moldboard plow, although the latter is relatively inefficient since it requires at least two passes down a row.

Other implements can be used such as a peanut lifter for harvesting groundnuts and weeding, a harrow for breaking up clods prior to use of a seeder, and a large size ridger for making drainage ditches and erosion control bunds. Carts, although very costly, have a multitude of uses and enable farmers to work their animals throughout the year, maintaining their state of training and amortizing their cost. An animal-drawn water-lift system (the dalou) permits irrigation of small garden parcels and increases animal use.

The maintenance of all this equipment poses a new set of problems for the farmer who often has little experience with machines. In the Eastern Region, for example, there are presently only a few blacksmiths who know how to manufacture

---

[1/] Scarification refers to light tillage (1 to 5 cm. deep) using a spring-toothed cultivator, illustrated in Figure 3.1.

spare ANTRAC parts and repair equipment. By contrast, tools used in the manual farming system are manufactured locally and are readily available.

2.2.3. Intensification of Land Use and Maintenance of Soil Fertility

A move from shifting cultivation to animal traction and the permanent utilization of fields accelerates the use of soil nutrients. Farmers must therefore learn to maintain the fertility of their land through the use of green manure, animal manure, compost, and chemical fertilizers. Farmers must also learn to prevent erosion. If improperly done, plowing increases the amount of soil washed away. This can be counteracted by contour plowing and the construction of bunds.

2.2.4. Changes in Crop Mixtures

Under the traditional system, farmers produce primarily to meet their own consumption needs. The adoption of ANTRAC greatly increases the farmer's capital needs and requires him to increase the area under cultivation or to alter the cropping pattern in order to produce a larger marketable surplus.

2.2.5. Supporting Services Required for a Successful ANTRAC Program

In order to assist farmers to make a successful transition from hoe cultivation to animal traction, a wide range of supporting services are required. These include:

1. a credit system to help farmers finance the purchase of equipment and animals;
2. an extension service, particularly for farmer training in the use of ANTRAC technology;
3. a livestock service to vaccinate draft animals and to give farmers advice on selection and feeding of animals;
4. a system to supply equipment, spare parts, and repair facilities;
5. a system of on-farm, adaptive (farming systems) research to identify problems and develop technological packages which are appropriate to local market, agronomic, and family economic conditions; and
6. a marketing system which enables farmers to sell their surplus production.

2.3. Summary Characteristics of Hoe and ANTRAC Households

Due to large agro-climatic differences across the 12 zones sampled in the 1978-79 farm survey, it is necessary to assess the impact of ANTRAC by comparing

ANTRAC households with a control group of hoe farmers within the same agro-climatic zone. Thus, the hoe farmer control group analyzed in this report consists of 106 households sampled within the five ANTRAC zones (see Table 1.1). Further, the performance of oxen or donkey traction is compared to that of hoe agriculture only within the relevant oxen zones (Diabo or Ougarou) or donkey zones (Piela, Diapangou, or Logobou).[1/] Because the ANTRAC and hoe farming samples vary in size within the individual zones, a weighting procedure was used in calculating mean values for the two oxen and three donkey zones.[2/]

Table 2.1 presents summary characteristics of the oxen, donkey, and hoe farmers surveyed. Both oxen and donkey farmers have larger families than their hoe farmer counterparts, a scale factor which should be kept in mind whenever comparing household means of ANTRAC and hoe farmers. ANTRAC farmers, particularly those with oxen, also have a larger work force, as indicated by the number of "actifs" (or active workers, persons of age 15 to 54). The ratio of dependents to total persons in oxen households (.53) is similar to that of their control farmers (.54), while it is much higher for donkey farmers (.63) than control farmers (.55).

The total area cultivated is higher for ANTRAC farmers than for hoe farmers, but on a per person basis the difference is not statistically significant. The most relevant measure of land intensity, the area cultivated per active worker,

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[1/] In oxen zones, 90 percent of ANTRAC farmers use oxen traction. Of the ANTRAC farmers in donkey zones, 85 percent use donkeys. Fifteen (12 percent) of ANTRAC households are excluded from the calculation of statistics for oxen zones and donkey zones because they represent exceptions to the classification system. Of these 15 households, 7 are donkey farmers residing in oxen zones (3 at Ougarou and 4 at Diabo), and 8 are oxen farmers in donkey zones (3 at Piela, 1 at Logobou, and 4 at Diapangou).

[2/] A simple average calculated for all oxen (or donkey) households would not be comparable to an average of all hoe households from the same zones because the hoe and ANTRAC sample sizes can differ for each zone. Among oxen zones, for example, the Diabo zone accounts for 54 ANTRAC users and 18 hoe households, while the Ougarou zone provides 18 ANTRAC and 18 hoe households. If based on unweighted household averages, a comparison between hoe and ANTRAC farming in the oxen zones would be biased because the hoe average would overrepresent Ougarou. To resolve this problem, when the ANTRAC and hoe sample size differs within a zone, the smallest of the two is weighted more heavily when calculating intra-zone values. Computationally, this means that the hoe subsample in Diabo is given a weight of 3 when statistics are calculated for oxen zones. For donkey zone statistics, the ANTRAC subsample in Logobou is given a weight of 2. This weighting system is not used when variances are calculated, however, because of the bias it would create.

Table 2.1 SUMMARY CHARACTERISTICS OF FARM HOUSEHOLDS IN THE OXEN AND DONKEY ZONES, 1978-79

	All ANTRAC Zones		Oxen Zones		Donkey Zones	
	HOE	ANTRAC	HOE	ANTRAC	HOE	ANTRAC
Number of Households Evaluated[a]	106	110	36	65	70	45
Persons per Household	7.75	11.21	6.67	11.14	8.83	11.27
Adult Workers per Household	3.50	4.71	3.04	5.27	3.96	4.14
Total Area Cultivated (ha)[b]	4.30	6.59	3.96	7.13	4.64	6.04
Proportion of Area in:						
Millet and Sorghum (%)	80.1	74.7	79.1	77.5	81.0	71.8
Groundnuts	9.6	9.6	10.3	6.8	8.8	12.4
Maize	3.0	3.4	3.3	3.8	2.7	2.9
Cotton	0.2	1.9	0.1	2.1	0.3	1.7
Rice	2.2	2.8	1.9	3.5	2.4	2.0
Soybeans	0.5	3.8	0.5	3.9	0.4	3.6
Other Crops	4.6	4.0	4.8	2.4	4.4	5.6
Total Area Cultivated per Person (ha)	0.560	0.588	0.593	0.640	0.526	0.536
Total Area Cultivated per Actif (ha)	1.26	1.39	1.29	1.33	1.22	1.45
Value of Livestock Owned (FCFA)	122,491	316,545	139,185	372,767	105,320	258,510
Percent of Non-Farm Income	18.7	12.5	32.0	7.5	0.6	21.5
Age of Household Head (years)	53	43	60	44	46	42
Education of Household Head (years)	.42	1.06	.44	.64	.40	1.65

[a]Because of time and resource constraints, complete area data was collected for only two-thirds of these households. In a random one-third sub-sample only sorghum and millet fields were measured. While harvest data was collected on all crops for all households, area data presented in this table are based only on measurements from two-thirds sub-sample.

[b]Estimated for the entire sample by using household size in the one-third subsample to project the non-sorghum/millet area.

is higher among the animal traction farmers. This will be explored in greater detail in section 4.6 of this report.

Cropping emphasis does not differ greatly between ANTRAC and hoe farmers. Note that the proportion of area devoted to sorghum/millet is very high, ranging from 72 to 81 percent across the subsamples. There is a slight reduction in the proportion of total area in sorghum and millet, along with a minor increase in relative areas of maize, cotton, rice, and soybeans in ANTRAC households. Oxen and donkey farmers have similar cropping patterns, although the latter de-emphasize sorghum and millet to a greater degree.

ANTRAC farmers tend to be more wealthy than hoe farmers. The value of livestock owned by ANTRAC farmers is more than twice that of hoe farmers, a difference only partly attributable to the ANTRAC animals alone. The proportion of household income originating from nonfarm sources is similar for ANTRAC and hoe farmers, although it is highly variable by zone. The heads of ANTRAC households tend to be younger and better educated than their hoe farmer counterparts.

We will return to these comparisons in Chapter 4 and to their economic implications in Chapter 5. First, however, in Chapter 3 we will examine past attempts to introduce ANTRAC technology in the Eastern Region, and the institutional structure and performance of the EORD ANTRAC program.

3. HISTORY AND INSTITUTIONAL EVALUATION OF ANIMAL TRACTION PROGRAMS

3.1. Previous Programs[1/]

There have been at least six different efforts to introduce animal traction in the Eastern Region since the early 1940s when the colonial government decided that animal traction should be used to increase the production of industrial crops, particularly cotton and groundnuts. This first scheme failed because: (a) the equipment, designed to be pulled by European oxen, was too heavy for the local animals; and (b) farmers were forced to use the equipment and were punished if they did not. A second scheme in the early 1950s used the same equipment but tried renting out the package instead of forcing farmers to use it. Unfortunately, fear of the intentions of the colonial administration and poorly adapted equipment limited acceptance of this program as well.

The third effort, based on "pilot farms", was begun in 1954. The idea was to bring together in one package all of the ingredients necessary for a successful animal traction farming system. The package consisted of a trained pair of oxen, plus a plow (28 or 36 kg Kirpies), a weeder (Ebra), a harrow (Puzenat), a cart, and gardening tools. The farmer was also given a stable for the oxen with a cement floor for collecting urine, a compost pit, a pit silo, a rack for drying hay, and a shed for equipment and grain storage. The package, financed by FIDES and the local Provident Societies (Societes de Prevoyance), cost an average of 128,000 FCFA per farm in 1956 and was provided free to the farmer.[2/] In return, the farmer contracted to adopt the practices recommended by the extension service for a duration of three years. These included composting litter and manure, hay and silage conservation, and a crop rotation system to be implemented on a 2-hectare demonstration plot measured off for him. One-half hectare of this was to be used for a garden and orchard. The rest was to be put into either rice (on bottom lands) or a rotation of cereal crops, groundnuts or cotton, and a green manure crop.

[1/] This chapter is based on interviews with extension agents who have worked in the region for 20 years, various reports by the Agricultural Production Bureau of the Eastern ORD, an analysis of some portions of the farm survey data, and other footnoted sources of information.

[2/] One U.S. dollar was approximately equal to 220 FCFA during the 1978/79 survey period.

By 1958, this scheme had failed for the following reasons:

1. Farmers felt they were working for the extension service. There was no real understanding of the benefits of the farming practices being extended. When they followed the agents' advice, it was because they felt an obligation to do so. Farmers were flattered by the attention they received, but if there was any relaxation in supervision, they generally abandoned the new technology.
2. The extension service provided insufficient technical support to farmers.
3. Although farmers were allowed to choose between cotton or groundnuts, they had to plant one of them. These were the only crops with a guaranteed market. There was no effort to improve the marketing of cereals which farmers preferred to grow in order to feed their families.
4. A lack of spare parts and skilled blacksmiths to repair the equipment caused worn equipment to lie idle.

From 1958 to 1961, the "Rural Communities" (Collectivites Rurales) provided interest-free loans for farmers to purchase animal traction packages, with the proviso that the recipients would serve as model farmers in their areas. The package consisted of oxen bought and trained by extension agents, and then resold to the farmers with the necessary equipment. This appeared to work fairly well for a time. One extension agent remembers that in Yobri (Diapaga Sector), women were a major force in introducing the package. They pushed their husbands to accept animal traction in order to avoid the arduous labor of seedbed preparation, particularly for rice. Although this system was a partial success, it was plagued by the same problems which the earlier "pilot farm" scheme faced--lack of a profitable market for cereals, absence of spare parts and repair facilities, and weak technical support for the farmers. The program ended in 1961 when a shift in policy orientation at the national government level eroded support for animal traction in favor of the introduction of tractor plowing.

The fifth program in the Eastern Region took place in the late 1960s and early 1970s, when the extension service arranged for about 20 volunteer farmers to be sent to the Center for Agricultural Training (Centre Polyvalent de Formation Agricole) at Matourkou, near Bobo-Dioulasso. The goal of this scheme was to provide farmers with in-depth training in the use of animal traction technology. Each trainee was provided with a pair of oxen, a cow, a plow, and a weeder. In addition, every two families were given a harrow, a seeder, and a cart. If he desired, the farmer could pay for his equipment over the three-year duration of

the training course. Each trainee was allotted a 7 hectare (ha) farm on which he was required to plant 2 ha of cotton and groundnuts, 1.5 ha of cereal crops, and 0.5 ha of forage crops. Another 2.5 ha was to be kept in fallow pasture land. The Center provided all chemical inputs (fertilizer and insecticides) and marketed all surplus production. The cost of inputs was deducted from the farmer's income.

Within the artificial environment of the center at Matourkou, this scheme worked fairly well. Farmers could expect to make a net income of 30,000 FCFA in 1965. But on their return home, they encountered some of the same problems which defeated the four previous efforts: lack of reliable markets and inadequate supply of spare parts and other supporting services. In spite of this, many of these farmers have continued to use animal traction and their farms are quite impressive. They do have a good technical background and it is from this group that the EORD has recently recruited three of its oxen trainers.

A sixth effort to implement animal traction was the voluntary work of a private French farmer, Maurice Colas, who spent almost 20 years in the Eastern Region in the 1960s and 1970s. While he trained farmers and supplied them with credit for oxen,[1/] his main innovation was provision of repair facilities and local manufacture of spare parts for existing plows. He also designed a locally manufactured donkey cultivator called the Houe Fada. Many of the people that he trained are now employed by the Eastern ORD as skilled workmen.

These projects shared several common features which led to partial or complete failure:

1. Most of the schemes had a predetermined cropping plan and animal/equipment package. Faced with an inflexible farm plan, the farmer tended to feel that he was working for the extension service. Since the emphasis on cotton and groundnuts was not backed up with an applied research program at the farm level, these crops were not well adapted to farmer objectives and resources.
2. The absence of stable, profitable markets for cereal crops made it difficult for farmers to use cereal surpluses in good years to meet loan obligations.
3. With the exception of Maurice Colas' efforts, the absence of spare part supplies and repair facilities rendered worn-out plows and weeders useless.

[1/] In 1974 when he left Diabo, Colas had loans outstanding to 174 farmers for oxen. The recovery of these loans was taken over by the EORD.

4. Most efforts were based on the "model farmer" approach and thus reached only a small number of people. These farmers were often isolated (either as individuals or as groups) from the supply of spare parts, veterinary services, the technical advice of extension agents, and other vital supporting services. It was easy for them to become discouraged and give up the package.
5. The projects all relied on pairs of oxen as draft animals, at least for plowing. While these animals are stronger and appreciate in value over time, they are much more expensive and difficult to feed than are donkeys or even single oxen. Single oxen, which have proven very effective for weeding and ridging, were never tried and it was only in the late 1960s that donkey plowing was introduced on a wide scale.
6. All schemes concentrated on the use of the moldboard plow for seedbed preparation. While this has undeniable benefits, it is slow and can delay planting significantly. Under certain circumstances, scarification can be more beneficial.
7. Each effort to introduce animal traction in the Eastern ORD attempted to impose the technology and make it work within a short 3- to 5-year period. Because the system involves the adoption of a complex technology and revolutionary change in farming practices, there was no hope of success in such a short time.

3.2. The 1974-80 Eastern ORD Program

During 1974-80, the EORD relied on extension of animal traction as the main strategy to increase dryland agricultural production. Animal traction was also the key to seedbed preparation in bottomland rice production systems, after an initial plowing of virgin land by tractors. Although EORD personnel have been involved in the extension of animal traction since the organization's inception in 1968, large-scale effort began in 1974 with the introduction of 26 traction units[1/] in the Diabo Sector. The program expanded rapidly, with over 1,700 units in use by April, 1980. Forty-two percent of these units were powered by oxen. Table 3.1 shows the evolution of the program up to April, 1980 by EORD sector and by type of traction unit. In spite of this considerable effort, less than 5

[1/] A "traction unit" typically refers to either a pair of oxen or a single donkey plus the corresponding ANTRAC equipment. Single ox or horse traction is uncommon in the Eastern Region.

Table 3.1 NUMBER OF ANIMAL/EQUIPMENT UNITS DISTRIBUTED BY THE EORD UP TO MARCH 31, 1980

Type of Animal Unit	Agricultural Campaign	EORD Sectors								ORD Total
		Bogande	Comin-Yanga	Diabo	Diapaga	Fada	Kantchari	Matiakoali	Pama	
Oxen Units	74-75 + 75-76	-	-	11	-	24	4	-	-	39
	1976 - 1977	-	-	71	1	27	1	-	-	100
	1977 - 1978	64	10	122	26	29	47	35	30	363
	1978 - 1979	7	19	8	5	3	14	5	29	90
	1979 - 1980	40	10	21	16	28	10	-	10	135
	TOTAL	111	39	233	48	111	76	40	69	727
Donkey Units	74-75 + 75-76	9	-	72	12	59	-	-	-	152
	1976 - 1977	-	-	42	9	35	-	-	-	86
	1977 - 1978	47	6	52	68	70	12	8	3	266
	1978 - 1979	13	4	84	52	49	41	19	7	269
	1979 - 1980	34	3	19	61	58	38	23	3	239
	TOTAL	103	13	269	202	271	91	50	13	1,012
Total	74-75 + 75-76	9	-	83	12	83	4	-	-	191
	1976 - 1977	-	-	113	10	62	1	-	-	186
	1977 - 1978	111	16	174	94	99	59	43	33	629
	1978 - 1979	20	23	92	57	52	54	24	36	359
	1979 - 1980	74	13	40	77	86	48	23	13	374
	TOTAL	214	52	502	250	382	167	90	82	1,739

percent of farms in the Eastern Region were equipped with a usable traction package as of 1980, even when equipment placed before 1974 is included.[1/]

3.2.1. The Eastern ORD's Approach to the Extension of Animal Traction

The EORD extension program for animal traction differs from most past programs in that it focuses not on a few model farmers, but on reaching a large number of farmers throughout the Department. It is difficult to provide isolated model farmers with essential support services. The EORD's approach assumes that if enough farmers adopt the technology, the demand for these services and the economic benefits derived from increased production will be sufficient to warrant the investment necessary to improve the services.

The EORD has begun to create the extension services necessary to support mass adoption of ANTRAC technology. There were 155 ANTRAC extension agents in 1980, or about 1 agent per 360 farm families, compared to less than 40 agents in the early 1960s. Eight specialists in agricultural credit publicize loan preconditions and ensure the smooth running of the credit program. Six livestock agents have been trained to improve health care and feeding of traction animals. Ten oxen trainers have also received short training courses on advising farmers how to choose and train their animals as well as helping extension agents give demonstrations of plowing and weeding techniques.

To reach the maximum number of farmers, extension agents work mostly through village groups (Groupements Villageois). This facilitates the dissemination of technical information. Demonstration of new techniques on collective fields reduces risk to individual farmers. A farmer must be a member of a village group and have the approval of the group president before he can receive credit. In addition, the group guarantees his loan.

Too much is currently expected of the extension agents. The new ones are young men, fresh from school. They often lack the experience and confidence necessary to give farmers proper support. A partial listing of their responsibilities includes:

1. The extension of ANTRAC technology and improved agronomic practices (such as the use of new varieties, fertilizers, and insecticides) and the conservation of forages;

[1/] Based on: 1975 population figures of 402,720 and a 1.93 percent annual growth rate; 7.27 members per household; 95 percent of households involved in farming; and an estimate that 500 units distributed before 1974 are still functioning.

2. Determination of credit worthiness and repayment capacity;
3. The distribution and collection of short- and medium-term credit;
4. The organization of village groups and support of group activities such as cereals banks, pharmacies, and shops;
5. Statistical reporting;
6. Sales of inputs;
7. Conducting adult literacy classes; and
8. Management of supplies.

It is doubtful that anyone could do all of these activities effectively even in the small zone under each agent's control. Furthermore, agents are often transferred in and out of a village so quickly that they do not have time to establish working relationships with the population.

3.2.2. The Credit System

The EORD provides low-interest, medium-term credit for both animals and equipment. Short-term credit is also available for seasonal inputs such as fertilizer and insecticides. An indication of the importance of the credit system is that 89.5 percent of oxen packages and 50.4 percent of donkey packages were bought on credit. For donkey traction, there is a four-year repayment schedule. For the higher investment in the oxen package, there is a five-year timetable. Both schedules include a one-year grace period to allow farmers to obtain a complete package and to begin to implement the new farming system. This is an important element as farmers rarely receive all of the components of the package during the first year.

A precondition of medium-term loans is that one-third of the area cultivated must be planted in cash crops to enable the farmer to pay back his loans. There is an important difference between the EORD system and previous ones, however, in that the farmer can decide what constitutes a "cash" crop. Thus, farmers can choose between industrial crops, whose markets are relatively well organized in some areas, and sorghum or millet, which contribute to food needs but whose markets are slightly less certain due to transport and organizational difficulties.

It is well beyond the scope of this paper to provide a detailed evaluation of the performance of the EORD medium-term credit program. However, due to the vital importance of this supporting service, a few summary observations have been drawn from Tapsoba (1981a), the key study of the EORD credit program.

To begin, it is useful to underline a few of the distinctive characteristics of the EORD credit system. First, the EORD does not play a significant role in mobilizing local financial resources for investment in agriculture. It primarily employs funds from outside sources in its lending program. Of a total of approximately 85 million CFA ($425,000) distributed in short- and medium-term credit between 1975 and 1980, only 9.5 percent came from the EORD's own funds. Just over 40 percent of the total came from the USAID Integrated Rural Development (IRD) project alone. Second, loans are provided to farmers in kind (equipment and animals) rather than in cash. Third, the EORD engages in a wide range of other agricultural and rural development activities in addition to the provision of credit. Most credit transactions with farmers have been carried out by extension agents who have, as we have seen, a wide range of other functions to perform.

In evaluating the institutional performance of the EORD credit system, we can examine two key financial indicators: the real cost of lending and the rate of loan repayment. First, the real cost of lending is defined here as the EORD's cost of administering each 100 CFA of loans outstanding. This can be calculated for a given year by dividing the value of the total loan portfolio outstanding by an estimate of operational costs incurred in that year. Costs can be estimated conservatively as 10 percent of the salary costs of EORD "credit staff" (sector and subsector chiefs, extension agents, and those headquarters staff directly involved in credit administration) and 10 percent of EORD operating costs including vehicle operation. On this basis, annual EORD costs in the three most recent credit years are:

Credit Year	Cost of Administration of Each 100 CFA of Total Loan Portfolio Outstanding
1977-78	27.6 CFA
1978-79	30.0 CFA
1979-80	19.2 CFA

These cost figures vary principally according to the total value of loans outstanding at the end of the credit year. Other methods used to calculate the real cost of EORD lending also show that the recurrent costs of the EORD acting as an agricultural lending institution are extremely high (Tapsoba, 1981a). These high costs led the GOUV to create a new nationwide agricultural lending institution, the CNCA,[1/] to administer agricultural credit in cooperation with the regional ORD's.

[1/] CNCA, "Caisse Nationale de Credit Agricole."

The second performance indicator is the rate of loan repayment. As the literature on agricultural credit stresses, a wide range of methods of calculating this measure may be used. The two figures examined here are based on a total portfolio of 71,528,000 CFA of animal traction credit extended between 1976 and 1980: the collection ratio (including payments on arrears) and the percentage of the medium-term portfolio in arrears on an annual basis. These figures are shown in Table 3.2. The annual collection ratio has varied between 38 and 57 percent. The percentage of portfolio in arrears has risen steadily from 2 percent in 1977 to 28 percent in 1980. These figures are quite disturbing since these indicators would normally reflect EORD performance favorably.[1/] However, they indicate that the EORD system has not been performing adequately in terms of loan collection. If the collection ratio is not substantially improved, the amount of original working capital available for new loans will be severely limited in future years, and there may be negative psychological effects on both EORD personnel and farmer borrowers.

Two questions must be raised at this point. First, can this poor performance be justified? Second, have measures been taken which can potentially improve the performance of the system? The answer, in both cases, is a qualified yes.

The following factors largely explain poor system performance to date:[2/]

1. The extremely rapid growth of EORD personnel and number of loans over the 1975-1978 period clearly outstripped EORD administrative capacity.
2. All field actions in the vast and sparsely populated Eastern Region are complicated by the almost total lack of reliable road and communications infrastructure.
3. The EORD is not primarily a credit institution. EORD field staff did not begin to receive detailed field training in credit administration until 1978.[3/] Specially trained credit workers (one per EORD sector) were not available until 1979.

[1/] This is because the collection ratio includes payments on installments in arrears in addition to current installments and because the percentage of portfolio in arrears will tend to remain low in early years since the value of the portfolio has been increasing rapidly.

[2/] Other reasons for loan repayment delinquency are contained in Stickley and Tapsoba (1979).

[3/] This resulted in a detailed credit training manual, ORD de l'Est, BDC (1979).

TABLE 3.2

EASTERN ORD MEDIUM-TERM CREDIT REPAYMENT PERFORMANCE:
COLLECTION RATIOS AND PERCENTAGE OF PORTFOLIO
IN ARREARS FOR 1976-1980
(in thousands of CFA)

	1976/77	1977/78	1978/79	1979/80
1. Total Portfolio at End of Credit Year	10,729	52,774	59,177	71,528
2. Installments Due	206	2,336	14,027	24,584
3. Total Repayments Made[a/]	78	1,332	6,092	11,300
4. Arrears at End of Credit Years	170	1,331	9,639	19,736
5. Collection Ratio (Row 3 - Row 2)	38%	57%	43%	46%
6. % of Portfolio in Arrears (Row 4 - Row 1)	2%	3%	16%	28%

[a/] Includes payments on arrears.

Source: Tapsoba (1981a), based on EORD Credit Account computer printouts.

4. Temporary or permanent attrition in EORD field personnel, particularly sector and subsector chiefs (due to reassignment, prolonged absences for training programs, firing, and resignation), has meant that in very few localities has there been stable, continuous contact between the EORD and farmers taking loans.
5. Personnel movements and rapid growth in the volume of loans had a disastrous impact on credit record keeping and accounting. This situation became so acute that it was necessary in 1978 to conduct a detailed sector by sector inventory simply to establish reliable records on the numbers and status of outstanding loans.[1/] This was the first step taken in a complete reorganization and computerization of credit record keeping, accounting, and administration which was completed in 1979.[2/]
6. Poor record keeping had a strong negative impact on loan collections in two ways. First, in many instances, farmers were simply not contacted by EORD personnel when credit installments became due. All evidence suggests that when farmers in the region fully understand their credit obligations, they take them seriously. The vast majority make every effort to make required payments even if they must liquidate household assets to do so. Second, poor record keeping and extremely frequent personnel movements led to loose program administration which permitted substantial embezzlement of farmer credit payments by some extension agents and subsector chiefs. In some individual cases, this embezzlement amounted to over 200,000 CFA.
7. Finally, improvements in the EORD rural credit system instituted in 1978 and 1979 did not show a positive impact on system performance in 1979-80 since there was an agent boycott of credit collections through most of the collection period.

The following factors should contribute to substantial improvement in credit administration and repayment:

1. The rate of growth of EORD personnel has stabilized since 1978 and the increase in the number of new loans has been fairly moderate.
2. Current field personnel have received substantial practical training in credit administration.

[1/] The results of this inventory are reported in ORD de l'Est, BDC (1979).

[2/] This program is discussed in Stickley (1980a, 1980b, and 1980c).

3. The new computerized system of credit administration has been in effect for about one year. This system has streamlined required paperwork and has made it more possible to assure program continuity even if there are continued personnel movements. It has also substantially decreased the potential for the embezzlement of credit payments. In fact, of the payments received during 1979-80, a substantial proportion involved voluntary reimbursement to the EORD of funds previously misused by field personnel.
4. Computer reports can now indicate those sectors and subsectors where repayment rates are low, calling for greater collection effort.

3.2.3. Marketing

ORD's have traditionally provided marketing services for cash and food crops. Marketing was a key component in the intensive zone strategy of the USAID IRD Project. However, the decision by the GOUV to concentrate cereals marketing activities in the hands of OFNACER (Office National des Cereales) has severely handicapped the EORD. While OFNACER provides a base price for cereals, its actions are fairly limited and unpredictable. Thus, farmers still complain that marketing is their number one constraint. In addition, lack of readily available capital and transportation facilities and poor national price policies have discouraged EORD cash crop marketing.

The EORD has, however, intervened in the grain marketing system by supplying short-term credit to village groups so they can buy grain at harvest time for local "cereal banks", when farmers need money and when the price of grain is low. The group then resells the grain at a later date when prices have risen. In some areas, the profits, which in the past have gone to large grain merchants, now stay within the region. Unfortunately, this is being done only on a limited scale.

3.2.4. Animal Insurance

For oxen traction users, the animals represent the most expensive part of the package; losing one can spell disaster for a farmer, and may lead him to abandon animal traction. A significant new addition to the ANTRAC package in the Eastern Region has been compulsory animal insurance for both donkeys and oxen. For a total of 15,000 FCFA for a pair of oxen and 3,750 FCFA for a donkey, the animals are insured for a period of five years against death by sickness or unavoidable accidents.

3.2.5. Types of Draft Animals

The EORD offers credit and assistance to farmers to purchase three different types of animal power systems: two oxen, one ox, or one donkey.[1/] Each system has benefits and drawbacks:

1. A pair of oxen provides the most power. Their value appreciates during the working years, but they are difficult to feed and initially very expensive. The 1980 price of a good three year old pair was about 70,000 FCFA but the EORD offered a maximum loan of only 55,000 FCFA. As a result, farmers often bought young or sickly animals when they could not afford to pay extra for a good pair.
2. A single ox is cheaper, easier to feed, and easier to handle than a pair of oxen. Crop maintenance operations can be performed more easily using one strong ox than using a pair of weak oxen. By comparison with a donkey, the single ox is stronger and it appreciates in value, although it is more expensive and more difficult to maintain.
3. The donkey is the cheapest animal (about 15,000 FCFA in 1980), and the easiest to train, handle, and maintain. However, the value of a donkey does not appreciate and it is not as strong as oxen.

This choice of animal power system provides the flexibility that is needed to adapt ANTRAC technology to a wide range of family sizes, family wealth positions, and local agro-climatic conditions. For example, a dryland farmer with sandy soils in the northern part of the Eastern Region might choose donkey traction because of the difficulty of feeding oxen and because he does not need as much power to cultivate his sandy soils. Another farmer, next to an irrigated perimeter, might prefer oxen because rice straw is available to feed them and because oxen are needed to prepare heavy bottomland soils.

3.2.6. Animal Training

In past projects, pre-trained animals have been sold to farmers. The teaching of training techniques was left to extension agents. This failed since the agents often did not have the necessary knowledge, time, or inclination. The EORD currently teaches farmers how to choose and train animals themselves. This

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[1/] There are only two farmers in the Eastern Region who currently use horse traction. Horses are as expensive as an ox, difficult to maintain, and, since they are considered prestige symbols, farmers are reluctant to use them for work. They walk faster than oxen, but the sustained effort of the small horses found locally is not as great.

is an important ingredient in a self-sustaining system. The EORD has now hired 10 oxen trainers (bouviers) to help farmers. This program seems to be working very well. The results of a survey show that 92.3 percent of the farmers who had received their oxen and equipment between January and June of 1979 had had assistance in training their animals. The amount of time worked by the animals during the first year was also significantly increased by the efforts of the bouviers.[1/]

3.2.7. Livestock Extension

The EORD livestock bureau has a veterinary service as well as an animal production extension service. The veterinary service is generally understaffed and poorly equipped. As a result, only 26 percent of oxen and 3 percent of donkeys purchased for the 1979-80 campaign were vaccinated.[2/] The EORD hired six new livestock extension agents in 1980 to help vaccinate animals. However, the supply of equipment and delivery of veterinary medicines is still inadequate and must be improved.

The animal production extension service is a new effort for the EORD, which has traditionally concentrated on vaccination programs. Livestock extension agents will be responsible for teaching farmers how to formulate rations for dry season maintenance of draft animals and for fattening older oxen for resale as meat animals.

3.2.7.1. Dry Season Feeding

Forage production for dry season feeding is important in maintaining animals in good shape for the plowing season, the time when maximum effort is demanded. Table 3.3 shows results from observation trials on numerous forage species carried out by the EORD to determine those best suited to local farming systems.[3/] Species with promising production potential are available for most ecological zones in the Eastern Region. The best alternatives seem to be: (a) planting pure stands of short-cycle mung beans in late July; or (b) intercropping high yielding cowpea varieties with cereal crops. The disadvantage of (b) is that serious insect problems occur if more than 25 percent of the field

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[1/] For more details, see ORD de l'Est, BPA (1980), pp. 12-13.

[2/] Based on a survey of 117 farmers made in December, 1979. See ORD de l'Est, BPA (1980), p. 21.

[3/] See Barrett (1979b).

Table 3.3 FORAGE SPECIES SHOWING POTENTIAL IN EASTERN UPPER VOLTA

Species and Varieties	Common Names	Minimum Rainfall Requirement (mm)	Preferred Soil Type	Dry Matter Production at Fada Kg./Ha.[a]	Observations
Perennial Legumes:					
Phaseolus Macroptilium	Siratro	600	Well drained, sandy	1,005	Produced well in pure stands as well as in grass-legume mixtures. Remains green into March.
Stylosanthès Gracilis	Brazil lucerne	900	Poorer soils clay or sandy	916	Takes two years to establish.
Annual Legumes:					
Phaseolus aureus "MG55"	Mung bean	600	-	1,004	Short-cycle (45 days to flowering produces best in a pure stand.
Vigna unguiculata "Vita I"	Cowpeas (Niébé)	600	Clay, well drained	2,750	There are many problems with insects in pure stands.
Grasses:					
Brachiaria ruziziensis	Congo grass	1,000	Rich, well drained	3,718	
Sorghum bicolor "Rio"	Forage sorghum	500	Clay, well drained	4,050	Difficult to convince farmers to grow sorghum for forage.
Sorghum almum	Columbus grass	400	Clay, bottom lands	2,570	Although less productive, easier to vulgarize.

[a]Yields of pure stands during the 1978-79 cropping season.

is planted in cowpeas. Also, most high yielding varieties of cowpeas are spreading types which interfere with weeding.

3.2.7.2. Fattening of Old Oxen for Resale as Meat Animals

Farmers already know the value of raising oxen for meat. In three cases during the early part of 1980, farmers in the Fada Sector were able to sell oxen for 70,000 to 90,000 FCFA a piece. In each case, the farmers had worked their animals four years, and in each case they bought a new pair for about 70,000 FCFA.

The marketing outlet provided by ONERA (Office National de l'Exploitation des Ressources Animales) should encourage fattening schemes, since they buy by weight and by animal quality. ONERA is willing to buy animals where lots of at least 10 animals can be assembled in each village of a zone supplying at least 30 animals. However, the EORD program to encourage farmers to fatten old oxen[1/] has not worked very well owing to lack of available supplemental feeds during the dry season.

3.2.8. Equipment

The EORD began its animal traction program by selling imported, Bourguignon plows. A six-inch plow (Tom 14) was sold for donkey traction and a nine-inch plow (BM2M) for oxen. Three-tined weeders and ridgers that can be mounted on the BM2M have been manufactured locally by COREMMA. The equipment is favored by farmers because of its light weight, but it has become difficult to find spare parts.

Plows produced in Upper Volta were introduced in the Eastern ORD in 1976. The first to be distributed was the HV1B, a nine-inch ox plow made in Ouagadougou. This is a solid plow, although farmers complain that it is too heavy and the handles are too high. Three- and five-tined weeders were also available. Unfortunately, many of the parts (i.e., plowshares and wheels) are not interchangeable with later models and again farmers have had difficulty finding spares.

In early 1977, an equipment assembly plant was opened by the EORD in Fada N'Gourma as part of the COREMMA (Cooperative Regional de Montage de Materiel Agricole) system. Since then, it has produced 2,150 plows, 2,400 weeders, 1,250 ridgers, and 400 carts. The EORD manages this installation. Duty-free raw materials are sold to the Fada plant by ARCOMA (Atelier Regional pour la Construction de Materiel Agricole) which is the parent organization. ARCOMA does

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[1/] See ORD de l'Est (1977).

most of the heavy work requiring expensive machines such as bending the plow beams. They are also responsible for making design changes in existing equipment and for developing new tools for specialized tasks such as bund formation.

COREMMA produces two lines of equipment, illustrated in Figure 3.1. The first is the HV2B multi-cultivator for oxen. It is based on a nine-inch plow with a steel beam. Besides the normal trapezoidal plow shares, a new model with a chisel point is now available to help break hardened soils before the rains start. The cultivator, which accepts the plow handle and wheel, has five flexible tines. It comes with scarifying shares and weeding shares. Rigid tines can also be mounted on the cultivator frame for scarification of hard soils. As of 1980, these were only available for demonstration purposes. An adjustable-wing ridger can be fitted to the plow beam. A prototype peanut lifter has also been produced.

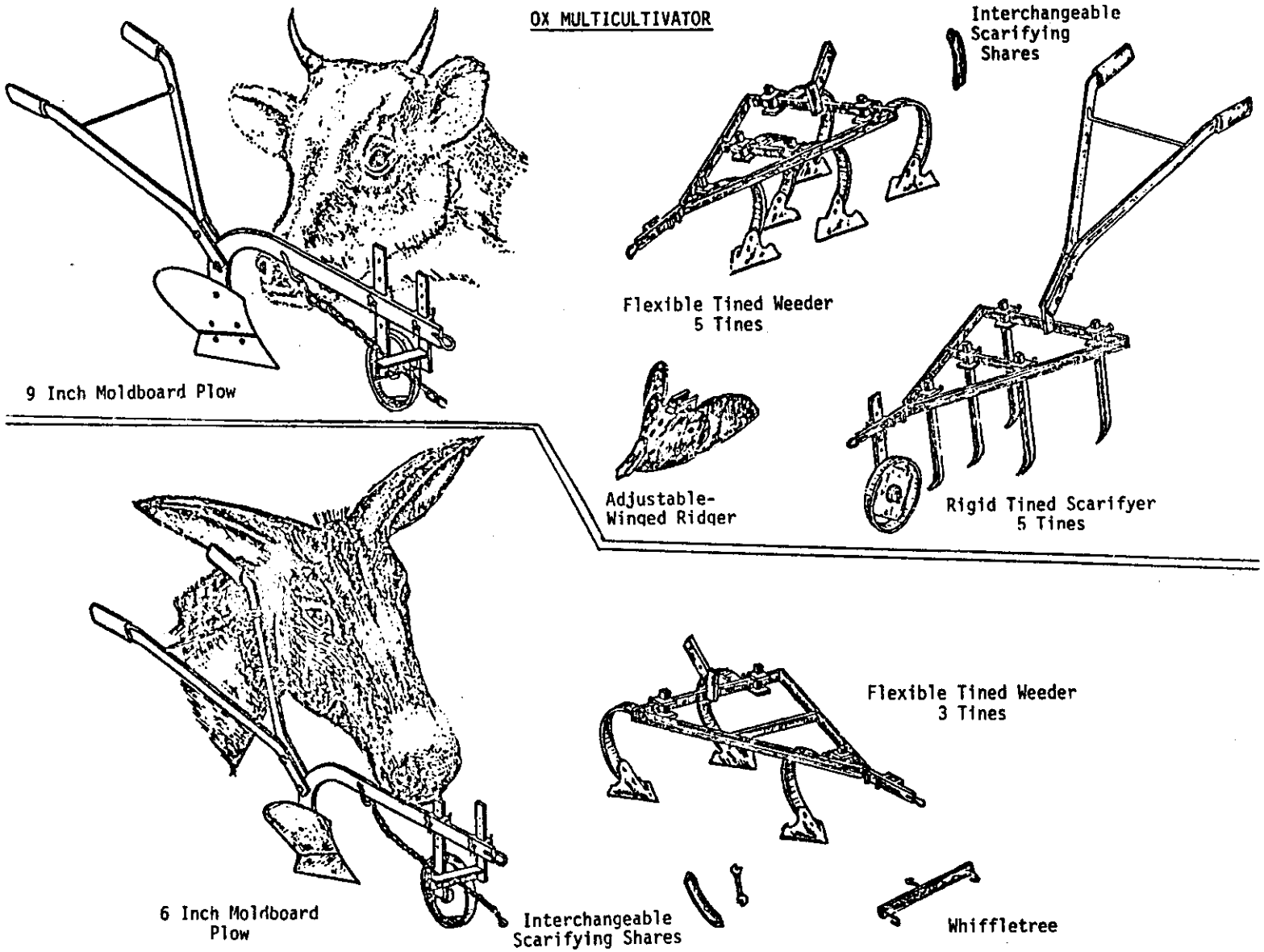
The second line is the HV2A multi-cultivator designed for donkey traction. It is based on a six-inch moldboard plow, and it has a three-tined cultivator as an accessory. There is no ridger available so ridging must be done with the plow.

An advantage of the COREMMA equipment is that certain parts are interchangeable between the donkey and oxen multi-cultivators. This reduces the cost of changing from one type of traction animal to the other. Furthermore, it reduces the number of parts which must be stocked by the EORD. ARCOMA has already made some improvements in the equipment. For 1981, the plows were given adjustable handles, the cultivator frame and HV2A plow beam were made lighter, and the cultivator tines were reinforced.

COREMMA manufactures three types of carts. These include two donkey carts which are designed for a maximum load of 500 kgs. In the first, the chassis is set up above the wheels, whereas in the second, the chassis sits directly on the axle and it has a sheet metal bed and sides. Farmers generally prefer the latter because it is more maneuverable and has metal sides which facilitate the transport of sand and gravel. The ox cart has a one-ton capacity. Again, the chassis is set above the wheels and the cart is delivered without sides. Farmers have often stated that this cart is too bulky for use on bush trails. It has not had a very wide acceptance, except in Bogande where there are many roads and little competition with other types of transport.

The EORD has developed a prototype animal-drawn, water-lift system (the dalou) which is now installed in Tiparka, near Fada. This will be of special

Figure 3.1 ARCOMA/COREMMA TILLAGE EQUIPMENT



interest for irrigation of gardens in such areas as Logobou and Piela where the water table is fairly high during the harmattan season.

COREMMA has been able to produce a large number of multi-cultivators but the equipment often arrives on the farm too late to be used during the first year. While the actual assembly operation is efficient and well-run, the supply of raw materials is erratic and slow. This is partially due to ARCOMA not delivering inputs on time. However, there is much room for improvement of the financial and logistical management of COREMMA in order to avoid such pitfalls as ordering the wrong size or type of part and setting inappropriate prices. If the EORD continues to manage the operation, they should seek personnel with experience in machinery manufacture and marketing.

3.2.9. The Supply of Spare Parts

The CNPAR (Centre National de Perfectionnement des Artisans Ruraux) in Ouagadougou has trained about 10 blacksmiths from the region as a first step in creating a network of skilled workers to repair and provide spare parts for the ANTRAC equipment package. CNPAR planned to open a regional training center in Fada in late 1981.

Since there have not been enough of these specialized blacksmiths in all parts of the region, the EORD has taken an active role in assuring the supply of spare parts. It has contracted with the existing blacksmiths to manufacture plow shares, plow soles, and yokes. The contracts enable the EORD to control the quality of the material and provide incentives to the blacksmiths for timely delivery. The blacksmiths, armed with the EORD's order, are able to get quality raw materials on credit from SACS (Service d'Assistance, de Conseil et de Soutien), a branch of the CNPAR. The EORD gets certain stock parts such as nuts and bolts from ARCOMA.

Although the EORD is now trying to standardize the equipment delivered to farmers, there are 9 different types of plows, 5 weeders, 4 ridgers, and 3 carts which are currently being used in the region. The supply of parts for all this equipment is a logistical nightmare. There are 26 different parts on the HV2B multi-cultivator alone which will eventually wear out. While many of these parts are interchangeable with parts on other plows, there are probably over 100 parts which must be kept in stock for all of the material currently being used.

3.2.10. Conclusion

The Eastern ORD is a relatively young organization which has enormous responsibilities. Because of rapid expansion in recent years, both in terms of

personnel and projects undertaken, there has been a lack of coordination and planning of ANTRAC activities. The recent arrival of new upper-level management personnel who have good technical backgrounds should help to overcome this problem.

The EORD's current program differs from earlier attempts to introduce animal traction in that it is based on the establishment of a "critical mass" of participating farmers and on the widespread provision of institutionalized support services for all phases of farming with draft animals. It remains to be seen whether the EORD can maintain and improve these support services over the next five to ten years, as will be necessary if animal traction is to become a viable, self-sustaining technology in Eastern Upper Volta.

4. TECHNICAL IMPACT OF ANIMAL TRACTION

This chapter uses farm survey and other data to provide an in-depth analysis of the technical impact of the Eastern ORD animal traction program at the farm level. The topics covered in this chapter include the husbandry of draft animals, farmer use of recommended tillage practices, the use of work animals for transportation, and an assessment of the impact of ANTRAC technology on total acreage, yields, income, cropping patterns, and allocation of household labor. The technical analysis of animal traction at the farm level will set the stage for an economic analysis of the program in Chapter 5.

4.1. Overview of the Traction Sample

As we have pointed out earlier, there are important demographic and socio-economic characteristics which distinguish our purposive sample of 125 animal traction farmers from the randomly selected sample of 355 traditional households using hoe cultivation. The traction farmers in our sample were identified by extension agents as the most successful ANTRAC users in the region. The objective was to select a sample of the "best" animal traction farmers in order to assess the potential of animal traction in the region. As a result, the surveyed ANTRAC farmers were slightly atypical in that they were wealthier[1/] and more educated than average hoe farmers. Due to the recovery of the EORD ANTRAC program, the level of experience was not high among surveyed ANTRAC farmers, despite the selection process. Fifty-eight percent of oxen farmers had less than three years of experience with ANTRAC, compared to 23 percent of donkey farmers.

The breakdown of animal traction farmers surveyed in 1978-79 by type of draft animal used for the majority of fieldwork operations is presented in Table 4.1. The relative proportion of oxen and donkey traction in the sample reflects the incidence of these two draft animal types in early 1978, when the sample was selected. At that time, only 42 percent of the draft animal units distributed by the EORD were donkeys. By 1980, however, donkey traction had become more widespread than ox cultivation by a margin of about 1.4 to 1.

4.2. Purchase, Sale, and Training of Draft Animals

4.2.1. Animal Purchases

Extension agents are supposed to participate in all ANTRAC animal purchases for which EORD credit is provided. For farmers in our sample with less than

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[1/] When evaluated on the basis of key consumer durables that are not strictly essential for survival, such as bicycles, mopeds, radios, and kerosene lamps, see Lassiter (1980), Table 15, page 23.

Table 4.1 NUMBER OF TRACTION UNITS OWNED BY ANIMAL TRACTION FARMERS,[a] 1978-79 SEASON

Type of Animal Used for the Majority of Field Work[b]	Number of Farmers	Number of Traction Units	
		Pairs	Single
Oxen	72[c]	83	7
Donkeys	52[d]	3.5	75
	124[e]	86.5	82

[a] Traction Unit = 2 oxen or 1 donkey.

[b] Horse traction is not analyzed in this report because only one farmer in the original sample of 125 traction farmers owned a horse.

[c] For the 72 farmers who primarily used oxen, 63 owned one pair, 8 owned two pairs, and 1 owned four pairs. No farmer used a single ox.

[d] Of the 52 farmers who used donkeys: 1 used a borrowed animal; 31 owned 1; 17 owned 2; 2 owned 3; and 1 owned 4 donkeys.

[e] Eleven of the 124 farmers owned both oxen and donkeys. Six of them used their oxen and five did not.

three years of experience, extension agents assisted in the purchase of 83 percent of their oxen but only 8 percent of their donkeys.

Crossbreeds (Zebu x Taurin) are generally recommended by extension agents for draft purposes because of their tolerance to trypanosomiasis and their more compact conformation. However, 66 percent of the oxen bought by our sample farmers were Zebus.[1/] This could be due to their larger size and their greater availability.[2/]

4.2.2. Castration and Placement of Nose Rings

Both castration and the placement of nose rings are designed to facilitate the handling of oxen. In our sample, 88 percent of the oxen were castrated and 92 percent had nose rings. Most of the animals which had not received these operations came from Ougarou area where ANTRAC has only recently been introduced.[3/] In Diabo, these services are performed by farmers themselves in many cases. This suggests a need for EORD assistance in performing these services in areas such as Ougarou where ANTRAC has been recently introduced.

Farmers in our sample reported that 70 percent of their oxen were castrated when they were 3 years or older. This is not a recommended practice because the trauma associated with castration is greater for older animals. Since farmers must buy what is available (generally bulls), they should either buy them at a young age and castrate them or leave them intact. The latter is probably preferable, since spirited animals are desirable for draft purposes.

4.2.3. Animal Training

Table 4.2 shows the percentage of animals trained by different categories of people.[4/] Eighty-seven percent of the donkeys and 80 percent of the oxen were trained by the farmer or a friend. Only 15 farmers had their oxen trained by an extension agent. Extension agents generally do not get involved in animal training because they often lack training and confidence.[5/]

[1/] This figure is approximate because it was difficult for interviewers to recognize the breed of oxen in all cases.

[2/] Approximately 60 to 70 percent of all cattle in the EORD are Zebu.

[3/] Twelve out of 18 uncastrated oxen and 7 out of 15 without nose rings were located in Ougarou.

[4/] There were no "bouviers" (farmers hired by the EORD as animal trainers) at the time of our survey.

[5/] Thirteen out of the fifteen farmers whose animals were trained by extension agents were from Ougarou.

Table 4.2 PERCENTAGE OF ANIMALS TRAINED BY DIFFERENT PEOPLE

Trainer	Donkeys (Percent)	Oxen (Percent)
Owner	73	77
Extension Agent	13.5	20
Friend	13.5	3
TOTAL	100.0	100.0

The average age of oxen surveyed was 3.4 years at purchase. Fifty-two percent were bought at age 4 or 5 when it is more difficult to train the animals and when they are more expensive. All working oxen surveyed were between the ages of 3 and 8 years old. There was no evidence of farmers working their animals beyond their maximum age of approximately eight years.

4.2.4. Sale of Draft Animals

Farmers sold 19 oxen and 10 donkeys during the 1978/79 survey year.[1/] Five of the oxen were sick and farmers managed to salvage 52 percent of the purchase price by selling them. Another seven oxen were healthy but they were sold after only two years' work because they were either too lazy or too aggressive to be trained.[2/] Farmers had worked the remaining seven oxen for four or five years so the animals were in prime condition when they were sold. Farmers, on the average, sold these animals for over three times the original purchase price.

Eight of the ten farmers who sold donkeys owned two or more and can be considered to be donkey traders. The average donkey sale price was 73 percent above the original purchase price. All of the donkeys sold were in good health at the time of sale.

[1/] The number of draft animal sales is probably underestimated because we found it difficult to distinguish between draft oxen sales and the sale of ordinary cattle. In addition, our sample represents an incomplete cross-section of the different stages of draft animal growth. Because of the large number of relatively new ANTRAC farmers sampled, animal sales would be low.

[2/] The average sale price was 55 percent above the original purchase price. Four of the five farmers involved in these sales came from Ougarou, another indication of the poor performance of farmers where ANTRAC is being introduced for the first time.

4.3. Animal Maintenance

4.3.1. Stabling and Feeding

Extension agents recommend that animals be kept on the farm in order to avoid contact with disease-bearing herds from outside the region and to avoid the greater danger of accidents when they are kept in the bush with Fulani herders. The EORD credit system requires that animals be kept at home throughout the year but farmers are sometimes forced to entrust their animals to the nomadic herders when they do not have adequate feed resources or when they do not have enough labor to feed them during the dry season. During the 1978/79 survey year, two-thirds of the oxen in our sample were kept in the "concession"[1/] at night and put out to pasture during the day. Most farmers who kept their oxen in the bush had less than two years of experience with ANTRAC.

Ninety percent of donkey farmers kept their animals at the "concession" at night during three-fourths of the year because of the danger of leaving animals unprotected in the bush. When donkeys are left in the bush, they must fend for themselves because the Fulani are not willing to herd donkeys. Also, many more donkeys than oxen were used for carting during the dry season so farmers had more reason to keep them at home.[2/]

Seventeen farmers (24 percent) experienced difficulties in feeding their oxen. A lack of feed and watering facilities was cited as a major problem. Most farmers (53 percent) were inexperienced. As was the case with oxen, 25 percent of donkey farmers complained of having problems with feeding their animals.

4.3.2. Cost of Feeding Animals

In general, the cash expense of maintaining a pair of oxen is about four times that for a donkey. This is an important consideration for a farmer faced with the choice between the two types of animals. The expenses for feeding donkeys and oxen are presented in Tables 4.3 and 4.4. Approximately 50 percent of the cash costs of feeding oxen are incurred in the period of May through July when animals are required to work the hardest.[3/] Salt and grain accounted for the largest amounts during this period for both types of animals. Farmers with

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[1/] Homestead or compound.

[2/] Thirteen farmers used their donkeys and only one farmer used his oxen for carting in the dry season.

[3/] This is also the period when farmers purchased the largest amount of food for their families.

Table 4.3 AVERAGE CASH EXPENSES FOR MAINTAINING TRACTION ANIMALS, BY QUARTER, 1978-79 CROP SEASON

Type of Animal	FCFA By Quarter				
	May-July 1978	August-Oct. 1978	Nov.-Jan. 1979	Feb.-April 1979	Total
Oxen (2)	1,993	355	660	796	3,804
Donkey (1)	466	130	244	98	938

Table 4.4 DISTRIBUTION OF ANNUAL CASH EXPENSES FOR ANIMAL FEEDING

Type of Expense	Oxen (Percent)	Donkeys (Percent)
Millet and Sorghum	13.0	22.4
Forage	11.2	15.1
Millet and Sorghum Bran	6.9	8.9
Salt	36.1	19.9
Medicine	18.2	10.5
Rope	4.8	18.9
Labor	7.0	4.3
Other	2.8	0.0
TOTAL	100.0	100.0

oxen, however, spent an average of 337 FCFA on medicine during the survey year. Expenses were lower during the August through October period when forage is plentiful and animals are generally in their best shape. In November through January, cash expenses increased and a major proportion was spent on purchasing crop residues to store for the dry season.[1/] The major expenses for oxen in the fourth quarter were salt, medicine, and grain.

4.3.3. Animal Health

Eighty-eight percent of oxen and 37 percent of donkeys in our sample had been "vaccinated" at least once in 1978.[2/] In order for a prophylactic treatment to be effective against trypanosomiasis, the animals should be treated at least three times and preferably four times in heavily infested areas. An ideal program would also vaccinate at least against rinderpest and contagious bovine pleuropneumonia. According to the Chief of the Livestock Service, he has neither the staff nor the equipment to carry out a vaccination program of this magnitude.[3/]

Morbidity rates are quite high among surveyed animals in 1978-79--24.7 percent for oxen and 20.2 percent for donkeys. "Trypanosomiasis" and "mange or streptotrichosis" were cited by farmers as the most serious health problems for oxen.[4/] The most serious problem for donkeys in terms of the number of work days lost was described by farmers as "Polio." This may be osteomalacia caused by a phosphorus deficiency. Most of the cases occurred during the dry season when P levels in crop residues and range grasses are extremely low. However, brucellosis is very common in the area and symptoms associated with that disease could be ascribed to "polio."

[1/] Oxen farmers spent 44 percent of their total cash expenses on forages in this third period and donkey farmers 52 percent. Most farmers do not produce enough crop residues on their own farms to feed their animals for the entire year. The average amounts spent annually per household on supplemental forages was relatively low (490 FCFA for oxen and 205 FCFA for donkey farmers).

[2/] The figure for oxen is perhaps somewhat unrepresentative because a study carried out by BDC in 1978 showed that only 54 percent of all oxen in the Eastern ORD had been vaccinated.

[3/] Personal communication, Dr. Derra, March, 1980.

[4/] This may be an overestimate. Trypanosomiasis is difficult to diagnose even for experienced veterinary assistants. Moreover, the Gourmantche and More words for trypanosomiasis are often used as catchalls for chronic diseases.

Table 4.5 shows that animal health problems were common and sometimes due to farmer negligence (lacerations). The table also shows that the incidence of illness falls more heavily on oxen than on donkeys.

During the survey year, the oxen of 31 farmers (43 percent) fell sick at least once. Eleven farmers, or 21 percent of the households which owned donkeys, had animals which fell sick during the year. Because of the importance of timely seedbed preparation and weeding it is essential that animals are in good health during this period. However, 22 percent of the ox teams had at least one animal too sick to work during this crucial period whereas only 6 percent of the donkeys were sick.

4.3.4. Treatment of Diseases and Mortality Rates

During the survey year, there were 60 cases of illness of oxen and donkeys serious enough to prevent them from working but farmers contacted a veterinary assistant or an extension agent in only 43 percent of these cases. Farmers may have avoided the high cost of treatment by EORD personnel[1/] or doubted the utility of seeking help from the ill-equipped and understaffed Livestock Service.

Farmers get most of their veterinary medicines from sources outside the EORD. Only a third of the purchases of commonly used medicines such as penicillin, injections, and pills were purchased from the EORD. The balance was either bought from a pharmacy or the black market. Home remedies, such as motor oil, salt, sugar, and various herbal concoctions, were used in 46 percent of the cases of disease.

Although the number of cases of sickness decreased during the harvest and dry season periods, the severity of cases generally increased, as can be seen by the average number of days lost per week in Table 4.6. This can be partially explained by poorer nutrition and decreased resistance to disease, especially during the dry season. Since many animals would not have worked even if they were healthy during these two periods, farmers probably applied a different standard as to what constituted an "animal too sick to work," so even this high morbidity rate may be underestimated.

[1/] The costs may be high relative to treatment by indigenous methods. The actual costs of the Livestock Service are heavily subsidized but farmers often must pay for the gasoline required to bring the veterinary assistant to his farm.

Table 4.5. INCIDENCE OF HEALTH PROBLEMS AND ACCIDENTS AND PERCENTAGE OF POTENTIAL DRAFT ANIMAL WORK TIME LOST

Type of Problem	Oxen			Donkeys		
	Number of Cases	Number of Days Lost Due to Sickness	Percentage of Total Time Lost	Number of Cases	Number of Days Lost Due to Sickness	Percentage of Total Time Lost
1. "Trypanosomiasis" (Trypanosomiasis, intestinal worms, liverfluke disease, any other chronic wasting diseases)	14	420	34.7	-	-	-
2. Mange or Streptotrichosis	7	357	29.5	-	-	-
3. "Boils on Mouth" (Foot and Mouth Disease, BVD)	3	140	11.6	-	-	-
4. Broken Horn or Laceration on Head	8	136	11.2	5	28	5.3
5. "Polio" (Osteomalacia, due to a P. Deficiency, or Arthritis, Bursitis, due to Brucellosis)	3	79	6.5	2	168	31.5
6. Sunstroke or Heat Exhaustion	2	42	3.5	-	-	-
7. "Boil on Eyes" (Pink Eye, either viral or bacterial, or due to Thelasia Worms)	2	23	1.9	5	74	13.9
8. Digestive Disorders (Constipation or Diarrhea)	2	10	0.8	1	56	10.5
9. Snake Bites	-	-	-	1	3	0.6
10. Unspecified	2	5	0.3	3	204	38.2
TOTAL	43	1,212	100.0	17	533	100.0

Table 4.6. ANIMAL SICKNESS: AMOUNT OF LOST WORK TIME AND PERCENT OF DRAFT ANIMALS AFFECTED

	Plowing Time May 1-July 16 (11 weeks)		Weeding & Ridging July 17-Oct. 1 (11 weeks)		Harvest Period[a] Oct. 2-Jan. 28 (17 weeks)		Dry Season[b] Jan. 29-April 30 (13 weeks)	
	Oxen	Donkeys	Oxen	Donkeys	Oxen	Donkeys	Oxen	Donkeys
Number of Animals Sick	19	5	19	3	8	6	8	5
Percentage of Animal Units Which Lost Work Time Due to Sickness	21.8	6.0	21.8	3.6	9.2	7.2	9.2	6.0
Average Number of Days Lost by Sick Animal Unit	9.9	4.8	29.4	6.7	26.4	64.2	31.9	20.8
Average Number of Days Lost Per Week	0.9	0.4	2.7	0.6	1.6	3.8	2.5	1.6

[a] The harvest period is the time when crop residues and standing hay are plentiful and of relatively good quality so nutrition should be fairly good.

[b] The dry season is the period when range hay is of lowest value and crop residues are often missing.

The mortality rate among oxen was much higher than that for donkeys. Eight oxen died during the 1978-79 survey year for a mortality rate of 4.5 percent.[1/] The single donkey death during the year represents a mortality rate of 1.2 percent. This rate is significantly lower than for oxen and is a reflection of the endurance of donkeys.

4.3.5. Animal Insurance

During the 1978/79 survey year, only 20 percent of the oxen owned by the surveyed farmers and 13 percent of the donkeys were insured. These figures are probably much higher now because of the EORD's subsequent requirement that all animals bought on credit must be insured. Since insurance is a new concept for both farmers and extension agents, it will take some time for the concept to become an accepted management strategy.

The insurance rates of 3,000 FCFA per year for oxen appear to be reasonable, given the 4.5 percent mortality rates observed.[2/] For donkeys, however, the rate of 750 FCFA per donkey per year seems high and we recommend lowering it to 600 FCFA per year. Even if the observed mortality rate of 1.2 percent increased to 3 percent per year and a 10 percent administration fee is included, the rate of 600 FCFA per donkey per year would cover the 18,000 CFA replacement cost of a donkey.

4.4. Use of Animal Traction for Tillage

4.4.1. Ownership and Use of Tillage Equipment

Table 4.7 shows the relationship between the length of experience with ANTRAC and the amount of equipment owned. All of the sample farmers owned a plow. Farmers with greater ANTRAC experience owned more equipment. Sixty percent of the farmers with more than three years of experience owned weeders or ridgers, while only 19 percent of farmers using oxen for less than three years owned a weeder or ridger.

[1/] Three died from unknown causes, two from snake bites, one from a broken leg, one from a pulmonary disease, and one from an accident.

[2/] It is not known how the original rate of 3,000 FCFA/year/pair was calculated. It does seem reasonable if one assumes the following: (a) a 5 percent annual mortality rate; (b) 10 percent of the farmer's premium is used to pay administrative costs; (c) average salvage value of 8,000 to 10,000 FCFA; and (d) only partial replacement cost reimbursement in order to discourage false claims. This means that if an animal died and the farmer collected insurance he would only have to pay between 8 and 12 percent of the cost of purchasing a new pair of oxen.

Table 4.7. TYPE OF TILLAGE EQUIPMENT OWNED BY OXEN AND DONKEY FARMERS BY YEARS OF EXPERIENCE WITH ANTRAC[a/]

Equipment	Number of Years of Experience With ANTRAC					
	Ox Traction Farmers			Donkey Traction Farmers		
	0-2 Years	3-6 Years	7-28 Years	0-2 Years	3-6 Years	7-28 Years
Plow Only	34	6	6	9	20	7
Plow and Weeder	0	0	1	3	5	2
Plow, Weeder, Ridger	7	8	9	0	4	2
Plow and Ridger	1	0	0	0	0	0
Total Number	42	14	16	12	29	11
Percent Who Owned a Weeder and/or a Ridger	19	57	63	25	31	36

[a/] This is based on equipment owned by May 1978 and does not include weeders and ridgers which farmers received during June and July of 1978.

About two-thirds of the ANTRAC farmers in the sample did not own a weeder because it was either too expensive (26 percent) or the EORD had not made them available for purchase (34 percent). Only 7 percent of the farmers said they did not want to purchase a weeder. Three-quarters of the farmers did not own a ridger. Thirty percent said they wanted one but the EORD had not yet supplied one, and 44 percent said they thought the ridger was too expensive. Only 4 percent said they did not want one.

In general, Table 4.8 shows that most farmers who owned the tillage equipment used it. All of the sampled farmers owned a plow. The eight oxen farmers who did not plow had only one or two years of experience with ANTRAC. Donkey farmers tend to use this equipment less than oxen farmers. When asked why they did not use the weeder or ridger, 42 percent of the farmers said their donkeys were not strong enough to pull the equipment. Fifty percent gave the following reasons for not using the equipment: they had not received the equipment until the year of the survey, animals were not trained, or they had not planted in rows. Of the oxen owners not using their weeding equipment, 60 percent said they had not planted in lines while 40 percent reported that their animals were not well enough trained to do the work.

4.4.2. Performance of Tillage Operations

Table 4.9 shows that the length of experience with ANTRAC is a major determinant of whether farmers used oxen or donkeys in performing different tillage operations. Since plowing is the easiest operation to master and the benefits of plowing are the most readily apparent, it is understandable that 82 percent of the farmers with less than two years experience plowed and all farmers with more than two years of experience plowed.

Although fewer farmers weed and ridge,[1/] a greater proportion of experienced farmers performed the operations. Twenty-seven percent of experienced donkey farmers and 56 percent of experienced oxen farmers weeded with ANTRAC. Oxen farmers who weeded had an average of 11 years of experience, whereas donkey farmers had only 6 years of experience.[2/] Farmers must have confidence to be able

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[1/] The number of farmers who weeded and ridged is different than the number who used weeding and ridging equipment because some used their plows for these operations.

[2/] Eleven out of 31 farmers who weeded had three years or less of experience with ANTRAC. Ten of the 11 lived in Diabo where traction has been used for 30 years.

Table 4.8. NUMBER AND PERCENTAGE OF FARMERS WHO OWNED AND USED EQUIPMENT

Type of Draft Animal	Number of Farmers in Sample	Plowing		Weeding		Ridging	
		Number of Farmers Who Owned Plows	Percent Who Used Plows	Number of Farmers Who Owned Weeders	Percent Who Used Weeders	Number of Farmers Who Owned Ridgers	Percent Who Used Ridgers
Donkey	52	52	96.2	16	37.5	6	33.3
Oxen	72	72	88.9	25	68.0	25	68.0

Table 4.9 RELATIONSHIP BETWEEN EXPERIENCE WITH ANIMAL TRACTION AND THE PERCENTAGE OF FARMERS WHO PERFORMED DIFFERENT TILLAGE PRACTICES

No. of Years of Experience With Animal Traction	Type of Draft Animal	No. of Farmers in Sample	Percentage of Farmers Who:		
			Plowed	Weeded	Ridged
0-2 Years	Donkey	12	83.3	16.7	16.7
3-6 Years	Donkey	29	100.0	27.6	20.7
7-28 Years	Donkey	11	100.0	27.3	9.1
Sub-Total	Donkey	52	96.2	25.0[a/]	17.3[b/]
0-2 Years	Oxen	42	81.0	9.5	9.5
3-6 Years	Oxen	14	100.0	35.7	42.9
7-28 Years	Oxen	16	100.0	56.3	50.0
Sub-Total	Oxen	72	88.9	25.0[c/]	25.0[d/]

[a/] Including seven farmers who used their donkey plows to weed.

[b/] Five farmers used their donkey plows to ridge.

[c/] One farmer used his ox plow to weed.

[d/] One farmer used his ox plow to ridge.

to weed. Furthermore, in order to weed and ridge with ANTRAC, farmers must learn to plant in rows. But farmers are reluctant to plant in rows because it involves line tracing, an additional time-consuming operation. More importantly, weeding requires well-trained animals to walk between the rows without damaging the plants. Also, the weeding equipment is expensive. For oxen traction, for example, the 24,460 FCFA price of a five-tined weeder and a ridger is 3,170 FCFA greater than the price of a nine-inch plow.[1/] The three-tined donkey weeder costs 10,510 FCFA but many farmers prefer using their donkey plow to avoid the expense and because they feel their donkeys are too weak to pull the weeder. The use of a plow is not as efficient as the use of a 3- or 5-tined weeder.[2/]

Table 4.10 presents the percentage distribution of fieldwork time for donkeys and pairs of oxen. Assuming that animals are used an average of 4 hours per working day, about half of the farmers used their donkeys and oxen less than 50 hours or 12 days during the entire 1978/79 survey year. This is an extremely low rate of utilization and it has important cost recovery implications because the animals must be fed throughout the year whether they work or not.

Table 4.11 reveals that donkey farmers plowed a slightly larger area than oxen farmers. Also, donkey farmers plowed 85 percent of their total area under cultivation while oxen farmers only plowed 59 percent. Not only were surveyed oxen farmers less experienced with ANTRAC, but it also takes longer to learn how to use the ox traction package.

Oxen farmers weeded and ridged a greater proportion of total area than donkey farmers. Farmers in the two zones with the most experience with ANTRAC, Diabo and Diapangou, weeded and ridged the largest proportion of their land.[3/] For farmers who performed the operations in these zones, oxen weeded 46 percent of cultivated area and donkeys 39 percent; oxen ridged 52 percent of total area while donkeys ridged 46 percent.

Farmers did very little custom field work. Donkey farmers spent less than 5 percent of their time on custom work whereas oxen farmers spent less than 14

[1/] 1981 EORD prices for COREMMA equipment: 5-tined weeder, 18,410 FCFA; and a ridger, 6,050 FCFA.

[2/] Farmers using a six-inch plow should theoretically make at least five passes in a row to weed the 80 cm. width, but since the earth thrown up by the plow covers weeds, normally only three passes are used.

[3/] Farmers from Diabo and Diapangou had an average of 5.5 years and 6 years of experience with ANTRAC, respectively.

Table 4.10. DISTRIBUTION OF ANNUAL FIELDWORK TIME FOR DONKEYS AND PAIRS OF OXEN,[a] 1978-79

Type of Draft Animal	Number of Draft Animal Units in Sample	Percentage of Draft Units Which Worked: 0 Hours	0.5 to 25 Hours	25 to 50 Hours	50 to 100 Hours	100 to 150 Hours	Over 150 Hours
Donkey	61	1.6	18.0	26.2	29.5	21.3	3.3
Oxen	80	11.3	8.8	25.0	33.8	15.0	6.3

[a] The Piela zone is excluded because of unreliable data during the rainy season.

Table 4.11. AVERAGE AREA AND PROPORTION OF AREA WHERE TILLAGE OPERATIONS WERE PERFORMED

Zone	Type of Draft Animal	Average Area Plowed (ha)	Percentage of Total Area Plowed	Average Area Weeded (ha)	Percentage of Total Area Weeded	Average Area Ridged (ha)	Percentage of Total Area Ridged
Diabo	Oxen	5.01	67.4	1.20	16.2	1.06	14.2
Ougarou	Oxen	0.69	13.4	0	0	0	0
Sub-Total	Oxen	4.06	59.2	0.94	13.7	0.82	12.0
Piela	Donkey	4.88	94.2	0	0	0.30	5.7
Logobou	Donkey	3.70	75.4	0.52	10.6	0.31	6.3
Diapangou	Donkey	5.11	80.5	0.99	15.6	1.35	21.3
Sub-Total	Donkey	4.53	84.8	0.52	9.8	0.65	12.2

percent. Plowing was the only type of custom work performed. Since seedbed preparation must be completed in a relatively short time, most farmers do not have time available for custom work. Income from custom work was likewise minimal, averaging only 63 FCFA for donkey farmers and 530 FCFA for oxen farmers.

4.4.3. Equipment Repairs

During the survey year, 15 farmers had difficulty using their equipment because of breakdowns. Oxen traction farmers spent an average of 1,380 FCFA for repairs and donkey traction farmers spent 1,264 FCFA on repairs.

4.5. Use of Animal Traction for Transport

Sample farmers showed a strong preference for donkey carts. Thirty-five farmers in the sample owned donkey carts and only seven owned oxen carts.[1/] The preference for donkey carting is also reflected in Table 4.12 which shows that donkey carts are used over four times as much as oxen carts. Most striking, however, is the fact that of total time worked by the different animals, 49 percent of donkey time was spent carting whereas oxen spent only 4 percent of their time carting.

Table 4.12 NUMBER OF CARTS OWNED AND AVERAGE TIME WORKED PER CART

	Donkey Carts	Ox Carts
Number Owned	35	7
Average Hours Worked Per Cart During 1978	136	29

Some farmers specialize in carting wood for fuel and construction. Wood transport accounted for 52 percent of total time spent carting. The transport of agricultural produce accounts for another 21 percent.[2/] Construction material, water, and forages each accounted for between 5 and 7 percent of total time

[1/] This includes five farmers who owned both a donkey cart and an oxen cart. Two preferred to use their donkey cart and three preferred an oxen cart.

[2/] This includes transport of the farmer's own agricultural produce as well as custom transport of the produce of other farmers.

carting. Most carting (45 percent) is done during the dry season when farmers build houses, water is scarce, and farmers have slack time. Seventy-two percent of the time spent carting in the dry season was spent carrying wood.

Donkey transport was concentrated in Logobou and Diapangou. Logobou is isolated and farmers rely on carts for much of their transport work. Diapangou is in a relatively more monetized region on the main road and has been served by extension activities for a long time. The 20 carts in these zones accounted for 80 percent of the carting time and 84 percent of the revenue earned from carting in our total sample.

Table 4.13 reveals that the rental of carts accounts for only 18 percent of the total carting time.[1/] The average cash income from rental of donkey carts was 1,981 FCFA; and 743 FCFA for ox carts. This seriously underestimates the income generated by carting because it does not include revenue in-kind from carting or income from the sale of the products transported. For example, the major revenue from carting is from firewood which was either sold directly or used by the farmer as fuel to produce other products, such as dolo or bean cakes. Most of the recorded carting rental income (88 percent) came from the transport of crops, baggage, and construction material.

Table 4.13 TOTAL TIME CARTS WERE USED AND PERCENTAGE OF TIME RENTED OUT

	Donkey Carts	Ox Carts
Average Time Worked Per Cart Per Year (Hours)	136	29
Percentage of Time Used on Personal Work	72.4	80.8
Percentage of Time Loaned Out	9.4	8.4
Percentage of Time Rented Out	18.3	10.8

[1/] Only 16 of the 35 donkey carts were rented; these 16 carts earned an average of 4,334 FCFA during the year. Only two of the seven oxen carts were rented and they earned an average of 2,600 FCFA. Rental rates for donkey carts were lower (87 FCFA/hour) than those for oxen carts (236 FCFA/hour), although the latter is based on only two observations. Oxen carts have twice the capacity of the 500 kg donkey carts.

Aside from hauling the farmer's own produce and firewood, the rationale for carting is that it generates income, increases the utilization of draft animals during the non-agricultural season, and helps keep the animals trained. Table 4.14 shows that the average total time worked by animal units during the year is more than doubled by using a cart. Moreover, farmers with carts use their animals throughout the year whereas farmers without carts only use animals during the rainy season. This finding would seem to recommend a further promotion of the use of carts. However, the market for carting services in an area can easily become saturated. Farmers should carefully study the market for transportation services before they invest in a cart.[1/]

Table 4.14 EFFECT OF CARTING ON UTILIZATION RATES OF ANIMAL UNITS IN 1978-79

	Average Total Hours Worked Per Animal Unit				
	May-July 1978	Aug.-Oct. 1978	Nov. 1978-Jan. 1979	Feb.-April 1979	Total
Farmers With Carts	55.9	26.4	25.1	47.2	154.6
Farmers Without Carts	53.4	10.6	-	-	64.0

[1/] There are several important factors to take into consideration, including the number of carts in the area, the demand for carting services, and the state of the roads in the area. In Soudougui, farmers reported that they were no longer using their oxen carts because of poor roads. In Bogande, there are more good roads and farmers seem satisfied with their oxen carts.

4.6. Estimated Production Effects of Animal Traction

The purpose of this section is to estimate the effect of ANTRAC use on cultivated area, crop mixture, and yields based primarily on the 1978-79 farm survey data. In addition, data from the 1979 plowing and fertilizer field trials are used to provide better controlled estimates of the yield effect of ANTRAC.

Caution is necessary in interpreting the survey results. An "ideal evaluation" of animal traction would follow particular farmers over a 5-10 year time span. In this study, however, we have had to rely on comparisons between hoe and ANTRAC farmers based on data from a single farm year, 1978-79. This has complicated the analysis in two ways. First, the impact of ANTRAC can only be inferred from cross-section comparisons between ANTRAC farmers and hoe farmers. Causality is difficult to establish because performance differences between the two subsamples may not be attributable to ANTRAC alone. Due to the sampling procedure, surveyed ANTRAC farmers tend to be more educated, innovative, and successful than typical hoe farmers. Second, the large size of the Eastern Region and its widely diverse agro-climatic, demographic, and socioeconomic characteristics all contribute to substantial variation in key performance indicators. Thus, some performance indicators vary more between zones than they do between hoe and traction farmers within each zone. Despite a large total sample size, the relatively small zonal cell sizes (particularly for area and labor data) make it difficult to separate the performance effects of ANTRAC from these exogenous factors. For this reason, multiple regression and analysis of variance were used where necessary to control for the effect of non-ANTRAC variables.

4.6.1. Area Effects of Animal Traction

As shown in Table 4.15, modest increases in cultivated area were found among ANTRAC households. Total area cultivated (column 3) is substantially higher for ANTRAC farms than for hoe farms, but this is primarily due to the larger overall household size. Both total family size (column 1) and the number of active workers[1/] per household (column 2) are appreciably higher for ANTRAC. Traction households cultivate 5 percent more land per capita (column 4) than their hoe counterparts, but this difference is not statistically significant.[2/]

[1/] Defined as persons from 15 to 54 years old.

[2/] Unless otherwise noted, all tests of statistical significance in this report are based on a 95 percent confidence level.

Table 4.15 HOUSEHOLD SIZE AND AREA CULTIVATED BY ZONE AND USE OF ANTRAC[a]

Zone	Type of Draft Animal	1 Number of Household Members During Rainy Season		2 Number of Active Workers (Persons 15-54 Years Old)		3 Total Area Cultivated per Household (Hectare)		4[b] Area Cultivated per Household Member (Hectare)		5[b] Area Cultivated per Active Worker (Hectare)		6 Percentage Change in Area per Active Worker Due to ANTRAC
		Hoe	ANTRAC	Hoe	ANTRAC	Hoe	ANTRAC	Hoe	ANTRAC	Hoe	ANTRAC	
Diabo	Oxen	6.83	11.34	3.08	5.16	3.98	7.44	0.63	0.70	1.40	1.49	+ 6.4
Ougarou	Oxen	7.92	12.10	3.92	6.20	3.61	5.15	0.48	0.46	0.95	0.85	+10.5
Sub-total[c]	Oxen	7.09	11.52	3.28	5.41	3.89	6.89	0.59	0.64	1.29	1.34	+ 3.9
Piela	Donkey	6.33	10.67	2.83	4.44	3.56	5.18	0.59	0.50	1.29	1.32	+ 2.3
Logobou	Donkey	9.48	11.73	4.54	3.91	4.68	4.91	0.47	0.54	1.11	1.51	+36.0
Diapangou	Donkey	7.75	12.00	3.33	4.70	4.12	6.35	0.57	0.56	1.39	1.43	+ 2.9
Sub-total[c]	Donkey	8.26	11.53	3.81	4.24	4.26	5.34	0.53	0.54	1.22	1.44	18.0
TOTAL ALL FARMERS[c]		7.68	11.53	3.55	4.83	4.08	6.10	0.56	0.59	1.26	1.39	10.3

[a]These figures are calculated only for the households for which there was area data, which includes only two thirds of the sample in each zone. Thus, they differ slightly from those in Table 2.1 which provides estimates for the entire sample. Donkey or horse farmers in areas where oxen traction predominates were excluded. Thus, 1 farmer from Ougarou and 4 from Diabo are eliminated. Likewise, oxen farmers in areas where donkey traction predominates were excluded so that 3 from Piela, 1 from Logobou, and 2 from Diapangou are eliminated. Another farmer is missing from Ougarou because he had no area data.

[b]The zonal averages for Column 4 and 5 are the averages of each household's value. In earlier reports we presented a figure which represents the zone treated as one farm, i.e. we have divided the average farm size by the average number of household members and active workers to arrive at the figure.

[c]For the sub-totals, and totals, village averages were weighted differently because sub-sample sizes differed. See footnote 1, page 13.

A better indication of the area effects of ANTRAC is area per active worker (column 5), since adult labor is the major input in the region's agriculture and is the primary constraint on farm production. As can be seen in column 6, ANTRAC is associated with a 4 percent increase in area per active worker for the oxen zones. Due to poor performance in the Ougarou oxen zone where there was actually a decrease in area per active worker of about 10 percent, the overall increase for oxen traction is not statistically significant.[1/] The increase in donkey zones of 18 percent is statistically significant as is the increase of 10 percent for traction farmers overall.

In fact, differences in acreage per active worker vary more between geographical zones than they do within each zone when comparing ANTRAC and hoe farmers. Farmers in the Diabo zone, for example, cultivate 60 percent more area per worker than farmers in Ougarou. The possible effect of agro-climatic or locational variables in determining area cultivated per worker explains our use of within-zone paired comparisons between hoe and traction farmers.

It was expected that the impact of ANTRAC would be greater for more experienced users. Surprisingly, analysis of the survey data did not demonstrate a statistically significant relationship between cultivated area per active worker and the number of years of ANTRAC experience. For practical reasons, our sample was not specifically designed to facilitate analysis of the effect of ANTRAC experience. Given the short history of ANTRAC and the geographical pattern of its implementation in the EORD, most farmers tend to have the same level of experience in a given zone.[2/] Thus, it was not possible to select a subset of successful ANTRAC farmers that was stratified by both zone and experience. In addition, variation in performance was high even within a given experience category and zone.[3/] Other indicators of experience were analyzed, but none indicated a correlation between experience and superior performance.

Due to the limited use of weeders among sampled farmers, only a small amount of data is available to estimate the area effect of the complete ANTRAC package.

[1/] The decrease in area per worker in Ougarou occurs for reasons mentioned earlier--lack of experience with the technology and lack of extension support.

[2/] For example, in Ougarou, 90 percent of ANTRAC farmers had only 2 years of experience or less.

[3/] Within the one- to two-year experience category in the Lantaogo village of the Diabo zone, the area per active worker ranges from 0.74 to 3.1 hectares.

Nonetheless, for the 12 oxen farmers with complete weeding data, the area cultivated per worker was 22 percent above that for oxen farmers who did not weed with draft power. Such an area effect was not found for donkey traction. Based on only 9 farms with donkey weeding data, the area per worker was 4 percent below that of non-weeders. This result is probably not representative of donkey weeding under optimal conditions, however, since most of the donkey weeding was performed with a plow.[1/] By contrast, most oxen weeding was conducted with a weeder. In addition, farmers weeding with oxen had more experience than those using donkeys (11 versus 6 years of experience, respectively).

In summary, the evidence of an acreage effect due to the use of ANTRAC technology is mixed. While we have shown a 10 percent average increase in area cultivated per active worker for animal traction users, this varies substantially among zones and between donkey and oxen farmers. The effect of ANTRAC on area cultivated was negative or minimal in those zones where ANTRAC has been recently introduced. For oxen farmers, the use of weeders was strongly related to increased area per worker while this was not demonstrated for donkey farmers practicing weeding.

4.6.2. Changes in Cropping Emphasis[2/]

Since sorghum and millet are the major staple foods in the region, the area planted to these crops is determined primarily by the food consumption requirements of the household. The large area in these crops is the most significant aspect of cropping mixtures in the Eastern Region. Area planted to these crops accounts for almost 80 percent of area cultivated for hoe farmers and 75 percent of area cultivated for traction farmers (see Table 4.16). In all zones except Logobou, traction farmers have larger absolute areas of these two cereals in order to feed their larger families. However, the proportion of total area planted to cereals is slightly smaller in all zones except Diabo.[3/]

[1/] As discussed in Section 4.4, weeding with a plow is much slower than when a weeder is used.

[2/] For further discussion of cropping patterns and the characteristics of individual crop enterprises, see Lassiter (1981).

[3/] The higher proportion of area planted to sorghum and millet in Diabo may be due to the fact that fields in the Diabo traction sample are generally much older and less productive than those for any other zone (see Table 9, p. 16 of Baker and Lassiter, 1980).

Table 4.16 PERCENTAGE OF AREA PLANTED TO DIFFERENT CROPS BY ZONE,[a] 1978-79

	Oxen Zones				Donkey Zones						Averages For					
	Diabo		Ougarou		Piela		Logobou		Diapangou		Oxen Zones		Donkey Zones		All Zones	
Crop	Hoe	Antrac	Hoe	Antrac	Hoe	Antrac	Hoe	Antrac	Hoe	Antrac	Hoe	Antrac	Hoe	Antrac	Hoe	Antrac
Sorghum/Millet	77.8	79.4	81.8	71.3	78.9	70.9	77.2	67.3	90.8	78.4	79.1	77.5	81.0	71.8	80.1	74.7
Maize	1.0	2.5	11.2	9.6	3.5	3.8	2.2	2.3	3.2	3.6	3.3	3.8	2.7	2.9	3.0	3.4
Rice	2.1	2.2	1.5	7.4	2.2	0.8	3.5	2.9	0.3	1.4	1.9	3.5	2.4	2.0	2.2	2.8
Groundnuts	13.0	8.1	1.4	2.0	14.1	21.8	9.8	11.6	1.8	6.1	10.3	6.8	8.8	12.4	9.6	9.6
Bambara Nuts	1.5	0.5	0.9	0.8	1.0	1.0	0.8	0.8	0.6	0.4	1.3	0.5	0.8	0.6	1.1	0.5
Soybeans	0.5	3.2	0.5	3.2	0.2	0.4	0.3	4.7	0.8	4.5	0.5	3.9	0.4	3.6	0.5	3.8
Cotton	--	2.6	0.4	0.8	--	--	0.6	2.7	--	0.1	0.1	2.1	0.3	1.7	0.2	1.9
Tubers	0.6	0.6	0.7	1.7	--	--	2.3	2.0	0.4	0.5	0.6	0.9	1.4	1.0	1.0	0.9
Gumbo	--	--	1.0	1.6	0.1	0.1	2.2	0.6	0.1	0.5	0.2	0.2	1.3	0.5	0.8	0.3
Other Crops	3.3	1.0	0.6	1.6	--	1.1	1.1	5.1	1.8	4.5	2.7	1.0	1.0	3.4	1.8	2.0
Cash Crops[b]	15.6	16.1	3.4	13.3	16.5	23.0	14.2	21.9	3.0	12.0	13.0	16.7	12.0	19.7	12.5	18.0
Legumes[c]	15.0	11.8	2.7	6.0	15.3	23.2	10.9	17.1	3.2	11.1	12.3	11.6	10.0	16.7	11.1	13.8

[a] These figures were weighted in the same manner as Table 2.1.

[b] "Cash Crops" are rice, peanuts, soybeans and cotton.

[c] Legumes are peanuts, Bambara nuts and soybeans.

Overall, there is little major difference between the cropping mixtures of ANTRAC and hoe households. The largest increases in cultivated area are in soybeans, cotton, and rice. However, the shift into cash crops[1/] is very slight, representing an increase in the proportion of area from 13 percent for hoe farmers to 18 percent for traction farmers. Further, the total area of cash crops per household is small--1.2 ha for ANTRAC and 0.5 ha for hoe farms.

4.6.3. Yield Effects

The estimates of the yield effect of ANTRAC are based on data from both the 1978-79 farm survey and from 1979 plowing and fertilizer field trials. The yield estimates presented here are weighted average yields.[2/] These yield estimates are lower than yield plot estimates presented in an earlier report (Baker and Lassiter).[3/]

The crop yields presented in Table 4.17 are generally higher for ANTRAC subsamples for most crops except soybeans. However, because of the small sample size for minor crops, only maize yields in all zones and groundnuts in oxen zones represent statistically significant yield increases. The most striking feature concerning yields is that they are quite low in general and dramatically so in the donkey zones, where half the sample (Piela and Diapangou) suffered severe drought. This drought effect should be considered when evaluating the relative performance of the donkey traction technology itself.

Average yield differences between hoe and traction farmers do not provide conclusive evidence of the impact of ANTRAC because they do not control for many

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[1/] Defined as rice, groundnuts, soybeans, and cotton.

[2/] Computationally, the weighted average yield represents the total harvest of a given crop for all households in a specific zone divided by the total area in that crop. An alternative estimate of yields is the average of the yields of each household without regard to the area cultivated by each household. The latter method gives high estimates because the high yields of small farms with only small compound fields are weighted the same as the lower yields of large farms using more extensive cultivation practices. The former method has some intuitive appeal because it provides a yield estimate for an "average hectare." Only unweighted yields are used to compute variances for tests of significance.

[3/] Subsequent analysis has led us to believe that yield plots overestimate yields for a variety of reasons--the "border effect," placement bias favoring better sections of a field or better fields, harvest error by the farmer, or "lost" plots in abandoned fields which are excluded from the analysis.

Table 4.17 YIELDS[a] FOR MAJOR CROPS UNDER HOE, OXEN AND DONKEY CULTIVATION IN ANTRAC STUDY ZONES, 1978-79 (kgs/hectare)

	All ANTRAC Zones		Oxen Zones		Donkey Zones	
Crops	HOE	ANTRAC	HOE	ANTRAC	HOE	ANTRAC
Millet and Sorghum	466	468	555	554	377	381
Groundnuts	213	238	59	179	366	296
Maize	425	686	500	746	349	585
Cotton	108[b]	171	118[b]	253	97[b]	88
Rice	442	465	329	630	554	300
Soybeans	283[b]	197	241[b]	294	324[b]	99

[a]Yields presented here are weighted averages per hectare based on estimates of total household production in 1978-79. They are calculated only for the two-thirds random subsample of farmers for which complete cultivated acreage was measured.

[b]These estimates are based on a small number of observations representing less than one hectare of cropland per zone.

factors that can obscure the results.[1/] In addition, the yields for ANTRAC farms presented in Table 4.17 are averaged across all cultivated fields, whether or not they were plowed or weeded with animal power. Regression analysis of sorghum/millet yields showed that yields were positively related to number of workers and labor inputs per hectare, and negatively related to farm size; however, the use of animal traction was not significantly related to yields.

The potential yield effects of animal traction were also evaluated based on data from field trials conducted in 1979. The effects of plowing and the application of natural phosphate fertilizer were tested in controlled experiments under farm-level conditions on 19 peanut fields and 24 sorghum/millet fields.[2/] The farmers chosen were a subsample of the 1978-79 farm survey's ANTRAC sample. Farmers from each of the five traction zones were represented.

Trial plots of 360 square meters were set out in each farmer's peanut and sorghum fields, and then divided into four subplots measuring 6 meters by 15 meters. Before the harvest, a yield plot of 3 meters by 3 meters was delimited in the center of each subplot. The four subplots consisted of: (a) a control plot which was scarified manually with a hoe; (b) a second plot which received a broadcast application of 150 kilograms per hectare of natural phosphate[3/] which was incorporated in the soil by manual scarification with a hoe; (c) a third plot which received the same amount of phosphate incorporated by animal plowing; and (d) a fourth plot which was plowed using animal traction, but received no phosphate.

As shown in Table 4.18, Treatment 4 (animal plowing only) produced an average increase in peanut yields of 18.2 percent. This amounts to an average 105.9

[1/] In particular, the large agro-climatic variability makes yield comparisons difficult, despite the paired zonal comparison method used. Fields within even one kilometer of each other can receive substantially different amounts and patterns of rainfall.

[2/] Originally, 42 farmers participated in the trials. However, reliable harvest data were obtained only for the 24 sorghum fields and 19 peanut fields.

[3/] The natural rock phosphate used comes from Kodjari in the Diapaga sector of the EORD. It is composed of 64 percent Tricalcium phosphate and has 30 percent content in phosphorus pentoxide (P_2O_5) and a 40 percent content in quicklime or calcium oxide (CaO). It is crushed to a fineness such that 90 percent of the particles are smaller than 0.09 millimeters in diameter. The solubility of the phosphate varies between 25 and 33 percent per year depending on rainfall and other factors.

Table 4.18 RESULTS OF NATURAL PHOSPHATE FERTILIZER AND PLOWING TRIALS CONDUCTED IN THE EASTERN REGION IN 1979

Treatment	Sorghum/Millet		Groundnuts	
	Treatment Results	Confidence Interval at 95% Certainty Level	Treatment Results	Confidence Interval at 95% Certainty Level
T1: yield of control plot (land prep. by hand no fertilizer) Kg/Ha	531.0	±117.5	582.1	±128.8
T2: land prep by hand; 150 Kg. phosphate. Percent increase over control plot yield	30.2%	± 20.5%	11.4%	± 11.4%
T3: ANTRAC plowing and 150 Kg. phosphate. Percent increase over control plot	65.0%	± 26.2%	26.8%	± 21.1%
T4: ANTRAC plowing, no fertilizer. Percent increase over control plot	16.7%	± 14.6%	18.2%	± 12.4%

Source: EORD BPA Plowing/Phosphate Trials, 1979.

kg/ha increment in yields which would give the farmer an increase in gross income of 5,749 FCFA per hectare.[1/] For sorghum and millet, there was an average increase of 16.7 percent in yields due to plowing. The yield increment was 88.7 kg/ha which would give a gross return to the farmer of 3,548 FCFA per hectare.[2/]

There is also a significant yield increase due to plowing under natural phosphate fertilizer (Table 4.18, Treatment 3). This fertilizer is readily available and inexpensive in the Eastern Region.[3/] The recommended method of application is incorporation by plowing. Plowing under 150 kg of the phosphate resulted in an average 65 percent increase in yields of sorghum and millet, and a 26.8 percent increase for groundnuts. This represents a yield increment of 345.2 kg of sorghum and millet which would give the farmer a net benefit[4/] of 10,808 FCFA per hectare. For groundnuts, the yield increment was 156 kgs/ha which represents a potential 5,469 FCFA net profit per hectare. These results are similar to those found elsewhere in Upper Volta (Bikienga et al., 1980; Stoop and Pattanyak, 1980).

4.7. Impact of Animal Traction on Household Labor Allocation

In this section we evaluate differences between hoe farmers and traction farmers in their use of labor in farming activities and in the relative amount of time spent on farm and nonfarm enterprises.[5/] First, we examine the impact of animal traction on the hours spent on various field activities. Key issues here include: (1) is there a savings in field labor time, as measured in worker

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[1/] This calculation is based on the official price of 54.29 FCFA/kilogram of groundnuts.

[2/] Based on official (OFNACER) base price of 40 FCFA/kg.

[3/] The official EORD price for natural phosphate is 20 FCFA/kg.

[4/] These calculations of "net" benefit assume no cost for plowing with animal traction. An economic analysis of fertilizer and plowing, including the costs of ANTRAC use, is provided in Section 5.4.4.

[5/] This section is based on analysis of detailed labor data collected for one-third of the farm households surveyed. Three different questionnaires were administered weekly to collect data on labor spent on field activities, livestock herding and care, and the overall allocation of family time. Section 4.7.1. is based on the first two questionnaires, and Section 4.7.2. on the third, which is less accurate since it recorded data only for the day previous to the interview (i.e., a one day per week labor enumeration).

equivalent hours[1/] per hectare; (2) does the seasonal pattern of labor use for cropping activities shift as a result of using animal traction; and (3) in which activities are labor requirements increased or decreased. Second, we examine the distribution of total household labor. The question is whether traction farmers allocate relatively more or less labor to non-cropping activities than do hoe farmers.

4.7.1. Allocation of Household Labor to Cropping Activities

Table 4.19 presents a summary of the weighted average worker equivalent (WE) hours per hectare allocated to the three principal labor activities--seeding, soil tillage,[2/] and harvest--for hoe, oxen, and donkey households. On average, ANTRAC households devoted 174 WE hours less labor per hectare than hoe households. This represents a reduction of 25 percent in average labor time per hectare. Sixty-eight percent (or 119 WE hours per hectare) of this reduction occurred in the category of soil tillage. As one might expect, the average labor reduction per household is substantially greater in oxen zones (31 percent) than in donkey zones (20 percent). As shown by multiple regression analysis, the labor reduction among ANTRAC households was statistically significant, controlling for other variables.

The savings in field labor associated with ANTRAC are somewhat offset by the additional labor required to feed and maintain draft animals. Delgado (1979) concluded that the absolute level, timing, and quality of the added labor for oxen traction are prohibitively high. Analysis of the 1978-79 Eastern Region survey data (Lassiter, 1982)[3/] indicates, however, that the labor requirements

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[1/] Worker equivalent man-hours are calculated by weighting hours worked by different age and sex categories by a coefficient of work productivity. See footnote b, Table 4.19, for the weighting coefficients used.

[2/] Soil tillage includes soil preparation (including plowing, weeding, and ridging), whether done by hand or with ANTRAC.

[3/] Based on livestock maintenance data from 12 oxen traction households and 12 donkey traction households. Weekly labor was collected from only 41 of the 125 surveyed ANTRAC households. Of these 41, 21 owned only draft oxen, 14 owned only donkeys, and 6 owned both. Unfortunately, it was not possible to analyze the labor data from 15 oxen households and 8 donkey households. This is mainly because the questionnaire used to record animal care labor data did not usually distinguish labor for draft animal care from labor for herding other animals, particularly range cattle. In addition, many of these unanalyzed households kept their draft animals on the range and made little or no use of them as work animals. The donkey data are estimated from 16 donkeys, averaged on a per donkey basis over 12 households. Half the donkeys included were used for carting as well as for field operations.

Table 4.19 AVERAGE WORKER EQUIVALENT HOURS OF FAMILY LABOR USED PER HECTARE FOR MAJOR FIELD ACTIVITIES ON ALL CROPS IN ANTRAC ZONES[a]

	All ANTRAC Zones		Oxen Zones[b]		Donkey Zones[b]	
Field Activity	HOE	ANTRAC	HOE	ANTRAC	HOE	ANTRAC
Seeding[c]	60	43	88	46	31	39
Tillage[d]	418	299	429	274	407	324
Harvest	148	134	126	117	170	151
Other[e]	60	36	42	38	77	33
Total	685	511	685	475	685[f]	547[f]

[a]Labor time was evaluated for 36 hoe and 41 traction households. These households, which represent one-third of all sampled households in all ANTRAC zones, are broken down as follows: oxen zones use--12 hoe and 23 ANTRAC households; donkey zones--24 hoe and 16 ANTRAC households. Non-family labor, which provides approximately 10 percent of total field labor, is not included.

[b]Averages within zones were weighted by total area cultivated per household. The averages for all ANTRAC zones are simple averages of the figures for the oxen and donkey zones. In deriving worker-equivalent hours, the following weights were used:

Activity	Adult Male	Adult Female	Younger than 15 or Older than 54
Seeding	1	.97	.87
Tillage	1	.85	.72
Harvesting	1	1.04	.83
Other	1	.90	.79

[c]Includes planting, transplanting, and thinning.

[d]Includes hand hoeing, weeding and ridging; and plowing, weeding and ridging with traction.

[e]Includes transport, threshing, fence building, and off-season land clearing.

[f]Total hours for all households in the donkey zones are underenumerated since the first two months of data had to be discarded for all households in Piela zone. On average, about 25 percent of field labor inputs occurred during this period. If the labor inputs of households in Piela are adjusted upward by 25 percent, we arrive at an estimate of approximately 725 hours per hectare for hoe households and 585 hours per hectare for ANTRAC households for the donkey zone as a whole.

of draft oxen care, while still sizeable, are not excessive. Average annual labor requirements for a pair of draft oxen in 1978-79 were 1,229 worker equivalent (WE)[1/] hours of which 974 WE hours were used during the cultivation season, including 220 WE hours required during the May 29-July 23 peak field labor peak. By contrast, Delgado predicted corresponding labor requirements of 2,184, 1,638, and 420 WE hours, utilizing primarily adult male labor. The 1978-79 survey data reveal not only lower labor requirements, particularly at peak periods, but also show that the average age of the draft animal caretakers was only 12.6 years.[2/] Moreover, the labor requirements for the maintenance and feeding of donkeys are substantially lower than those of oxen. Only 264 WE hours were required over the entire year, of which 228 WE hours were used during the cultivation season and 37 were used during the June-July bottleneck period.

When the labor requirements for draft animal care during the cultivation season are taken into account, the net labor savings effect of ANTRAC is reduced, but not eliminated. Total household labor use in oxen farming, including animal care requirements, is still 11 percent below that of hoe farming[3/] (versus 31 percent labor savings when oxen care is not counted). For donkey farming, total field and donkey care labor requirements are 15 percent below hoe farming[4/] (versus 20 percent excluding donkey care). This may slightly overstate the impact of draft animal maintenance labor because only a small proportion is required at the peak cultivation period. In addition, the opportunity cost of family labor is low not only during the dry season, but even during non-peak periods in the cultivation season. Analysis of similar data from Northern Nigeria (Norman, Pryor and Gibbs, 1979, p. 100) showed the following per hectare labor reductions associated with oxen traction for different crops: sorghum, 16 to 17 percent; cotton, 17 to 28 percent; and maize, 33 percent.

The monthly allocation of labor allocated to major cropping activities is illustrated in Figure 4.1. In general, the total labor profiles for the two

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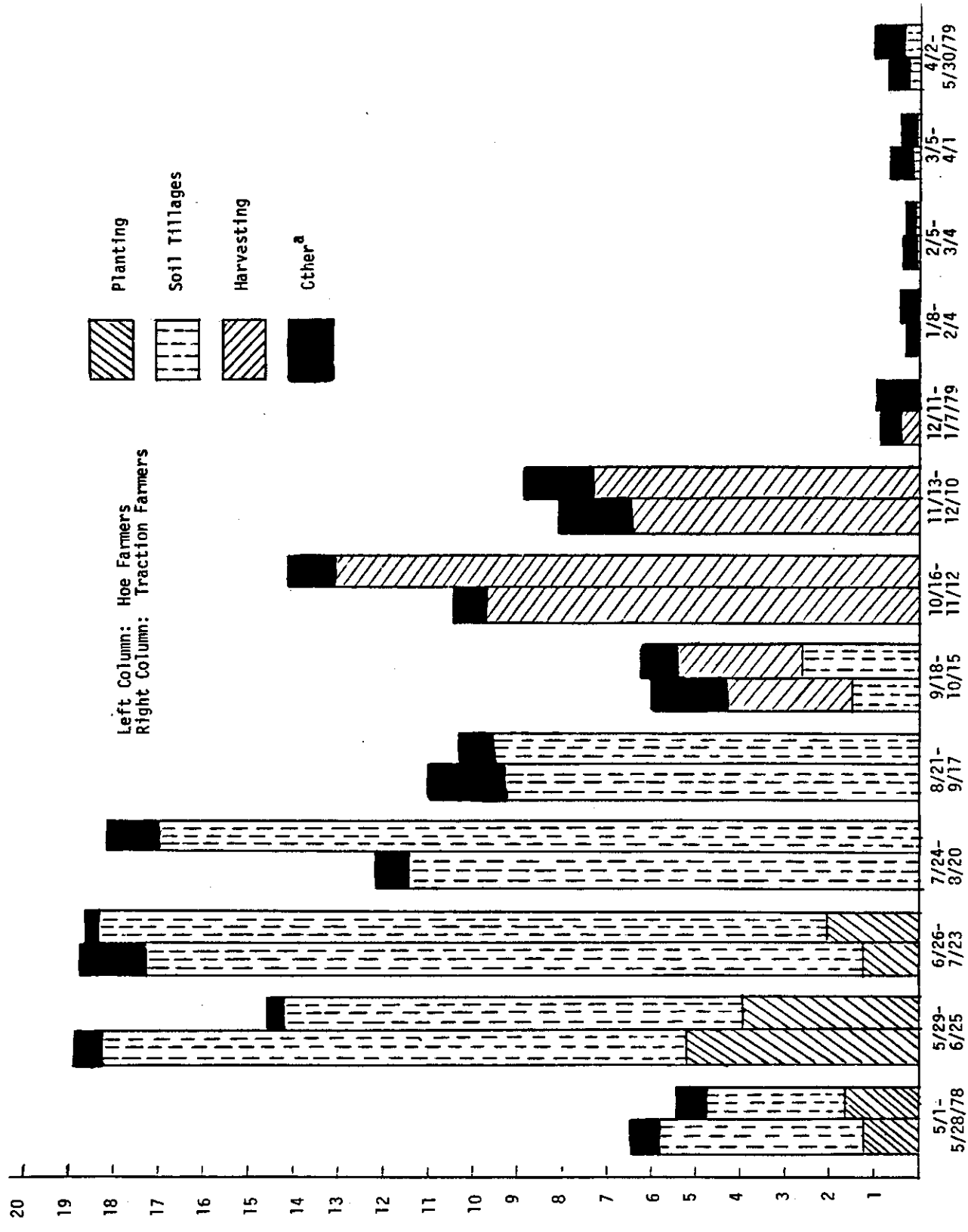
[1/] Because of the predominant importance of weeding labor in the annual labor calendar, weeding labor equivalence coefficients were used to weight the labor hours used in animal care.

[2/] In 2 of the 12 oxen households, girls (one only 5 years of age) participated in oxen care.

[3/] Assuming an average oxen traction farm size of 7.13 ha.

[4/] Assuming an average donkey traction farm size of 6.04 ha.

Figure 4.1 ALLOCATION OF MAN-HOURS WORKED ON CROPPING ACTIVITIES BY PERIOD AND MAJOR ACTIVITY



[a]Other includes land preparation, building graineries, etc. Also, if man-hours worked on a major activity such as planting represented less than 10 percent of the hours worked in a month, that activity was included in other.

subsamples are remarkably similar throughout the year. Over 50 percent of the annual hours per hectare are worked during the three peak months (May 29 through August 20) in both subsamples (54 and 53 percent for hoe and traction households, respectively). The proportional savings in labor time per hectare for traction households is slightly greater in the peak season than for all months during the year. There is a slight shift toward periods 3 and 4 (late June to late August) among traction households as compared to hoe households whose labor use peak occurs during periods 2 and 3 (late May to late June). This suggests that greater labor savings may be possible as more traction farmers adopt ANTRAC weeding, which should save labor in periods 3 and 4.

The histograms in Figure 4.1 further show that the cropping season lasts through early December. Planting is done primarily in periods 1 to 3 (through late July). Soil tillage is the dominant use of labor through mid-September. Harvesting of early crops begins to be a major demand on labor time in mid-September, continuing through mid-December. During the remainder of the year nearly all time is spent on other cropping-related activities, including land clearing, drying and storing grain, constructing grain storage huts, etc.

4.7.2. Proportional Allocation of Household Labor to Farm, Non-Farm, and Leisure Activities

The allocation of potential labor time to leisure, farm and non-farm activities is shown in Table 4.20. Part A presents a simple breakdown into total hours worked and hours spent resting, walking, ill, or visiting a local market. Figures are presented for both oxen and donkey zones since there are important zonal variations in the way work time is allocated. Because of the small sample sizes and the one day per week enumeration of data, the aggregated figures in the first two columns are the most reliable indicators of differences among the subsamples. In terms of the proportional allocation of work time, there is very little difference between the subsamples. As would be expected, members of traction households spend a slightly greater proportion of their time on livestock raising and agricultural trading. However, contrary to expectations, traction households allocated a greater proportion of their work time to household fields, but less to household chores, agricultural transformation and other activities.

As can be seen in Table 4.20, women in animal traction households spend a greater proportion of their working time on household fields as compared to women in households using hoe tillage. They also spend proportionally less time on household chores than do women in hoe households. In large part, this apparent effect of ANTRAC can be attributed to the differing demographic structures of the

Table 4.20 ALLOCATION OF POTENTIAL LABOR TIME TO LEISURE, FARM AND NON-FARM ACTIVITIES[a]

	All ANTRAC Zones[b]		Oxen Zones		Donkey Zones	
	Hoe	ANTRAC	Hoe	ANTRAC	Hoe	ANTRAC
Number of Households	36	41	12	23	24	18
A. Hours			(Hours per Day)			
Hours Worked[c]						
Men	5.5	5.4	5.5	5.8	5.4	5.0
Women	7.4	5.8	7.3	5.8	7.5	5.7
Household	6.5	5.6	6.5	5.8	6.4	5.4
Hours Resting, Walking, Ill						
Men	6.5	6.4	6.5	6.2	6.6	7.0
Women	4.6	6.2	4.7	6.2	4.5	6.3
Household	5.5	6.4	5.5	6.2	5.6	6.6
B. Proportional Allocation of Hours Worked			(Percent)			
Household Fields						
Men	57.4	56.2	59.1	62.0	55.6	50.4
Women	26.7	35.6	27.6	44.5	25.8	26.6
Household	40.5	44.1	41.0	52.3	40.0	35.8
Livestock Raising						
Men	12.5	14.4	11.1	19.7	14.0	9.2
Women	2.7	4.2	4.4	6.3	1.0	2.2
Household	6.9	8.6	7.2	12.3	6.7	4.9
Household Chores						
Men	3.7	3.5	4.3	2.8	3.1	4.2
Women	46.0	35.2	46.8	31.2	45.1	39.2
Household	27.7	22.0	28.7	18.4	26.6	25.6
Agricultural Transformation						
Men	0.5	0.8	0.2	1.0	0.8	0.6
Women	18.5	14.8	18.2	14.4	17.8	15.1
Household	10.4	8.9	10.5	8.4	10.3	9.5
Agricultural Trading						
Men	2.9	5.4	0.9	1.3	4.8	9.1
Women	0.9	3.9	0.2	0.4	1.6	7.4
Household	1.8	4.4	0.5	0.8	3.0	8.0
Other[d]						
Men	23.0	19.8	24.4	13.2	21.7	26.5
Women	5.7	6.3	2.8	3.2	8.7	9.5
Household	12.7	12.0	12.1	7.8	13.4	16.2

[a]Potential labor time is defined as a 12 hour day; the daylight hours in the Eastern Region. Leisure is derived as a residual of time not accounted for on work activities.

[b]Figures for sub-samples within zones are weighted averages for all people in the sub-sample households. Figure for combined zones is a simple average since zonal effects are important but sub-samples are unequally represented in each zone. Note that this only partially corrects for agro-climatic effects within sub-samples since it does not eliminate variance due to different village characteristics within zones.

[c]Actual hours are used in this analysis rather than man-hours since work productivity indices were not obtained for non-cropping activities.

[d]Includes work on fields of others, livestock raising for others, wage labor, construction, artisanal activities, small industry, and schooling.

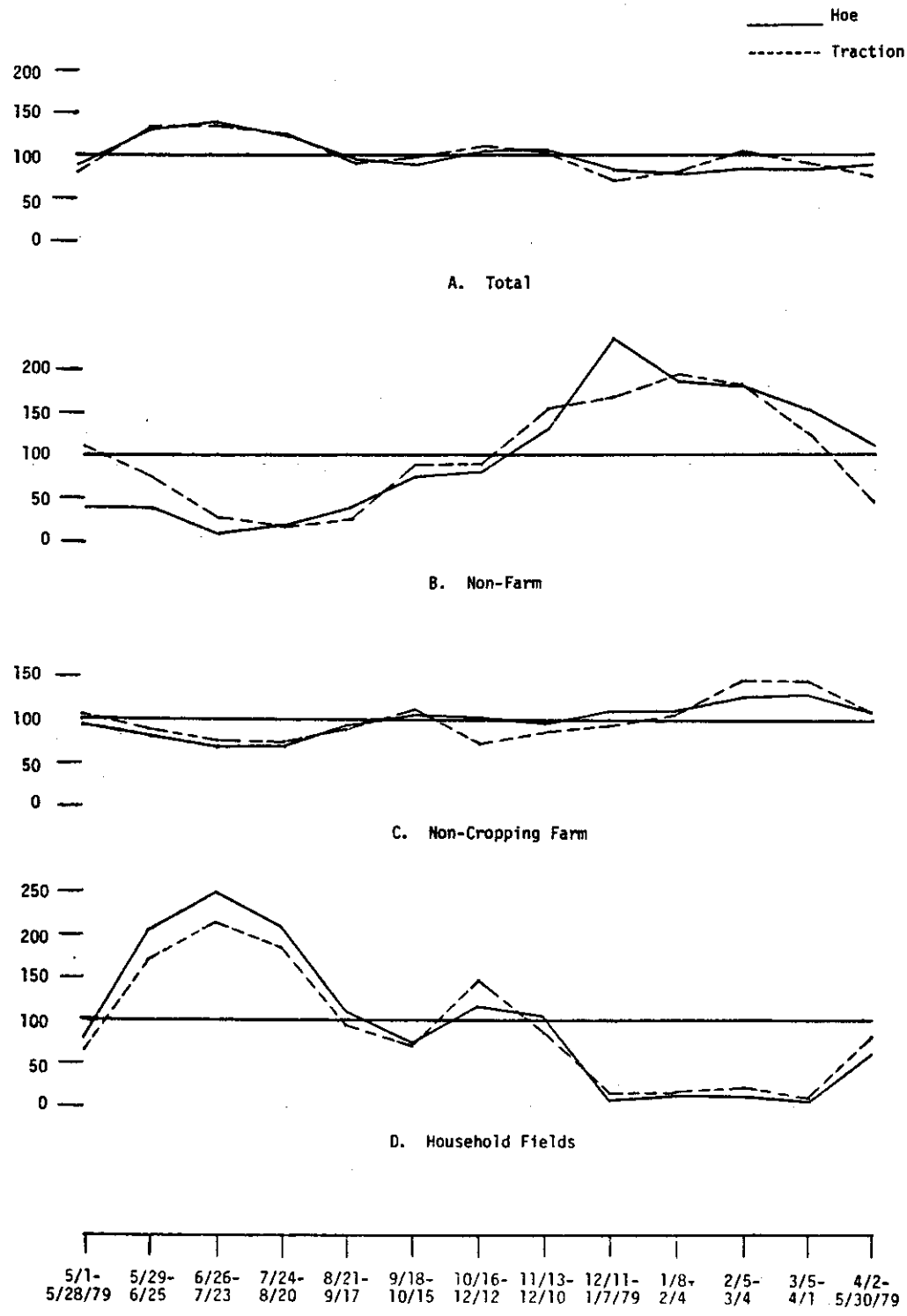
sample households. Traction households, as noted above, are larger and have more women to share household chores. To the extent that the time needed for household chores increases less than proportionally to increases in household size, each woman in the larger ANTRAC households can spend less working time on household chores. Despite the increased proportion of women's work time going to field work, the total hours of fieldwork by women, as well as by men, is lower in ANTRAC households. The reduction in fieldwork labor is slightly greater for men, 30 percent, as compared to a reduction of 21 percent for women.

A final labor allocation question often raised in relation to animal traction programs is whether animal traction enables a more even distribution of labor over the year. In Figure 4.2, seasonal indices for labor inputs in household field activities, non-cropping farm activities, non-farm activities and total labor time are shown for hoe versus traction households. It can be seen that the labor profiles for the two subsamples are very similar. Labor used on household fields and non-farm activities is more evenly distributed over the year in traction households. The coefficient of variation for monthly labor inputs to household fields is .68 for traction households and .79 for hoe farming households. The coefficient of variation for non-farm activities is .59 and .69, respectively. These figures tend to support the view that animal traction reduces labor requirements for household fields during the peak season, enabling a more even distribution of labor for non-farm activities. On the other hand, labor for non-cropping farm activities is less evenly distributed among traction households.

Turning to the distribution of all household labor inputs over the year, it can be seen that total labor is more evenly distributed than any of the component categories. This results from the fact that non-farm labor is primarily counter-seasonal to cropping labor. Thus, the coefficients of variation for total labor inputs are .19 for hoe farmers and .21 for traction farmers. This suggests that animal traction only slightly reduces the seasonal variation of labor inputs into cropping and non-farm activities.

In summary, the main impact of animal traction on household labor allocation is a significant reduction in total WE hours worked per hectare in crop production, even when the labor for draft animal care is taken into account. While there is a slight shift in the peak cropping season for traction households, the profile of the agricultural calendar remains quite similar for both subsamples. Regarding total household labor allocation, there again appears to be little difference among subsamples. It appears that traction households spend slightly more of their work time on livestock and agricultural trading.

Figure 4.2 SEASONAL INDICES OF MAN-HOURS WORKED ON HOUSEHOLD FIELDS, NON-CROPPING FARM ACTIVITIES AND NON-FARM ACTIVITIES



5. AN ECONOMIC ANALYSIS OF HOE, DONKEY, AND OXEN FARMING

5.1. Introduction

In this section, financial and cash flow analyses are used to evaluate the economics of oxen traction, donkey traction, and traditional hoe technology at the farm level. These analyses are based on EORD survey data from 110 ANTRAC and 106 hoe farming households from the 1978-79 crop season.[1/] In addition, the medium-term financial impact of animal traction is assessed on the basis of 10-year income projections under various assumptions of current and potential ANTRAC performance. The components of total farm and total household income[2/] analyzed in this chapter include: (a) the actual value of cash transactions, (b) the imputed value of unsold farm and nonfarm production,[3/] and (c) the imputed values of in-kind costs.

Acreage and yield data, first discussed in the previous chapter, have been used to derive the total value of crop production per household in 1978-79, as presented in Table 5.1. The value of each of the major crops is presented separately in order to show its relative economic importance. The prices used are weighted average sales prices for the 1978-79 season. The relative share of the different crops in the value of production is similar to that demonstrated by the allocation of cultivated acreage to each. Sorghum and millet are by far the most important, contributing 63 to 85 percent of the total value of crop production for each of the four subsamples. Their reduced importance in the donkey zones tends to reflect the localized effect of drought on sorghum and millet yields. Among hoe farmers, cowpeas, groundnuts, maize, and rice are the next most important crops economically. These crops are of similar importance to ANTRAC farmers, except that the order is slightly different: rice, cowpeas, groundnuts, and maize.

[1/] For more details on these technologies, see Chapter 2 for an overview of regional farming systems and sections 4.6 and 4.7 for detailed descriptions of field crop statistics and household labor allocation. Also see the bibliography for a full listing of previous farm survey reports.

[2/] Total farm income refers to all income attributable to the following farm-related activities: crop production, livestock raising, crop and livestock trading, and crop processing. Total household income refers to income generated by all activities, farm and nonfarm.

[3/] The largest component of unsold production consists of crops directly consumed by the household which represent 80 to 90 percent of the value of crop production.

Table 5.1 TOTAL VALUE OF CROP PRODUCTION, 1978-79

Crop	Price/Kg[a]	Oxen Zones				Donkey Zones			
		TRAD		ANTRAC		TRAD		ANTRAC	
		FCFA	%	FCFA	%	FCFA	%	FCFA	%
Sorghum	45.5	59,821	69.9	81,167	54.3	36,449	43.6	36,871	39.2
Millet	45.5	12,792	14.9	29,206	19.6	18,775	27.5	13,217	14.1
Niadi[b]	45.5	0	0.0	14	0.0	7,319	8.8	10,476	11.1
Maize	39.6	2,663	3.1	6,767	4.5	2,827	3.4	4,129	4.4
Groundnuts	68.9	1,971	2.3	4,857	3.3	1,114	1.4	11,447	12.2
Bambara Nuts	59.0	1,103	1.3	1,242	0.8	1,109	1.3	1,105	1.2
Cowpeas	73.2	5,192	6.1	10,035	6.7	8,105	9.7	6,551	7.0
Soybeans	72.4	239	0.3	4,302	2.9	282	0.3	1,013	1.1
Sesame	57.6	6	0.0	39	0.0	421	0.5	561	0.6
Cotton	67.4	58	0.1	1,818	1.2	73	0.1	916	1.0
Rice	90.2	1,746	2.0	9,909	6.6	7,127	8.5	7,726	8.2
TOTAL		85,591		149,356		83,601		94,012	
Sorghum & Millet & Niadi		72,613	84.8	110,387	73.9	62,543	74.8	60,564	64.4

[a]This represents the weighted average selling price realized by sample households during the 1978-79 survey period.

[b]A 60-day, short season millet variety grown in the Logobou area.

5.2. Farm Household Income

A statement of annual income for sampled farm households is presented in Table 5.2. Net household income is defined as the sum of five income components: crop production, livestock raising, trade in agricultural products, agricultural processing and the sale of gathered crops, and "other" sources of income.

The overall picture which emerges is one of a subsistence economy with a surprisingly low degree of monetization. Looking at the major source of total farm household income, crop production, only 8 to 15 percent of the value of crop production was sold by the four subsamples in 1978-79. Both ANTRAC and hoe farmers use only minimal amounts of purchased seed, fertilizer, or hired labor. The total value of crop production is higher among ANTRAC farmers than among hoe farmers. However, since oxen households are 67 percent larger and donkey households are 28 percent larger than traditional households, this difference mainly reflects the larger scale of ANTRAC farms. On a per capita basis, the value of crop production, relative to hoe farmers, is only slightly higher (+4.5 percent) for oxen traction and moderately lower (-11.9 percent) for donkey traction.

Table 5.2 shows that the introduction of animal traction imposes a variety of production costs which are substantially higher than those encountered by hoe farmers. For example, ANTRAC-related variable costs in 1978-79 (feed grain purchased or supplied by the household and ANTRAC animal maintenance costs) amounted to 5,544 FCFA for oxen farmers and 4,134 FCFA for donkey farmers, increases of 59 percent and 44 percent, respectively, above hoe levels. Annual fixed costs (excluding depreciation on animals) were 8,224 FCFA for oxen and 6,243 FCFA for donkey farmers, fully 154 and 127 percent higher, respectively, than for hoe farming.

Due to its potential for increasing returns from crop production, ANTRAC can generate direct revenues which may help cover some of these added costs through either contract services (plowing or carting) or the sale of mature oxen which appreciate greatly in value during the time they work as draft animals. Among oxen farmers, such contract revenues were not substantial, amounting to only 660 FCFA, because of inexperience and a lack of popularity of oxen carts. However, the value of appreciation on oxen, estimated at 10,000 FCFA per ox per year, more than covered all ANTRAC-related costs in 1978. Among donkey farmers, contract revenues were more substantial than for oxen farmers, due almost exclusively to a

Table 5.2 FARM HOUSEHOLD ANNUAL INCOME STATEMENT, 1978-79

	Oxen Zones		Donkey Zones	
	HOE	ANTRAC	HOE	ANTRAC
Number of Households	36	64	72	46
I. Crop Production Enterprise				
Revenue				
Value of Crop Production[d]	85,591	149,356	83,601	94,012
of Which, Value Sold	6,661	9,680	9,569	13,798
Contract Plowing Revenues	0	+ 524	0	+ 70
Contract Transport Revenues	0	+ 136	0	+ 1,635
Variable Costs				
Purchased Seed	- 484	- 583	- 784	- 1,273
Value of Household Seed[a]	- 4,175	- 7,930	- 4,490	- 6,981
Fertilizer and Insecticides	- 28	- 402	- 153	- 788
Wage Labor	- 250	- 490	- 217	- 315
Grain Purchased for "Invitation" Field Labor[b]	0	- 31	0	- 48
ANTRAC Feed Grain (Purchased)	0	- 640	0	- 328
ANTRAC Feed Grain (Value of Household Grain)[a]	0	- 1,672	0	- 2,826
Other ANTRAC Maintenance Costs[c]	0	- 3,232	0	- 980
Fixed Costs				
Repairs to ANTRAC Equipment	0	- 68	0	- 26
Replacement Parts for ANTRAC Equipment	0	- 1,012	0	- 1,075
Interest Payments for ANTRAC Credit	0	- 1,915	0	- 47
Depreciation on ANTRAC Equipment[e]	0	- 5,229	0	- 5,095
Depreciation on ANTRAC Animals[e]	0	+22,645	0	- 2,081
Repairs of Other Tools and Equipment	- 36	- 67	- 61	- 77
Depreciation on Other Tools and Equipment	- 1,996	- 3,170	- 2,324	- 2,678
Net Revenue				
Net Revenue from Crop Production	78,622	146,220	75,572	71,099
II. Livestock Enterprise				
Revenue				
Sales of Animals	3,652	27,693	17,337	33,281
Sales of Animal Products	345	5,434	1,684	680
Costs				
Animal Purchases	- 5,556	-26,961	-10,127	-30,924
Feed and Maintenance Expenses	- 411	- 1,031	- 3,084	- 1,641
Net Revenue				
Sub-total	- 1,970	5,135	5,810	1,396
III. Agricultural Trading				
Revenue				
Value of Sales (Net of Transport Costs)	1,594	2,877	7,867	17,913
Costs				
Value of Purchases (Net of Transport Costs)	- 1,358	- 3,406	- 6,682	-19,402
Depreciation	- 61	- 599	- 234	- 215
Change in Value of Inventories[a]	0	+ 2,058	- 9	+ 3,626
Net Revenue				
Sub-total	175	930	942	1,922
IV. Agricultural Transformation & Gathered Crops				
Revenue				
Sales of Transformed Crops	1,052	2,744	1,994	8,185
Sales of Gathered Crops	513	3,406	994	631
Costs				
Purchases of Variable Inputs	- 797	- 2,718	- 1,489	- 9,897
Depreciation on Equipment	- 240	- 254	- 797	- 339
Net Revenue				
Sub-total	528	3,178	702	- 1,420
NET FARM INCOME	77,355	155,463	83,026	72,997
V. Other Sources of Income				
Revenue				
Gross Returns to Non-Ag. Trading & Artisanal Activities	38,422	14,822	8,858	34,385
Salaries	11	484	0	4,817
Pensions	0	5,807	9	860
Inheritance & Net Cash Gifts	- 382	14	- 2,673	5,972
Costs				
Variable Costs of Non-Ag. Trading & Artisanal Activities	- 1,120	- 7,943	- 5,156	-24,457
Depreciation	- 572	- 641	- 527	- 1,535
Net Revenue				
Sub-total	36,359	12,543	511	20,042
TOTAL NET HOUSEHOLD INCOME	113,714	168,006	83,537	93,039

Notes on Table 5.2

a. Crop values based on average sales prices listed in Table 5.2.

b. "Invitation" labor refers to festive work parties of a reciprocal nature in which food and sorghum beer are the primary in-kind payment. These cash purchases of grain substantially understate the real costs of invitation labor which primarily utilize household food stocks, rather than purchased grain.

c. Chiefly non-grain feeding expenses, salt, and medicines for animal maintenance.

d. Refers to cart rental services. This does not include the sale of carted products, such as firewood, but only the rental of the cart for transport use.

e. The following straight-line depreciation schedule was used for ANTRAC equipment and animals. (Note that the values in parentheses represent appreciation.)

ANTRAC Item	1978 Price (FCFA)	Estimated Working Life (Years)	Salvage Value (FCFA)	Annual Depreciation Rate (FCFA)
Oxen Traction:				
Plow	18,250	10	2,000	1,625
Weeder (5 Teeth)	19,635	7	1,500	2,591
Ridger	6,470	5	500	1,194
Accessories	7,225	5	250	1,395
Cart	44,735	10	3,000	4,174
1 Ox	35,000	4	75,000	(10,000)
Donkey Traction:				
Plow	11,320	10	1,000	1,032
Weeder	17,200	8	1,500	1,963
Ridger	4,850	6	500	725
Accessories	5,185	5	200	997
Cart	44,735	10	2,000	4,274
1 Donkey	18,000	7	3,000	2,143

small number of high-income generating donkey carts.[1/] However, these donkey contract revenues were offset by the fact that donkeys depreciate in value.

The average net revenue from cropping activities was 86 percent greater for oxen farmers than hoe farmers in the same study areas with the estimated appreciation of oxen alone contributing a 16 percent increase. For donkey farmers, average gross revenue from cropping is 12 percent higher but, when higher ANTRAC costs are included, donkey farmers have net cropping revenues 6 percent lower than hoe farmers in the same zones. The poor income performance of donkey traction is influenced by the fact that a drought seriously reduced overall yields in donkey zones. The timing of the drought (early June through July in Piela and an early end of rains in Diapangou) may have disproportionately penalized an ANTRAC cropping strategy by prohibiting plowing in Piela and severely penalizing late planting in both villages. In addition, this drought was more severe in some ANTRAC villages than the neighboring control villages due to rainfall differences in Diapangou and soil differences in Piela. In general, however, donkey traction has lower costs than oxen traction, which can make donkeys appealing to small, poor, or inexperienced farmers.

While crop production is by far the largest source of total farm household income, Table 5.2 presents four other important components. Although livestock raising and crop trading do not contribute substantial net revenues on the average, they have important cash flow benefits for many ANTRAC households. Proportionately twice as many ANTRAC farmers engaged in crop trading and two to three times as many in cattle trading (Ouedraogo and Wilcock, 1980, p. 36). Although the net revenue from crop trading is higher for ANTRAC households, their net revenue from livestock raising is higher than for hoe households only in oxen zones. Unfortunately, a major component of the net revenue of the livestock enterprise, the growth in value of herds, is not included in Table 5.2, which may explain these ambiguous results.[2/]

[1/] It should be noted that donkey cart revenue in Table 5.2 may substantially underestimate the potential revenue from carting in certain areas because this figure reflects only direct cart rental fees and not the sale of hauled goods such as firewood, water, or gravel. As shown in Chapter 4, over half of donkey cart time was used to haul firewood. In heavily populated areas such as the donkey zones--Diapangou, Piela, and Logobou--there is a flourishing market for firewood. Firewood carting can be a substantial source of revenue; in some areas, donkey wood haulers can easily net 10,000 FCFA per month.

[2/] The analysis of the change in the value of farm livestock inventories over the 1978-79 season was considered beyond the scope of this report because of the large amount of time and computer resources it would have entailed.

Agricultural transformation and gathered crops contribute little to total income. Certain transformation activities, for which much of the production may be consumed but little sold (such as weaving, food preparation, and dolo making), can result in negative net revenues. A surprising proportion of total household income is generated from other sources of income. The mean values of such income for some zones is somewhat exaggerated by a few individuals who are either skilled laborers (such as masons or carpenters) or retail traders.

Table 5.3 indicates the absolute and relative importance of the five major income components for sampled farmers. Four components are summed to make up net farm income; all five components are included in total household income. The table also includes several efficiency measures: net crop production revenue, net farm income, and net household income on a per capita, per active worker, and per hectare basis. On all efficiency measures (except net household income per active worker), donkey farmers had lower incomes than the hoe farmer control group. As stressed earlier, this is largely due to drought in donkey areas which affected traction farmers more than hoe farmers.

For oxen farmers, the results are more encouraging. All standardized income measures are higher for oxen households for both net crop production revenue and total farm income. Total household income measures for oxen farming are lower than for hoe farming, however, due to unusually high levels of other income attributable to 2 of the 36 hoe farmers in the oxen zones. For oxen farmers, net farm income is 20 percent higher per capita, 16 percent higher per active worker, and 12 percent higher per hectare, than for hoe farmers in the same zones.

By any measure, income is clearly very low for both hoe and animal traction farmers. Hoe farmers had a net household income per capita of 13,255 FCFA ($60.25) a year. The ANTRAC households had a per capita average income of 1,586 FCFA lower than that for hoe farmers. It is clear that such low per capita incomes represent a level of material poverty which severely limits the potential for savings and investment among most farmers in the Eastern Region.

In summary, the survey data indicate that the income effects of ANTRAC were not substantial during the 1978-79 season. Oxen farmers had a modestly higher per capita farm income than hoe farmers, while that of donkey farmers fell below hoe farming levels. Unfortunately, these survey data are limited in their ability to provide a fair test of ANTRAC profitability. Although the ANTRAC sample represents farmers considered by extension agents to be relatively more successful in using traction, the program is young and most of these farmers are

Table 5.3 SUMMARY FARM HOUSEHOLD INCOME CHARACTERISTICS

	Oxen Zones		Donkey Zones	
	Hoe	ANTRAC	Hoe	ANTRAC
Value of Major Sources of Income	FCFA	FCFA	FCFA	FCFA
I. Crop Production	78,622	146,220	75,572	71,099
II. Livestock Raising	- 1,970	5,135	5,810	1,396
III. Crop Trading	175	930	942	1,922
IV. Agricultural Processing	528	3,178	702	- 1,420
V. Other Sources	36,359	12,543	511	20,042
NET FARM INCOME[a]	77,355	155,463	83,026	72,997
NET HOUSEHOLD INCOME	113,714	168,006	83,537	93,039
Relative Importance of Sources of Income	Percent	Percent	Percent	Percent
I. Crop Production (% of total)	69.1	87.0	90.5	76.4
II. Livestock Raising	- 1.7	3.1	7.0	1.5
III. Agricultural Trading	0.2	0.6	1.1	2.1
IV. Agricultural Processing	0.5	1.9	0.8	- 1.5
V. Other Sources	32.0	7.5	0.6	21.5
Efficiency Measures	FCFA	FCFA	FCFA	FCFA
Net Crop Production Revenue per Person	11,787	13,126	8,559	6,309
Net Crop Production Revenue per Active Worker	25,863	27,745	19,084	17,174
Net Crop Production Revenue per Hectare	19,854	20,508	16,287	11,771
Net Farm Income per Person	11,597	13,955	9,403	6,477
Net Farm Income per Active Worker	25,446	29,450	20,968	17,632
Net Farm Income Hectare	19,534	21,804	17,894	12,085
Net Household Income per Person	17,049	15,081	9,461	8,256
Net Household Income per Active Worker	37,406	31,879	21,095	22,473
Net Household Income per Hectare	28,716	23,563	18,003	15,404

[a]Net Farm Income in the sum of major income components I through IV.

still in the process of learning the different elements of the package. Traction teams are typically underutilized, particularly for weeding and ridging. Many farmers are inexperienced and many EORD ANTRAC services are not fully operational. Traction animals tend to be fed and cared for at less than recommended levels. As a result, most ANTRAC farmers surveyed were not yet achieving substantial productivity increases. Thus, the income effect of ANTRAC should rise in future years as performance improves both at the farm and program level.

5.3. Cash Flow

5.3.1. Annual Cash Flow

Although net income is a very useful measure of economic welfare, the farm cash flow position has important practical consequences in an area such as the Eastern Region. Due to poorly articulated markets plus a low level of monetization in the rural economy, where less than 10 percent of agricultural production is sold, farmers are limited in their ability to generate cash. Cash flow problems can inhibit the adoption of interventions such as ANTRAC which have highly variable cash expenditures and revenues. The EORD credit program alleviates this problem partly, but not entirely, as seen below.

The annual cash flow statement presented in Table 5.4 shows the extremely low level of annual cash flow for both ANTRAC and hoe farmers. Of the already low net cropping revenues and household net incomes, only a very minor proportion is realized as cash revenue. While the absolute value of cash inputs into crop production is small, the cash inputs in hoe farming are quite large relative to the amount of cash revenue generated, varying from 26 to 30 percent of the value of sales in the two subsamples. Oxen traction, moreover, causes a dramatic increase in the current cash costs of crop production. Even when contract revenues are included, net current cash costs amount to 6,524 FCFA or 67 percent of crop sales, leaving a net cash revenue of only 3,156 FCFA (item 5 in Table 5.4). Current cash expenses for donkey traction are less than those for oxen; most are recovered through cash revenues generated from contract services. Thus, the net current cash costs of crop production amount to only 3,325 FCFA for donkey farmers, or 24 percent of crop sales. In terms of net cash flows generated from crop production, donkey traction outperformed hoe agriculture, both on an absolute and a per capita basis, while oxen traction did not.[1/]

[1/] While 66 percent of the ANTRAC sample farmers had an outstanding ANTRAC loan from the EORD, many did not make repayments in 1978-79 due to poor credit (footnote is continued on page 82)

Table 5.4 ANNUAL CASH FLOW STATEMENT, 1978-79

Cash Flow Item	Oxen Zones		Donkey Zones	
	HOE	ANTRAC	HOE	ANTRAC
Crop Production			FCFA	
1. Value of Sales	6,661	9,680	9,569	13,798
2. Non-ANTRAC Inputs	- 1,752	- 2,682	- 2,879	- 2,621
3. ANTRAC Related Current Cash Expenses	0	- 4,502	9	- 2,409
4. ANTRAC Related Revenues	0	+ 660	0	+ 1,705
5. Net Cropping Cash Revenue	4,909	3,156	6,681	10,473
6. Major Food Purchases	- 4,966	-11,617	- 9,505	-20,782
7. Net Cropping Cash Surplus	- 57	- 8,461	- 2,824	-10,309
Livestock Production				
8. Revenues	3,997	33,127	19,021	33,961
9. Expenditures	- 5,967	-27,992	-13,203	-32,565
Agricultural Trading				
10. Revenues	1,594	2,877	7,867	17,913
11. Expenditures	- 1,358	- 3,406	- 6,682	-19,402
Agricultural Processing and Gathering				
12. Revenues	1,565	6,150	2,988	8,816
13. Expenditures	- 1,037	- 2,972	- 2,286	-10,236
Other Sources of Income				
14. Revenues	38,051	21,127	6,194	46,034
15. Expenditures	- 1,120	- 7,943	- 5,155	-24,457
Capital Expenditures				
16. Non-ANTRAC Equipment Purchased	- 183	- 126	- 504	- 276
17. ANTRAC Equipment Purchased	- 333	- 640	- 0	- 2,399
Credit				
18. Borrowing and Reimbursements Received	1,155	6,853	2,854	9,169
19. Loans and Repayments	- 1,870	-19,237	- 3,138	- 7,724
20. Net Cash Flow	34,437	- 643	5,131	8,525

The problem of current cash expenditures for ANTRAC is even more acute when one considers cash cropping revenue net of cash food expenditures. In Table 5.4, net cash surplus from cropping (defined as net cash revenue from cropping less major cash purchases of food) can be considered as a rough measure of a household's ability to produce enough food to feed itself and generate a cash surplus from the crop production enterprise alone. Neither traditional nor ANTRAC farmers generated such a surplus in 1978, a result most marked in donkey zones due to poor rainfall. Although 1978 was a year for rebuilding on-farm grain stocks following several years of sporadic drought which may have caused low cash sales, only the hoe farmers sold more crops than they purchased. This implies that ANTRAC farmers, at least during the 1978-79 season, were less food self-sufficient than hoe farmers and that they had to generate current cash revenues from sectors other than crop production in order to meet the annual cash flow requirements of both ANTRAC adoption and food needs. Thus, in Table 5.4, one sees that the net cash deficit of the ANTRAC cropping enterprise (represented under net cropping surplus) is offset by positive cash flows from the other economic sectors, principally "other sources of income."

In summary, the current cash costs of ANTRAC create a serious annual cash flow problem, caused primarily by capital expenditures on equipment and animals plus the scheduling of financing.[2/] The modest output increases attributable to

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[1/](continued from page 80) collection efforts by the EORD. Repayment behavior therefore has a substantial effect on the annual cash flow position shown in Table 5.4, at least for oxen farmers. Of the 19,237 FCFA in cash loans and repayments of oxen traction farmers, 12,697 FCFA represents repayments on EORD medium-term ANTRAC loans. Since ANTRAC credit collection efforts were delayed until after the survey period, donkey farmers reimbursed only 284 FCFA to the EORD during the 1978-79 season. A more reasonable assessment of the cash flow effects of ANTRAC financing would be to use the value of ANTRAC credit repayment that the typical oxen or donkey farmers from our survey should have paid in 1978-79. For the median ANTRAC farmer in each subsample, this implies a cash repayment of 22,600 FCFA for oxen farmers and 14,175 FCFA for donkey farmers. If these repayment values are taken into account (net of ANTRAC credit repayments already included in Table 5.4), the annual net cash flow becomes -10,546 FCFA for oxen farmers and -5,366 FCFA for donkey farmers.

[2/]This cannot be fully depicted in an annual cash flow statement because the problem involves year-to-year changes in cash flow position. Further, our sample of ANTRAC farmers does not accurately represent a cross-section of farmers at the various stages of ANTRAC financing that are characteristic of the EORD medium-term credit program.

oxen traction are not accompanied by increases in crop sales because some of the additional output is consumed. This, plus high current cash costs, makes oxen a less attractive investment than donkeys on a current cash basis. While oxen traction is financially more rewarding than donkey traction (although this is somewhat exaggerated by the effects of drought on our donkey sample), an oxen traction farmer must have other sources of liquidity to carry him through cash deficit years until capital gains are realized from the sale of his oxen team. Donkey traction also requires alternative sources of liquidity but to a lesser extent because of its lower cash costs. The lower and less variable cash costs of donkey traction may account for its popularity in spite of its poor financial performance in 1978-79. These factors are examined further in the next section.

5.3.2. Monthly Cash Flow

The annual cash flow statement obscures important changes in the cash flow position during the cropping season. Tables 5.5 and 5.6 present the monthly cash flow for hoe and ANTRAC households, respectively.[1/] In the hoe sample, the monthly cash balance in Table 5.5 is quite low, as one would expect, but also surprisingly uniform throughout the year. Crop sales are heavier in the December through March post-harvest period but relatively high levels of sales are maintained throughout the year, except for late August through mid-October. Cash expenditures for crop production inputs are concentrated during the May through August cultivation season; however, these are so low that net cropping cash revenue remains positive on average. Major food purchases are also concentrated in this period, the latter part of which represents the "hungry season," creating an important cash deficit. This cash deficit appears to be covered by higher levels of either livestock sales, crop sales, or other sources of income.

In contrast, the monthly cash balance of ANTRAC farmers, presented in Table 5.6, is far more variable throughout the year. The timing of crop sales is slightly more seasonal for ANTRAC farmers than for hoe farmers. In addition, cash expenditures for crop production inputs are greater, making net cash revenue from cropping negative throughout most of the cultivation season. Although ANTRAC-related cash expenses are less seasonal than other agricultural input costs, they still represent the most important cause for this negative net

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[1/] Since monthly statements present cash flow values that are averaged over a large sample, the average monthly stream of cash revenues and expenditures is smoother than it would be for an individual household. The monthly cash flow statement for a typical hoe farming household would show infrequent transactions (particularly for non-crop related activities) and occasional large transactions (particularly for livestock or agricultural trading).

Table 5.5 MONTHLY CASH FLOW STATEMENT FOR HOE HOUSEHOLDS

Cash Flow Item	May 1-May 28, 1978	May 29-June 25	June 26-July 23	July 24-Aug. 20	Aug. 21-Sept. 17	Sept. 18-Oct. 15	Oct. 16-Nov. 12	Nov. 13-Dec. 10	Dec. 11-Jan. 7, 1979	Jan. 8-Feb. 4	Feb. 5-Mar. 4	Mar. 5-Apr. 1	Apr. 2-May 30, 1979
Crop Production													
1. Value of Sales	1,277	411	632	470	205	285	472	952	1,224	1,104	547	1,840	893
2. Non-ANTRAC Inputs	- 826	- 630	- 479	-217	-107	- 47	- 87	- 51	- 9	- 4	- 38	- 63	-102
3. ANTRAC Related Current Cash Expenses	0	0	0	- 9	0	0	0	0	0	0	0	0	0
4. ANTRAC Related Revenues	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Net Cropping Cash Revenue	451	- 219	153	244	98	238	385	901	1,215	1,100	509	1,777	791
6. Major Food Purchases	-1,375	-1,164	-1,559	-652	-897	-753	- 322	-213	- 471	-330	-341	-384	-638
7. Net Cropping Cash Surplus	- 924	-1,383	-1,406	-408	-799	-515	63	688	744	770	168	1,393	153
Livestock Raising													
8. Revenues	1,380	1,714	1,285	1,141	581	647	2,279	204	961	1,375	711	1,279	1,112
9. Expenditures	-1,252	- 800	-1,379	-762	-697	-880	-1,683	-321	- 535	-443	-870	-426	-770
Agricultural Trading													
10. Revenues	1,613	843	251	224	839	66	124	51	200	566	106	1,055	302
11. Expenditures	- 66	- 311	- 16	-280	- 86	-249	- 776	-829	-1,185	-462	-356	- 19	-467
Agricultural Transformation and Gathering													
12. Revenues	145	306	28	192	108	302	187	119	230	54	349	289	245
13. Expenditures	- 81	- 141	- 113	- 55	- 58	-138	- 103	-205	- 84	-174	- 88	- 54	- 8
Other Sources of Income													
14. Revenues	421	50	1,486	1,039	554	575	630	948	336	596	803	4,669	720
15. Expenditures	- 258	- 85	- 425	-377	-380	- 77	- 316	-164	- 904	- 41	-420	-181	-137
Capital Expenditures													
16. Non-ANTRAC Equipment Purchased	- 19	0	- 29	- 6	- 42	- 38	- 33	- 29	- 125	- 32	- 12	- 3	- 24
17. ANTRAC Equipment Purchased	- 1	- 91	- 12	0	0	0	0	0	0	0	0	0	0
Credit													
18. Borrowing and Reimbursements Received	108	133	137	418	136	325	346	62	382	54	206	20	77
19. Loans and Repayments	- 356	- 187	- 221	-263	-169	-214	- 244	-164	- 355	-148	-277	- 14	-104
20. Net Cash Flow	710	48	- 414	863	- 13	-196	474	360	- 332	2,115	320	8,008	1,099

Table 5.6 MONTHLY CASH FLOW STATEMENT FOR ANTRAC HOUSEHOLDS

Cash Flow Item	May 1-May 28, 1978	May 29-June 25	June 26-July 23	July 24-Aug. 20	Aug. 21-Sept. 17	Sept. 18-Oct. 15	Oct. 16-Nov. 12	Nov. 13-Dec. 10	Dec. 11-Jan. 7, 1979	Jan. 8-Feb. 4	Feb. 5-Mar. 4	Mar. 5-Apr. 1	Apr. 2-May 30, 1979
Crop Production													
1. Value of Sales	645	1,849	552	454	757	409	690	487	2,469	776	704	3,476	751
2. Non-ANTRAC Inputs	-1,173	- 620	- 829	- 676	- 166	- 168	- 178	- 65	- 37	- 53	- 25	- 54	- 190
3. ANTRAC Related Current Cash Expenses	-1,147	- 394	- 378	- 119	- 121	- 58	- 109	- 310	- 170	- 105	- 239	- 223	- 215
4. ANTRAC Related Revenues	59	176	221	39	26	35	24	89	142	18	21	60	60
5. Net Cropping Cash Revenue	-1,616	1,011	- 434	- 302	496	218	427	201	2,404	636	461	3,259	406
6. Major Food Purchases	-4,274	-2,958	-1,909	- 743	- 452	- 517	- 707	-1,874	-1,187	- 807	-1,046	-1,503	-1,476
7. Net Cropping Cash Surplus	-5,890	-1,947	-2,343	-1,045	44	- 299	- 280	-1,673	1,217	- 171	- 585	1,756	-1,070
Livestock Raising													
8. Revenues	1,559	5,048	6,907	681	7,799	11,122	2,236	19,134	9,760	2,011	1,159	2,643	8,214
9. Expenditures	-3,021	-4,433	-4,300	-3,763	-6,112	- 5,676	-7,107	-7,081	-3,662	-3,162	-5,576	-4,866	-3,570
Agricultural Trading													
10. Revenues	307	2,023	928	303	156	707	467	1,526	951	36,046	1,173	14,807	3,496
11. Expenditures	- 667	- 178	- 471	- 489	-1,180	-18,707	-2,652	-3,203	- 528	-8,234	- 741	-4,691	-1,388
Agricultural Transformation and Gathering													
12. Revenues	145	697	286	132	613	270	466	468	505	436	621	1,190	1,307
13. Expenditures	- 240	- 452	- 397	- 177	- 665	- 449	- 300	- 399	- 377	- 468	- 489	- 630	- 324
Other Sources of Income													
14. Revenues	2,515	3,551	2,634	4,019	3,667	4,733	3,062	2,903	1,730	2,215	3,913	3,050	2,263
15. Expenditures	- 896	- 742	-1,835	-2,955	-1,355	- 1,061	-3,628	-1,374	- 129	- 693	-1,682	- 754	- 987
Capital Expenditures													
16. Non-ANTRAC Equipment Purchased	- 14	- 4	0	- 9	- 18	- 57	- 33	- 29	- 7	- 20	- 11	- 15	0
17. ANTRAC Equipment Purchased	- 172	- 596	- 475	- 98	- 464	- 59	- 8	0	- 41	- 1	- 4	- 65	- 303
Credit													
18. Borrowing and Reimbursements Received	149	346	312	272	448	2,704	1,601	715	196	286	606	246	533
19. Loans and Repayments	-1,324	- 826	-1,662	- 573	- 432	- 654	-1,610	-1,523	-1,505	-2,597	-1,751	-1,633	-1,466
20. Net Cash Flow	-7,549	2,487	- 416	-3,702	2,501	- 7,426	-7,786	9,464	8,110	25,648	-3,367	11,038	6,705

cropping revenue. When the May through July food purchases are deducted from net cropping revenue, the cash deficit becomes quite sizable, averaging -3,393 FCFA per month, relative to hoe farmers who averaged only -1,238 FCFA per month. ANTRAC farmers were less able to cover this deficit within the same month from other sources of income, as hoe farmers were. Throughout the rest of the year, the monthly cash flow varies greatly, but in a manner unrelated to cropping activities.

In summary, the cash flow analysis implies that ANTRAC not only requires diversified sources of income that can help offset the annual cash flow deficit of ANTRAC crop production, but it also requires a short-term source of liquidity (either credit, cash, or easily liquidated assets) that can cover the monthly cash deficits. Given the scarcity of formal short-term credit in the Eastern Region, particularly for food purchasing,[1/] this means that the current ANTRAC program is suited only to economically diversified households who have easy access to cash. Families most likely to meet these criteria will tend to be large in size (allowing greater economic diversification), have important sources of regular non-agricultural cash income (such as skilled labor or retail trading), have easily liquidated assets (mainly livestock), or have easy access to reliable informal sources of credit.

5.4. Medium-Term Income Analysis

Three major problems have hampered the analysis of the technical and financial impact of ANTRAC in the Eastern Region to date. First, although only relatively successful ANTRAC farmers were surveyed, their performance is far below the potential for the technology. Inexperience is a major explanation because 44 percent of the ANTRAC farmers had only two years' experience or less. In addition, the failure of the EORD to provide the necessary support services led to a lack of weeding and ridging equipment, high animal morbidity rates, and poor animal training. Farmer inexperience and poor extension services contributed to low ANTRAC weeding and ridging rates which also limited the impact of ANTRAC.

Second, a reliable evaluation of ANTRAC performance requires more than a single season's data. With cross-section analysis, the impact of ANTRAC can only

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[1/] Informal credit in cash or in kind (usually grain) is often important in meeting these short-term cash or food deficits. See Tapsoba (1980a, 1980b, and 1981) for detailed discussions of both formal and informal credit in the Eastern Region.

be inferred from differences between ANTRAC and hoe farmers. These differences could be a function of variables which are not directly related to ANTRAC. Zonal differences in weather, soils, marketing patterns, and prices all affect the survey results. An ideal evaluation would follow particular ANTRAC farmers over a several-year period.

Third, a longer time horizon is necessary to evaluate the evolution of ANTRAC adoption at the individual farm level. ANTRAC adoption represents a revolutionary change from hoe farming. A critically important learning period is required before the full benefits of the technology can be realized. During this same period, the investment costs, cash requirements, and animal maintenance costs are substantial. Thus, assessment of the economic viability of ANTRAC at the individual farm level must take account of the early lean years as well as the performance plateau which is achieved only late in the investment period.

To address these issues, a series of 10-year income projections has been developed. These income projections evaluate donkey and oxen traction under four levels of ANTRAC adoption: Case 1: unsuccessful adoption (the plowing package but with no area or yield increase); Case 2: partial adoption (plowing only); Case 3: complete adoption (plowing and weeding); and Case 4: complete adoption plus phosphate fertilizer. The incomplete adoption package (plowing alone) represents the technique most commonly used by ANTRAC farmers in the Eastern Region in 1978. The higher level technologies represent conservative estimates of the performance path one could reasonably expect ANTRAC users to follow as they, and their extension agents, gain experience. Thus, these technologies represent the medium-term performance potential for ANTRAC adopters. Traction weeding is the logical next step in ANTRAC adoption and has been more heavily promoted by the EORD since 1979. Phosphate fertilizer currently represents the only other agronomic intervention that appears feasible in the near future because of its local availability, low cost, and favorable returns.

The technical and financial coefficients used in the 10-year income projections are based primarily on two sources of data: (1) the 1978-79 farm survey; and (2) the 1979-80 plowing and fertilizer trials described in section 4.6.3 above. However, due to problems of data variability, sampling design, and limited sample size, not all coefficients could be based on statistically significant survey or field trial results. This is particularly true for assumptions concerning: (1) the learning curve for ANTRAC plowing and weeding; (2) the

yield effect of ANTRAC weeding; and (3) the degree to which the technical performance of oxen exceeds that of donkeys. In these cases, coefficients were used that reflect "best judgement" estimates, based on the field experience of the MSU field team as well as the interpretation of survey data.

The yield and area assumptions for oxen and donkey traction under Cases 2, 3, and 4 are presented in Table 5.7. A key assumption is that the area and yield increases occur gradually over a two- to six-year period, depending on the technology and type of draft animal used. In addition, it is assumed that the animal traction technology affects only 60 percent of sorghum/millet acreage and 80 percent of the acreage of other crops. This is a conservative estimate which reflects the proportion of acreage plowed by ANTRAC farmers surveyed in 1978. Similarly, the ANTRAC-related acreage expansion is accompanied by a slight decrease in the relative acreage of sorghum and millet, from 80 percent to 75 percent. The yield increase assumptions are more conservative than estimates from the plowing trials because they incorporate a negative yield impact due to later planting associated with ANTRAC plowing and due to greater weed competition when ANTRAC plowing is adopted without ANTRAC weeding. Area and yield increases for donkey traction are assumed to be 67 percent of those for oxen traction in the "plowing alone" case, and 50 percent in the other two cases. This reflects the lower strength and stamina of donkeys.[1/] In addition, it incorporates a lower yield response to plowing and to fertilizer, due to the shallower plowing of donkey traction. In general, the acreage and yield increases assumed in Table 5.7 represent substantially more conservative estimates than those typically attributed to animal traction or to fertilizer use in Upper Volta.[2/]

5.4.1. Net Benefits Assuming No Production Increase

In Case 1, the net benefits to investment in animal traction plowing are calculated under the pessimistic assumption of no area or yield increase. Table 5.8 shows the analysis for the donkey plowing case. Year 0 serves as a

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[1/] The 1978-79 survey data showed larger area increases for donkey farmers than for oxen farmers. Because donkey farmers were more experienced and farmed lighter soils than oxen farmers, the acreage expansion assumptions in Table 5.7 attempt to correct for these experience and soil differences.

[2/] For other estimates of area and yield effects attributable to animal traction use, see Republique de Haute-Volta, Ministere de Developpement Rurale (1979). For other estimates of yield effects of rock phosphate application, see Bikienga, et al. (1980) and Dupont de Dinechin (1967).

Table 5.7 ASSUMED INCREASES IN AREA, YIELD AND TOTAL VALUE OF PRODUCTION FOR OXEN AND DONKEY CULTIVATION UNDER THREE LEVELS OF TECHNOLOGY ADOPTION

	Level of Technology Adoption					
	Case 2:[a] Plowing Only		Case 3: Plowing Plus Weeding		Case 4: Plowing +Weeding +Phosphates[b]	
	Oxen	Donkey	Oxen	Donkey	Oxen	Donkey
	Percent Increase Over Hoe Farming					
Sorghum and Millet:						
Area	3.0	2.0	18.8	9.4	18.8	9.4
Yield	-		6.0	3.0	34.8	17.4
Net Change in Production	3.0	2.0	25.9	13.0	60.0	30.0
Other Crops:						
Area	37.5	25.0	100.0	50.0	100.0	50.0
Yield	10.4	6.9	14.4	7.2	40.0	20.0
Net Change in Production	51.8	34.5	128.8	64.4	180.0	90.0
All Crops:[c]						
Area	9.9	6.6	35.0	17.5	35.0	17.5
Yield	2.0	0.7	7.7	3.9	35.8	17.9
Net Change in Production	12.1	8.1	45.4	22.7	83.3	41.7
Net Increase in Value of Production:[d]	15.7	10.5	52.6	26.3	91.2	45.6
Number of Years Required to Achieve This Level	4	2	6	4	6	6

[a]Case 1 is minimum adoption of animal traction with no increases in area cultivated or in yields per hectare.

[b]Based on 150 kg./ha. applied only to the 5.03 hectares which are plowed and weeded.

[c]Based on 80 percent of area in sorghum and millet in Year 0.

[d]Based on 74 percent of value of production from sorghum and millet in year 0.

Table 5.8 DONKEY PLOWING, NO AREA OR YIELD EFFECT[a]

	YEAR										
	0[b]	1	2	3	4	5	6	7	8	9	10
Revenue (FCFA)											
Value of crop production	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155
Contract plowing	-	-	500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sale + salvage ANTRAC animals	-	-	-	-	-	-	-	-	3,000	-	10,700
Sale + salvage ANTRAC equip.	-	-	-	-	-	-	200	-	-	-	1,000
(1) sub-total	109,155	109,155	109,655	111,155	111,155	111,155	111,355	111,155	114,155	111,155	122,855
Variable Costs (FCFA)[c]											
Purchased + own seed	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380
Fertilizer	120	120	120	120	120	120	120	120	120	120	120
Wage labor	300	300	300	300	300	300	300	300	300	300	300
ANTRAC animal feed	-	2,000	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
ANTRAC animal maintenance	-	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
(2) sub-total	6,800	9,800	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Fixed Costs (FCFA)											
Buy + repair non-ANTRAC equip.	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850
Repair of ANTRAC equip.	-	-	1,000	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Buy ANTRAC equip + insurance	-	25,280	-	-	-	-	5,485[d]	-	-	-	-
Buy ANTRAC animals	-	18,000	-	-	-	-	-	-	18,000[e]	-	-
(3) sub-total	2,850	46,130	3,850	4,350	4,350	4,350	9,835	4,350	22,350	4,350	4,350
Financing (Credit) (FCFA)											
(4) Loan receipts AT equip + ins.	-	19,795	-	-	-	-	-	-	-	-	-
(5) Loan receipts AT animals	-	15,000	-	-	-	-	-	-	15,000	-	-
(6) Loan repayment	-	-	14,175	14,175	14,175	-	-	-	-	5,765	11,350[f]
Net Benefit After Financing (1+4+5) - (2+3+6)	99,505	88,020	80,630	81,630	81,630	93,805	90,520	95,805	95,805	95,805	95,975
Incremental Net Benefit (change from Year 0)	-	-11,485	-18,875	-17,875	-17,875	-3,700	-8,985	-3,700	-3,700	-3,700	-3,530

[a] Package: one donkey, plow, accessories
[b] The hoe farmer benchmark
[c] One US $ is approximately equal to 220 FCFA
[d] Replace accessories after 5 years
[e] Replace donkey after 7 years
[f] Value of donkey loan outstanding

benchmark against which to compare the costs and returns of animal traction over the 10-year horizon. The figures for Year 0 are those for a typical 10-person, 5-worker hoe farming household.[1/] The initial area cultivated in Year 0 by hoe farming methods is 5.65 hectares.

Most of the figures for Years 1-10 in Table 5.8 represent projections based on the assumptions in Table 5.7. The purchase price of the animals and tillage equipment, and the loan repayment schedule, are taken from the records of the EORD medium-term credit program for 1979. Other ANTRAC-related costs during Years 1-10 are based on empirical estimates.[2/] Replacement of animals and equipment follows the depreciation schedule contained in footnote (e) of Table 5.2. The salvage value of all ANTRAC assets is shown in the year of replacement and in Year 10.

Table 5.8 illustrates the effect of ANTRAC investment costs, operating expenses, and loan repayment on farm income, assuming no area or yield increase. The results indicate that the value of crop production would have to be 8-10 percent higher on average in each year in order to cover the costs of investing in donkey plowing, i.e., to achieve the level of net returns obtained under hoe farming.[3/]

Under the same assumption of no area or yield increase, oxen traction results in slightly higher net returns than the hoe technology, yielding an internal rate of return (IRR) of 2 percent (Table 5.9). A large part of the revenue increase comes from the sale of mature oxen whose value increases from 70,000 to 150,000 FCFA during the four-year work period. The financial importance of oxen appreciation is recognized by farmers; it may motivate many aspiring livestock producers to "adopt" animal traction in order to obtain the credit for animal purchase offered by the EORD at a low 5.5 percent annual interest

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[1/] The figures for Year 0 are estimated by projecting from the per capita values found among hoe households surveyed in 1978-79 within both the oxen and the donkey zones.

[2/] The costs of equipment repair, animal feed, and animal maintenance are somewhat higher than those found in the 1978-79 survey data. These higher costs reflect the more realistic levels that would be needed to sustain ANTRAC performance over the medium-term.

[3/] Average annual incremental net benefits are roughly -9,240 FCFA, which is 8.5 percent of the value of production (109,155 FCFA). The term "incremental net benefits" refers to the difference between net benefits under animal traction in Year 1 and those achieved in Year 0 (the hoe cultivation case). It measures how much better or worse off a hoe farmer would be if he adopted the animal traction package shown in the table concerned.

Table 5.9 OXEN PLOWING, NO AREA OR YIELD EFFECT[a]

	YEAR										
	0[b]	1	2	3	4	5	6	7	8	9	10
Revenue (FCFA)											
Value of crop production	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155	109,155
Contract plowing	-	-	500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Sale + salvage ANTRAC animals	-	-	-	-	-	150,000	-	-	-	150,000	110,000
Sale + salvage ANTRAC equip.	-	-	-	-	-	-	250	-	-	-	1,250
(1) sub-total	109,155	109,155	109,655	111,655	111,655	261,655	111,905	111,655	111,655	261,655	222,905
Variable Costs (FCFA)[c]											
Purchased + own seed	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380
Fertilizer	120	120	120	120	120	120	120	120	120	120	120
Wage Labor	300	300	300	300	300	300	300	300	300	300	300
ANTRAC animal feed	-	6,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
ANTRAC animal maintenance	-	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
(2) sub-total	6,800	16,300	18,300	18,300	18,300	18,300	18,300	18,300	18,300	18,300	18,300
Fixed Costs (FCFA)											
Buy + repair non-ANTRAC equip.	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850
Repair of ANTRAC equip.	-	-	1,500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Buy ANTRAC equip + insurance	-	48,635	-	-	-	-	7,135	-	-	-	-
Buy ANTRAC animals	-	70,000	-	-	-	70,000[d]	-	-	-	70,000	-
(3) sub-total	2,850	121,485	4,350	4,850	4,850	74,850	11,985	4,850	4,850	74,850	4,850
Financing (Credit) (FCFA)											
(4) Loan receipts AT equip + ins.	-	41,500	-	-	-	-	-	-	-	-	-
(5) Loan receipts AT animals	-	50,000	-	-	-	-	-	-	-	-	-
(6) Loan repayment	-	-	22,600	22,600	22,600	44,010[e]	-	-	-	-	-
Net Benefit After Financing (1+4+5) - (2+3+6)	99,505	62,870	63,905	65,905	65,905	124,495	81,620	88,505	88,505	168,505	199,755
Incremental Net Benefit (change from Year 0)	-	-36,635	-35,600	-33,600	-33,600	24,990	-17,885	-11,000	-11,000	69,000	100,250

[a]Package: 2 oxen, plow, accessories
[b]The hoe farmer benchmark
[c]Approx. 220 FCFA=one US $
[d]Assumes oxen farmers can purchase new oxen without taking new loan
[e]Larger payment in final year

Internal Rate of Return = 2 percent

rate. However, Table 5.9 shows that the incremental net benefits after financing (loan receipt and repayment) are quite variable, and are negative in 7 out of the 10 years.

5.4.2. Area and Yield Effect from Plowing

A more common case for both donkey and oxen traction farmers is one where traction plowing leads to modest increases in area cultivated and yields. This is consistent with the empirical evidence on adoption and performance levels in the Eastern Region in 1978-79. Plowing without traction weeding also reflects the highest level of ANTRAC adoption one can expect unless the ability of the EORD to provide support services for the more sophisticated technical packages is developed.

The donkey plowing package earns an IRR of only 4 percent, as shown in Table 5.10. By comparison, oxen plowing produces an IRR of 14 percent (Table 5.11), due to the combination of productivity increases and to the appreciation of oxen value. While oxen plowing is more profitable than donkey plowing in terms of internal rate of return, it generates negative incremental net benefits at the outset. Average annual incremental net benefits are 14,275 FCFA, but during the first four years the average is -27,640 FCFA, resulting mainly from high initial investment costs. This provides further support for the conclusion earlier in this chapter that oxen farmers need other sources of liquidity to see them through these cropping income shortfalls. For oxen plowing, the costs of equipment, animal purchase, and interest on loans amount to 138,945 FCFA. In Year 1, the farmer's cash outlay (not covered by loan receipts) amounts to about 33,600 FCFA. This is over ten times the level of cash costs required under hoe farming (roughly 3,000 FCFA out of 9,650 FCFA in fixed and variable costs). Negative incremental net benefits in Years 1-4 also occur because the production benefits of oxen plowing are not fully realized until Year 4, and because the appreciation in value of oxen is not realized until the animals are sold in Year 5.

To farmers who do not have sufficient sources of non-farm income to cover the cash requirements and overall deficits of oxen plowing during Years 1-4, donkey plowing may be more attractive. For donkey plowing, the costs of equipment, animal purchase, and interest on loans are less than half those required for oxen plowing (65,665 FCFA compared to 138,945 FCFA). Moreover, the additional costs of seed (to plant the larger area cultivated) and animal feed and maintenance are less than 40 percent of those for oxen plowing (5,320 FCFA

Table 5.10 DONKEY PLOWING WITH AREA AND YIELD INCREASE

	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
Value of Crop Production	109,155	109,155	120,630[a]	120,630	120,630	120,630	120,630	120,630	120,630	120,630	120,630
Purchased and Own Seed	6,380	6,380	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700
Incremental Net Benefit	-	-11,485	-7,720	-6,720	-6,720	7,455	2,170	7,455	7,455	7,455	7,625

[a]Assumes the benefits of plowing are not realized until Year 2.

Internal Rate of Return = 4 percent

Table 5.11 OXEN PLOWING WITH AREA AND YIELD INCREASE[a]

	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
Value of Crop Production	109,155	109,155	113,435	117,715	126,280	126,280	126,280	126,280	126,280	126,280	126,280
Purchased and Own Seed	6,380	6,380	6,535	6,695	7,010	7,010	7,010	7,010	7,010	7,010	7,010
Incremental Net Benefit	-	-36,635	-31,475	-25,355	-17,105	41,485	-1,390	5,495	5,495	85,495	116,745

[a]Assumes full benefits not realized until Year 4: 25% in Year 2, 50% in Year 3, and 100% in Year 4.

Internal Rate of Return = 14 percent

compared to 13,735 FCFA). The benefits of donkey plowing are also realized more quickly, by Year 2 compared to Year 4 for oxen plowing.

As a result of this cost structure, the donkey plowing package presented in Table 5.10 results in an average net cost of only 8,160 FCFA per year over the first four years (versus 27,640 FCFA for oxen). Many farmers may be able to cover deficits of this magnitude through income from the sale of crops. Although hoe farmers in the 1978-79 sample sold an average of only 9.6 percent of the total value of crops produced, this is 10,480 FCFA for a 10-person household which would cover the early year deficits of donkey traction.

5.4.3. Plowing and Weeding

The benefits of oxen or donkey plowing alone fall well below the full economic potential of animal traction technology. Assuming that the availability of family labor for weeding is a key constraint to production, the expansion of cultivated area through animal plowing would exacerbate the weeding bottleneck. Without the help of ANTRAC weeding on the expanded acreage, yields are likely to be lower than under hoe cultivation. Thus, the combination of animal traction plowing and weeding (Case 3) is assumed to allow area and yield increases beyond those possible with plowing alone.[1/]

The estimated returns to weeding are substantial for both donkey and oxen cultivation. As shown in Table 5.12, donkey plowing and weeding produces an internal rate of return of 28 percent, and negative incremental net benefits in only 3 of the 10 years. For oxen plowing and weeding (Table 5.13), the IRR is 24 percent, slightly lower than for donkey traction. Although the rate of return is slightly lower for oxen traction, it should be kept in mind that oxen traction represents a larger-scale investment than donkey traction. Thus, the average annual returns are greater for oxen plowing and weeding than for donkey traction.[2/] In addition, much of the return to oxen plowing and weeding is due to oxen appreciation.[3/]

[1/] Section 4.6 provided empirical evidence of a larger ANTRAC area effect when oxen-powered weeders are used. The "yield effect" of ANTRAC weeding is indirect--we assume that the use of ANTRAC weeding permits the full yield effect of plowing to be realized, as estimated from field trials.

[2/] Average annual incremental net benefits are 32,369 FCFA for oxen plowing and weeding, 3.4 times as large as for donkeys (9,614 FCFA). Total incremental net benefits discounted at 15 percent are 49,767 FCFA for oxen, 2.5 times larger than for donkeys (20,128 FCFA).

[3/] Assumptions regarding appreciation are therefore critical. If the sales price of a pair of mature oxen is reduced from 150,000 FCFA to 110,000 FCFA, the IRR drops from 24 percent to 18 percent.

Table 5.12 DONKEY PLOWING AND WEEDING

	0[b]	1	2	3	4	5	6	7	8	9	10
Revenue (FCFA)											
Value of crop production	109,155	109,155	116,340[c]	123,520	137,885	137,885	137,885	137,885	137,885	137,885	137,885
Contract plowing	-	-	500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Sale + salvage ANTRAC animals	-	-	-	-	-	-	-	-	3,000	-	10,700
Sale + salvage ANTRAC equip.	-	-	-	-	-	-	200	-	-	-	1,000
(1) sub-total	109,155	109,155	116,840	125,520	139,885	139,885	140,085	139,885	142,885	139,885	151,585
Variable Costs (FCFA)[d]											
Purchased + own seed	6,380	6,380	6,660[e]	6,940	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Fertilizer	120	120	120	120	120	120	120	120	120	120	120
Wage labor	300	300	300	300	300	300	300	300	300	300	300
ANTRAC animal feed	-	2,000	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
ANTRAC animal maintenance	-	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
(2) sub-total	6,800	9,800	11,280	11,560	12,120	12,120	12,120	12,120	12,120	12,120	12,120
Fixed Costs (FCFA)											
Buy + repair non-ANTRAC equip.	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850
Repair of ANTRAC equip.	-	-	1,500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Buy ANTRAC equip + insurance	-	37,275	-	-	-	-	5,485	-	-	-	-
Buy ANTRAC animals	-	18,000	-	-	-	-	-	-	18,000	-	-
(3) sub-total	2,850	58,125	4,350	4,850	4,850	4,850	9,835	4,850	22,850	4,850	4,850
Financing(Credit) (FCFA)											
(4) Loan receipts AT equip + ins.	-	31,790	-	-	-	-	-	-	-	-	-
(5) Loan receipts AT animals	-	15,000	-	-	-	-	-	-	15,000	-	-
(6) Loan repayment	-	-	19,060	19,060	19,060	-	-	-	-	5,765	11,530
Net Benefit After Financing (1+4+5) - (2+3+6)	99,505	88,020	82,150	90,050	103,855	122,915	118,130	122,915	122,915	117,150	123,085
Incremental Net Benefit (change from Year 0)	-	-11,485	-17,355	-9,455	4,350	23,410	18,265	23,410	23,410	17,645	23,580

[a]Package: one donkey, plow, weeder, accessories

[b]The hoe farmer benchmark

[c]Increases are phased as follows: 25% in Year 2, 50% in Year 3, and 100% in Year 4

[d]Approx. 220 FCFA=one US $

[e]Seed costs rise in proportion to area cultivated

Internal Rate of Return = 28 percent

Table 5.13 OXEN PLOWING AND WEEDING[a]

	YEAR										
	0[b]	1	2	3	4	5	6	7	8	9	10
Revenue (FCFA)											
Value of crop production	109,155	109,155	113,435[c]	117,715	126,280	146,445	166,610	166,610	166,610	166,610	166,610
Contract plowing	-	-	500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Sale + salvage ANTRAC animals	-	-	-	-	-	150,000	-	-	-	150,000	110,000
Sale + salvage ANTRAC equip.	-	-	-	-	-	-	250	-	-	-	1,250
(1) sub-total	109,155	109,155	113,935	120,215	128,780	298,945	169,360	169,110	169,110	319,110	280,360
Variable Costs (FCFA)[d]											
Purchased + own seed	6,380	6,380	6,535	6,695	7,010	7,815	8,615	8,615	8,615	8,615	8,615
Fertilizer	120	120	120	120	120	120	120	120	120	120	120
Wage labor	300	300	300	300	300	300	300	300	300	300	300
ANTRAC animal feed	-	6,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
ANTRAC animal maintenance	-	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
(2) sub-total	6,800	16,300	18,455	18,615	18,930	19,735	20,535	20,535	20,535	20,535	20,535
Fixed Costs (FCFA)											
Buy + repair non-ANTRAC equip.	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850
Repair of ANTRAC equip.	-	-	1,500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Buy ANTRAC equip + insurance	-	74,245	-	-	-	-	8,745	-	-	-	-
Buy ANTRAC animals	-	70,000	-	-	-	70,000	-	-	-	70,000	-
(3) sub-total	2,850	147,095	4,350	4,850	4,850	74,850	13,595	4,850	4,850	74,850	4,850
Financing (Credit) (FCFA)											
(4) Loan receipts AT equip + ins.	-	65,500	-	-	-	-	-	-	-	-	-
(5) Loan receipts AT animals	-	50,000	-	-	-	-	-	-	-	-	-
(6) Loan repayment	-	-	28,530	28,530	28,530	55,555	-	-	-	-	-
Net Benefit After Financing (1+4+5) - (2+3+6)	99,505	61,260	62,600	68,220	76,470	148,805	135,230	143,725	143,725	223,725	254,975
Incremental Net Benefit (change from Year 0)	-	-38,245	-36,905	-31,285	-23,035	49,300	35,725	44,220	44,220	124,220	155,470

[a] Package: 2 oxen, plow, weeder, accessories

[b] The hoe farmer benchmark

[c] Value of crop production and seed costs phased from Year 2-6: one-third in Years 2-4; two-thirds in Years 5-6

[d] Approx. 220 FCFA=one US $

Internal Rate of Return = 24 percent

The internal rates of return are slightly higher when a longer income horizon is used. When evaluated over a 20-year rather than a 10-year horizon, the rate of return to oxen plowing and weeding rises from 24 percent to 27 percent. The increase for donkey traction is from 28 to 33 percent.

Because traction weeding is a technically difficult task to learn for both the farmer and his animals, few farmers even attempt it until they have several years' experience. An inexperienced farmer with poorly trained animals can do much more damage when weeding a field of partially grown crops than when plowing a bare field. Thus, the plowing and weeding case assumes that donkey weeding begins in Year 3 and oxen weeding in Year 5, with full usage and benefit levels achieved in Years 4 and 6, respectively. Even this learning period may be an optimistic estimate of the average time required for both animals and farmers to acquire the necessary skills and experience.[1/]

Unfortunately, such a learning period is not taken into consideration in the 1980 EORD ANTRAC program, which required farmers to purchase weeders as part of the initial equipment package. As a result, the ANTRAC farmer must pay the substantial cost of a weeder as part of his loan well before he has the skills to use it.[2/] Profitability would be improved if the weeder were distributed and financed at a later date. Assuming purchase in Year 3 for a donkey weeder and in Year 5 for an oxen weeder, the IRR for animal plowing and weeding rises from 28 percent to 32 percent for donkeys and from 24 percent to 27 percent for oxen.

5.4.4. Plowing, Weeding, and Phosphates

Finally, phosphate fertilizer application with ANTRAC plowing and weeding was examined in Case 4.[3/] Local rock phosphates became available in 1980 from

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[1/] The income horizons shown above do not incorporate any learning period for replacement animals. In the oxen case, if new animals in Years 5 and 9 are able to increase production only to the Year 4 level, then the IRR drops from 24 percent to 19 percent. In the donkey case, if the new animal is purchased one year earlier in Year 7 to allow a year's training, the IRR drops from 28 percent to 25 percent.

[2/] A donkey weeder costs roughly 17,200 FCFA (1979 prices) versus a donkey plow at 11,300 FCFA. Oxen weeders and plows are slightly more expensive: 19,600 and 18,250 FCFA, respectively.

[3/] A phosphate plus plowing combination was not evaluated since it is likely that weed competition would substantially reduce the yields potentially attainable from fertilization.

Kodiari in the southeastern part of the region.[1] The yield response to phosphate application in association with plowing and weeding is discussed in Section 4.6. Due to lower cost and greater availability relative to imported fertilizer, local phosphates may be an attractive potential addition to the current ANTRAC package.[2] Tables 5.14 and 5.15 show that the returns to plowing, weeding, and phosphates are quite favorable, as indicated by an IRR of 34 percent for oxen and 35 percent for donkeys. As in the earlier cases examined, the lower costs of the donkey package offset its lower area and yield effects, relative to the oxen technology.

One potential drawback to incorporating phosphate fertilizer into the ANTRAC package is the additional cash outlay involved. Our calculations assume a rate of 150 kg per hectare, with the acreage affected growing to a maximum of 5 hectares in Year 6 for both oxen and donkeys.[3] At a cost of 20 FCFA per kg, this amounts to 15,000 FCFA per farm per year. In addition, the viability of such a package would depend on a marketing system capable of delivering sizeable quantities of phosphates, and of providing an outlet for the increased agricultural production.

5.4.5. Summary

Table 5.16 summarizes the internal rate of return calculations for the various ANTRAC technical packages considered above. The effect on IRR of lengthening the time horizon to 20 years, of delaying purchase of the weeder, and of reducing the appreciation in oxen value is also shown.

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[1] The chemical composition of local rock phosphates is given in Section 4.6.3.

[2] The price for local phosphates charged by the EORD to credit customers was 1,000 FCFA per 50 kg sack in 1979. Imported superphosphates and 18-35-0 cotton fertilizer were both 1,850 FCFA per 50 kg sack. Imported urea was priced at 1,480 FCFA per 40 kg sack. (ORD Est Fada, Bureau de Developpement Communautaire, Section Credit et Cooperation, "Fiche Technique sur le Credit Rural," March, 1979.)

[3] The basic plowing and weeding calculations assumed that donkey farmers would be ready to begin weeding in Year 3, becoming fully operational in Year 4. In order to allow time for acquiring additional working capital for fertilizer, it is assumed in the plowing, weeding, and phosphates case that the build-up of usage and benefits does not peak until Year 6 for donkeys, the same as for oxen. Sale of oxen in Year 5 provides sufficient surplus for oxen farmers to begin applying fertilizer at the same time as they introduce the weeding operation.

Table 5.14 DONKEY TRACTION: PLOWING, WEEDING, AND PHOSPHATE FERTILIZER[a]
(Figures in FCFA)[b]

	YEAR									
	1	2	3	4	5	6	7	8	9	10
Increased Value of Crop Production[c]	0	1,755	3,510	7,015	14,030	21,045	21,045	21,045	21,045	21,045
Increased Fertilizer Cost	0	1,260	2,515	5,030	10,060	15,090	15,090	15,090	15,090	15,090
Change in Net Revenue	0	495	995	1,985	3,970	5,955	5,955	5,955	5,955	5,955
Incremental Net Benefits	-11,485	-16,860	-8,460	6,335	27,380	24,580	29,365	29,365	23,600	29,535

[a]Package: donkey, plow, weeder, 150 kg/ha tricalcium phosphate
[b]Approx. 220 FCFA=one US dollar
[c]Phased as follows: one-third in Years 2-4; two-thirds in Years 5-6
Increases relative to levels for donkey plowing and weeding (Table 5.12)

Internal Rate of Return = 35 percent

Table 5.15 OXEN TRACTION: PLOWING, WEEDING, AND PHOSPHATE FERTILIZER[a]
(Figures in FCFA)[b]

	YEAR									
	1	2	3	4	5	6	7	8	9	10
Increased Value of Crop Production[c]	0	3,510	7,015	14,035	28,070	42,100	42,100	42,100	42,100	42,100
Increased Fertilizer Cost	0	1,260	2,515	5,030	10,060	15,090	15,090	15,090	15,090	15,090
Change in Net Revenue	0	2,250	4,500	9,005	18,010	27,010	27,010	27,010	27,010	27,010
Incremental Net Benefits	-38,245	-34,655	-26,785	-14,030	67,310	62,735	71,230	71,230	151,230	182,480

[a]Package: 2 oxen, plow, weeder and 150 kg/ha tricalcium phosphate
[b]Approx. 220 FCFA=one US dollar
[c]Phased as follows: one-third in Years 2-4; two-thirds in Years 5-6
Increases relative to oxen plowing and weeding (Table 5.13)

Internal Rate of Return = 34 percent

Table 5.16 INTERNAL RATE OF RETURN TO SELECTED OXEN AND DONKEY TRACTION INVESTMENT CASES[a]

Case No.	Level of Technological Adoption	Internal Rate of Return (Percent)	
		Oxen	Donkey
1	Limited Plowing (No area or yield effects)	2	negative
2	Plowing Only	14	4
3	Plowing + Weeding	24	28
4	Plowing + Weeding + Phosphate Fertilizer	34	35
5	Case #3 with deferred purchase of weeder[b]	27	32
6	Case #3 with 20-year horizon	27	33
7	Case #3 with smaller appreciation in oxen value[c]	18	-

[a]Calculated over a 10-year horizon except for line 6.

[b]Weeder purchased in Year 3 (donkey) and Year 5 (oxen).

[c]Sale value of 110,000 FCFA instead of 150,000 FCFA per oxen pair.

Except for the plowing-only case, donkey traction brings somewhat higher rates of return than oxen traction despite the lower area and yield increases that it generates. This is explained by the substantially lower costs of the various donkey packages, and by the shorter learning period required to reach full benefits with donkey plowing and weeding.

The calculations suggested the likelihood of serious cash flow problems in the first four years following adoption, especially in the case of oxen traction. For many farmers, such annual cash flow deficits are prohibitively high. Recommendations for remedying the cash flow problem are discussed in the following section.

The analysis in this section assumes no year-to-year variability in crop yields. The variable climatic conditions actually faced by farmers in the region would clearly affect the net returns and cash flow associated with animal traction cultivation. Below average crop yields, especially during years immediately following adoption, would worsen the cash flow problem and reduce long-run profitability. The combination of this risk factor and the cash flow problems already evident under average yield assumptions tend to worsen the potential acceptability of animal traction technology in the eyes of farmers.

The medium-term income analysis provides a useful method of evaluating the impact of ANTRAC. First, it represents a longer time horizon than is typically used by donors, program planners, or even the individual adopting farmers. It would be more typical to overlook the long learning process, the initial deficit years, and the resulting deferral of benefits of ANTRAC adoption. Second, the 10-year income projections may help explain why the performance of ANTRAC was so mediocre at the farm level during the 1978-79 season. Since the EORD ANTRAC program began only in 1974, most ANTRAC users in 1978-79 were relatively recent adopters. The median oxen farmer surveyed had only 2 years' experience and the median donkey farmer had only 4 years' experience. This implies that many ANTRAC farmers surveyed were operating in the deficit years of the ANTRAC investment period.

6. SUMMARY AND RECOMMENDATIONS

This chapter has three objectives: (a) to highlight principal findings in the report; (b) to summarize the major problems impeding the performance of animal traction in Eastern Upper Volta; and (c) to recommend changes which may improve future ANTRAC programs in the Eastern Region of Upper Volta and elsewhere in West Africa.

6.1. Overview of Findings

This report has a dual focus. First, it evaluates the institutional performance of the EORD ANTRAC program. Second, it analyzes the technical and economic impacts of ANTRAC adoption at the farm level, based on a sample of the relatively most successful ANTRAC farmers in the Eastern Region. The recent increase in the use of ANTRAC technology has been dramatic in this region--a ten-fold increase from 1974 to a level of approximately 1,800 donkey and oxen units by 1979. Yet the technical, economic, and institutional performance of the EORD ANTRAC program has not kept pace with this growth. Given the complexity of the ANTRAC technology, which requires a revolutionary change in farming systems, the limited success of the EORD ANTRAC program is to be expected. However, farmer interest in the program has exceeded the EORD's capacity to serve all potential adopters.

Overall, the EORD approach to expanding the use of animal traction is moving in the right direction. The first five years of the program have created the skeleton of a viable ANTRAC system. More flesh and muscle must now be added to this framework over the next ten years if the goal of a self-sustaining, economically viable system is to be reached.

In Chapter 3, six previous programs to introduce ANTRAC technology into the Eastern Region, dating back to the 1940s, are described. Problems encountered by these previous efforts still occur in the current program, such as the lack of reliable marketing outlets, the lack of improved biological or mechanical technologies, and the need to produce dramatic results within too short a time period.

The current program, however, has improved on previous efforts in the following ways:

1. It has stressed a broader approach to farmer adoption in order to create a self-sustaining "critical mass" of participants, avoiding the more limited "model farmer" approach;

2. It incorporates improved equipment manufacturing, assembly, and repair systems;
3. It utilizes donkey traction in addition to oxen traction; and
4. It allows farmers to choose their own cropping pattern and is thus more adaptable to regional agro-climatic and land resource conditions.

In Chapter 3 and the first part of Chapter 4, the major institutional components of the EORD program are evaluated both at the program level and at the farm level. Overall, the EORD's provision of vital supporting services has been inadequate, which has impeded the farm-level success of ANTRAC use. Some of this deficiency is due to the extremely rapid growth of EORD personnel and responsibility from 1975 to 1980. The rest is due to inherent weaknesses in some program components which must be remedied before improved farm-level results can be obtained. These weaknesses are summarized for each major program component:

1. Extension and Farmer Training. Young extension agents, often poorly trained and supervised, are not providing farmers with the ANTRAC training and support they need. Agents often have no clear program of work or have too many tasks to perform simultaneously. Further, many are not able or willing to help farmers learn correct ANTRAC techniques. This is reflected in survey data indicating purchase of inappropriate work animals, lack of animal training, low equipment utilization (particularly for weeding), and poor animal maintenance practices. By contrast, a recently introduced program utilizing locally recruited farmers to serve as animal trainers (bouviers) has been highly successful.
2. Credit Services. The provision of medium-term credit has been adequate in terms of number of ANTRAC packages provided on credit to farmers, but more careful attention must be given to the evaluation of individual farmer debt-carrying capacity. The real problem has been poor performance of credit administration and low loan recovery rates--the collection ratio averaged only 47 percent over the 1976-79 period and the percentage of total portfolio in arrears was 28 percent in 1980. A reorganization of credit accounting and administration made in 1979-80 should, however, greatly improve this performance.
3. Marketing Services. From 1979 to 1981, the EORD discontinued all marketing services, except for its village-level "cereal bank" program, largely due to changes in national policy. During this period, there

was no cash crop production and marketing scheme in the Eastern Region except for a cotton project in the Diapaga Sector introduced in 1979.

4. ANTRAC Equipment Services. The ARCOMA-COREMMA equipment manufacturing system is a major improvement over past systems. Still, there remain substantial organizational and logistical problems. Survey data reveal that ANTRAC farmers were often hampered by the inadequate or delayed provision of equipment and spare parts. For example, the low ANTRAC weeding rates were largely attributable to a lack of weeders.
5. Livestock and Veterinary Services. The Veterinary Services were inadequate for the needs of ANTRAC farmers. Only about half of all work oxen in the Eastern Region were vaccinated at least once in 1978. Survey data revealed that substantial amounts of work time were lost due to draft animal sickness. There was often little contact between veterinary agents and farmers. Livestock extension services were not effectively provided to farmers by EORD personnel. Many animals--particularly in newer ANTRAC zones--are not correctly stabled and consequently suffer from health and discipline problems. Since the sale of mature oxen is quite profitable, the potential returns to good animal maintenance practices are quite high.

The final sections of Chapter 4 deal with the technical impact of ANTRAC adoption on farmers' cultivated acreage, cropping mix, yields, and family labor allocation, based on analysis of the 1978-79 farm survey. The use of work animals off family fields is also explored. Six areas of technical impact are summarized here:

1. Equipment Utilization. All ANTRAC farmers in the sample owned plows, but 4 percent of donkey farmers and 10 percent of oxen farmers did not use them during the survey year. Among donkey farmers, 31 percent owned a weeder and 12 percent owned a ridger but only one-third of those farmers owning the equipment used it. Among oxen farmers sampled, 35 percent owned a weeder and a similar percentage owned a ridger. Oxen farmers were also more likely to use this specialized equipment with about two-thirds of those owning each type reporting its use during the survey year. Experience counts greatly in the use of weeders among oxen farmers--10 percent of those with two years' or less experience weeded versus 56 percent for those with seven or more years of experience.

Oxen farmers plowed 60 percent of their cultivated area, but weeded only 14 percent with draft power. Donkey farmers plowed and weeded 85 and 10 percent of crop area, respectively. Assuming that draft animals work only 4 hours a day, the average ANTRAC team was used only 15 or 16 days a year, representing an extremely low ANTRAC utilization rate.

2. Other Use of Work Animals. Custom plowing was not a widespread practice in the Eastern Region in 1979 and produced little revenue for farmers. The use of animals for carting is a potentially important source of revenue. There is a striking difference in average rates of cart utilization with the popular donkey cart being used 136 hours per year, almost five times as much as of the newer, more cumbersome oxen cart. ANTRAC farmers with carts used their animals almost one and one-half times as much as those without carts.
3. Acreage Effects. The acreage expansion effects associated with animal traction were highly variable across our diverse sample of users. There was an increase in area cultivated of just over 10 percent per active worker for traction farmers compared to hoe farmers. These effects were more pronounced for surveyed donkey farmers (18 percent) than for oxen farmers (4 percent). Among ANTRAC farmers, larger increases in acreage per worker were shown for farmers who used animal weeding.
4. Effects on Cropping Mix. Both ANTRAC and hoe farmers devote 75 to 80 percent of their land to sorghum and millet. ANTRAC farmers do grow slightly more cash crops, but the overall difference in cropping mixture is small.
5. Yield Effects. Survey data do not show substantially higher yields per hectare for ANTRAC farming, except for some minor crops. Since yield data were averaged from both plowed and unplowed fields, the potential yield impact of ANTRAC is understated. Further, few ANTRAC farmers were using complete draft tillage techniques. By contrast, controlled plowing and fertilizer trials in farmers' fields showed greater potential yield increases, particularly when both plowing and locally available rock phosphate were used.
6. Effects on Household Labor Allocation. Survey data indicate a reduction in field labor use per hectare and a more even distribution of labor over the year for ANTRAC farmers. Although traction households spend a slightly greater proportion of their time on livestock raising

and agricultural trading, in other respects the proportional allocation of work time differs very little between hoe and ANTRAC subsamples.

The economic analysis in Chapter 5 compares ANTRAC farmers and hoe farmers in terms of cropping income, farm and household income, and both annual and monthly cash flows. A number of important conclusions emerge:

1. Income. Although based on a sample of the relatively most successful ANTRAC users in 1978-79, the income effect of ANTRAC was found to be negligible at the farm level. A modest increase in net farm income per active worker of 16 percent was found for oxen farmers, but this increase is attributable to appreciation in oxen value as well as to increased crop production. Donkey farmer incomes were even lower than those of hoe farmers in the same zones, which may be attributable to adverse drought conditions affecting traction users in two out of three donkey zones.
2. Production Costs. ANTRAC adoption substantially increases the direct costs of crop production. Often these costs must be offset by revenues from sources other than crop production. The appreciation in value of work oxen and the use of donkeys for carting help cover costs, but having a nonfarm source of revenue appears to be a prerequisite to successful ANTRAC adoption.
3. Cash Flow Problems. Increases in the magnitude and timing of production costs introduce a serious cash flow problem, particularly for oxen farmers. ANTRAC use requires alternative sources of liquidity to offset monthly and annual cash flow deficits. Households most likely to have alternative sources of liquidity are those which are larger in size and more diversified, have important sources of regular nonfarm cash income, have stocks of easily liquidated assets, or have access to reliable sources of credit.
4. Medium-Term Income Analysis. Based on survey results, fertilizer and plowing trials, and subjective evaluation, a series of 10-year income projections are presented in Chapter 5 to evaluate both oxen and donkey traction for four levels of ANTRAC adoption: Case 1: unsuccessful adoption (the plowing package but with no area or yield increase); Case 2: partial adoption (plowing only); Case 3: complete adoption (plowing and draft weeding); and Case 4: complete adoption plus fertilizer.

Under partial adoption (Case 2), the internal rate of return (IRR) to ANTRAC investment over the 10-year period is modest--14 percent for oxen traction and only 4 percent for donkey traction. Further, the income of donkey and oxen farmers was reduced during the first four years of adoption, averaging 8,160 FCFA and 27,640 FCFA per year, respectively. The IRRs improve substantially with more complete ANTRAC adoption when weeding (Case 3) and fertilizer (Case 4) are added, ranging from 24 to 33 percent.

Overall, the survey data indicate that the technical and economic performance of ANTRAC at the farm level was not dramatically different from that of hoe farming because of the recency of ANTRAC adoption, poor program performance, and the lack of experience of most ANTRAC farmers. Further, the 10-year income projections confirm that the economic benefits of the most common ANTRAC package--plowing alone--are small even under optimal conditions. More favorable benefits are obtained by more complete ANTRAC packages which include weeding, but even these benefits are less dramatic than often assumed.

ANTRAC adopters are confronted with substantial financial risks, due to limited earnings opportunities, uncertain supporting services, and a highly variable climate. For oxen traction adopters in 1980, 30,000 to 35,000 FCFA of the farmer's initial investment was not covered by loans, over ten times the level of annual cash costs typically incurred by hoe farmers. Under such conditions, adoption of the less costly, quicker-yielding donkey traction package (where soil conditions permit) is relatively attractive despite its lower absolute level of net returns.

Analyzing the institutional, technical, and economic performance of the recent EORD animal traction program has suggested several major problems which need to be tackled:

1. Inadequate adaptation of the biological and mechanical aspects of the traction technology to local agro-climatic and economic conditions;
2. Related to (1), net returns which are too low and financial risks which are too high to stimulate widespread and successful adoption;
3. Severe cash flow deficits in the initial years of adoption, especially for oxen traction;
4. Inadequate supporting services such as training and extension, veterinary services, input supply, and equipment maintenance and repair; and
5. Inadequate marketing infrastructure.

The next section discusses specific measures which can be taken to overcome these problems.

6.2. A General Strategy for Improving the Adoption and Effectiveness of Animal Traction Technology

The shift from hand hoe to animal cultivation of crops represents a revolutionary change, especially in an area where animals historically have not been used for draft purposes. An individual farmer can easily take five to ten years to acquire the management skills necessary to realize the full benefits of the complete ANTRAC package. Widespread adoption and effective use of animal traction also depend on provision of a broad range of supporting services by government and/or private organizations. Developing the necessary institutions for these support services is an even slower process. When considering introduction or expansion of animal traction, donors should therefore plan in terms of a 10-to 20-year time frame. This is the core of a successful strategy for agricultural development based on expanded use of animal traction.

6.3. Recommendations for Improving Animal Traction Programs

Within the overall strategy outlined above, there are numerous concrete steps which can be taken to improve the EORD ANTRAC program. Many of these recommendations are likely to be relevant to programs in other areas.

6.3.1. Developing a Viable Locally Adapted Technical Package

The major focus of the EORD ANTRAC program should shift towards efforts to develop a range of improved technical packages through farming systems research. On-farm applied research should be conducted to identify the agronomic, mechanical, and economic constraints on the adoption of the ANTRAC package so that modifications can be made to suit local marketing opportunities, family income and demographic characteristics, and agro-climatic conditions.[1/] Supervision of this research program should be the responsibility of the Applied Research Section of the EORD's Bureau of Economic Analysis and Planning (B.A.E.P.), in collaboration with the Bureau of Agricultural Production (B.P.A.). Suggested research activities are:

1. Development of improved grain varieties and cash crops. As we have seen, food grains occupy about 80 percent of the average farmer's cultivated land. Even with ANTRAC use, food self-sufficiency is a primary

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[1/] For a clear exposition of the relevancy of farming systems research to small farmer development programs, see Norman (1980).

goal. As of 1980, there were no improved food grain varieties which had been sufficiently tested under local conditions to warrant recommendation for farmer use. In addition to testing varieties from outside Upper Volta, regional trials should be implemented to test the wide range of local sorghum and millet varieties.[1/] In regions such as eastern Upper Volta where little agronomic research has been conducted, improved local grain varieties properly grown can lead to a 20 percent increase in yield. A reliable cash crop option should also be developed. Given the high cash costs of ANTRAC, either cash cropping or off-farm cash income activities are essential. One possibility is cotton; animal traction has been most successful in Upper Volta in areas with strong cotton programs (Dedougou and Bobo-Dioulasso). Rice is another possible cash crop; it is ideally suited to bas-fonds soils and has high returns. However, careful exploration of the agronomic and market potential of these crops, as well as groundnuts, soybeans, and maize, is required.

2. The use of local phosphate fertilizer, which appears promising, should be further examined with on-farm trials.
3. The EORD should strengthen its links with IRAT, ICRISAT, SAFGRAD, and other national agronomic research organizations which are undertaking farming systems research.
4. Further modification of the mechanical components of the package is needed. Mechanical seeders, scarifiers, chisel plows for late rainy season plowing, and the local "dalou" water-lift system are all potentially valuable additions to the ANTRAC package.[2/]

6.3.2. Extension and Farmer Training

ANTRAC is a far more complex technology to learn and successfully adopt than is typically thought. For an average farmer, the two- to six-year learning period is both arduous and economically risky. An effective extension service which can provide farmer training is essential in order to make this learning period as brief as possible. In addition, training traction animals to plow is a difficult task requiring special skills not found among new adopting farmers.

[1/] These are described in detail in Swanson (1979).

[2/] See Shulman (1979) for a useful discussion of the evolution of draft animal technology in Mali, where ANTRAC is widely used.

Traction weeding requires even more specialized training skills. This animal training should be the responsibility of the extension service. There is general agreement that the extension services provided by the EORD are in need of improvement to increase effectiveness. The following are suggested remedies:

1. The bouvier (farmer animal trainer) program should be continued and expanded. These farmer animal trainers have proven very successful.[1/] Since bouviers are experienced ANTRAC farmers, they provide practical advice to new adopters concerning the use of ANTRAC technology and animal husbandry practices. The regular EORD extension agents are not sufficiently trained or experienced for this.
2. EORD extension agents should be provided with additional training and more specific job assignments. In the past, "all-purpose" extension agents were responsible for direct contact with farmers. However, lack of technical skills and supervision from above made it difficult for them to assist farmers effectively. In order to overcome this problem, more specialized extension agents have been introduced. As part of the reorganization of the credit system, credit specialists have been made responsible for credit administration. Specialized livestock agents have been placed in certain sectors to provide veterinary care to draft animals and to carry out vaccinations. Specialization of tasks with accompanying training should also be introduced for agents responsible for crop production advice, input supply, and marketing.
3. The frequent relocation of village extension agents should be avoided. EORD workers should be kept at a given work site for a minimum of three to four years so that good working relationships can be established with farmers.

6.3.3. Financing

The initial investment costs of ANTRAC adoption are large in comparison to those of hand hoe farming. Further, the cash components of both the fixed and variable costs of ANTRAC use are substantial relative to the cash flow patterns of hoe farming. As a result, a large-scale ANTRAC program must include a credit system which can service the diverse needs of a large number of small farmers on a cost-effective basis. In addition, the long-run viability of a self-financing

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[1/] For an evaluation of the bouvier program and other farmer training techniques, see Barrett (1980).

ANTRAC program requires the identification of credit worthy borrowers and the enforcement of loan repayment.

The reorganization and computerization of the EORD credit system, plus the administrative tightening envisioned under the CNCA, should go a long way toward improving field operations. However, the following additional steps should also be taken:

1. Credit specialists should evaluate each farmer's debt-carrying capacity more carefully, examining the relative viability of oxen and donkey traction in light of the household's resources. The debt capacity section of the EORD credit manual should be revised based on the 1978-79 farm survey to permit individual 10-year income projections for each farmer considering ANTRAC adoption.[1/]
2. Stricter criteria should be set for oxen traction credit, including factors such as family size, sources of liquidity, and ability to provide one ox. Low priority should be given to credit for the purchase of oxen by farmers who already own several cattle.
3. Particularly in areas where animal traction is new, village group or extended family loans for ANTRAC should be explored on a pilot basis. This would reduce the level of risk for individual farmers during the early learning phase.
4. The administration of the animal insurance program must be improved in order to permit a faster replacement of dead animals. In addition, the premiums for donkey insurance should be lowered.
5. The one-year grace period of the current credit system should be increased to two years. New ANTRAC farmers, especially those who adopt oxen traction, rarely get a complete animal and equipment package in time to train the animals and learn the new techniques for effective use during the first year.
6. In order to reduce the credit and cash flow burden on farmers, a gradual schedule of equipment acquisition should be pursued by the EORD. The loan period for oxen traction should be extended to six or seven years. Farmers should be advised to adopt only the plow at first. After farmers and animals have demonstrated sufficient experience, they should be encouraged to adopt the cultivator and ridger.

[1/] ORD de l'Est, BDC (1979b).

7. Short-term credit should be provided for the replacement of worn-out ANTRAC equipment and work oxen. This would be particularly useful to oxen farmers because it would allow animal transactions to be made at optimal periods to reduce the purchase price and maximize the sale price of fattened animals. It would also allow the farmer to train new animals hitched to the older ones.

6.3.4. Marketing

Market outlets are a prerequisite to successful use of ANTRAC because of the need to sell farm produce in order to cover the increased cash costs associated with the technology. In addition, net revenues can be directly increased through improved product marketing and more efficient market channels. In the longer run, investments in infrastructure to facilitate private market exchange can substantially improve farmers' access to more favorable prices. However, considerable resources would be needed for improved road transportation, physical marketplace infrastructure, and improved price communication. There are three less expensive options which can be pursued:

1. Market research should be conducted to help develop a reliable cash crop option, as discussed in Section 6.3.1.
2. Since food grains constitute such a large proportion of farm production (generally 75 to 80 percent), EORD participation in the marketing of surplus grain and cash crops at official prices should be explored.
3. The EORD should increase its promotion of village-level "cereal banks."

One interesting option would be to combine points 2 and 3 through an OFNACER-EORD-village group partnership in village-level grain marketing and storage. In deficit years, the village group would purchase grain to hold in its "cereal bank" at the local level; in surplus years, the same village group could be used to collect and funnel the grain surplus to OFNACER with EORD assistance. The advantage would be that in surplus regions or years, producers would have a better chance to receive the official producer price. In deficit years, capital would be made available at the village level, more grain could be stored than would otherwise be the case, and local price fluctuation would be dampened. This is of major consequence to producers who may have to make "hungry season" grain purchases. ANTRAC farmers, particularly if they are devoting more land to cash crops, might also need to purchase grain even though their total crop productivity is higher.

6.3.5. ANTRAC Equipment Services

At present, ANTRAC equipment is typically used only a few days per year. Equipment failure during peak periods can jeopardize the entire year's income if repairs cannot be made quickly. This indicates the need both for reliable equipment and for a dependable spare parts supply and repair network. It is also essential that the equipment delivery system be improved to assure that equipment is available to farmers when they want it.

CNPAR's program to train new blacksmiths and supply them with capital goods and quality raw materials should be accelerated. At the same time, a program to give traditional blacksmiths rudimentary training in plowshare manufacture and repair techniques should be instituted since this would permit the rapid establishment of an inexpensive repair network. A stock of raw materials for these blacksmiths should be created at Fada.

6.3.6. Livestock and Veterinary Services

Animal health problems during key cultivation periods can jeopardize farm production. With the high animal morbidity rates of the Eastern Region, the health of traction animals is constantly at risk. Vulnerability to disease is greatest at the height of the working season, when work animals are weakest. Even with the best of care, traction animals must be vaccinated on schedule three to four times per year. Thus, adequate veterinary services must be available.

The proper feeding and care of traction animals require labor, expense, and expertise which are quite different from traditional livestock raising practices. As a result, livestock extension services are required to promote good animal nutrition and stabling practices.

In order to improve these services, the following changes are suggested:

1. Both the veterinary and livestock extension services should be explicitly treated as essential services in the ANTRAC program, giving them equal importance with the agricultural extension service.
2. Livestock agents, in conjunction with "bouviers," should provide practical advice concerning forage production and conservation, dry season feeding, and optimal strategies for the fattening and sale of work oxen.
3. Livestock agents should establish demonstration stables for work animals in major ANTRAC villages.

6.4. Conclusions

Animal traction remains a moderately promising means of improving farm productivity. However, there is no easy avenue to achieving its full benefits. As Sargent et al. (1981) found, pre-project expectations of benefits from ANTRAC have often been wildly exaggerated. Greater attention to the farm-level performance of ANTRAC, and applied research to improve it, are required to make ANTRAC a more reliable investment.

As often designed and promoted, the ANTRAC package calls for too many changes too soon. Farmers should be allowed to adopt ANTRAC technology in stages; immediate acquisition of the full package merely saddles the farmer with high debt service obligations long before his use of the technology is extensive and skillful enough to make it pay.

Future programs involving animal traction in Upper Volta, or elsewhere in West Africa, should build on the experience gained to date. The essential requirements for a successful animal traction program are acceptance of a 10- to 20-year time horizon and a commitment to institutionalizing a field-level farming systems research program to tailor the crop and equipment package to local circumstances.

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