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THE FARM-LEVEL IMPACT OF ANIMAL DRAFT POWER:
SURVEY RESULTS FROM UPPER VOLTA

by

Eric Crawford
David Wilcock
Gregory Lassiter

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Department of Agricultural Economics
Michigan State University

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Introduction

Since the 1930s, the use of animal draft power has been widely proposed as a technological innovation for improving farm productivity in West Africa. Based on experiment station research, animal traction (ANTRAC) utilized in an integrated crop-animal farming system is expected to have beneficial effects which go well beyond the labor-saving impact of mechanization discussed in the literature on technical change [Gotsch, 1972]. The strong appeal of ANTRAC has resulted in part from the shortage of other promising technologies for dryland agriculture, as well as from its image as an "appropriate" technology requiring few capital- or energy-intensive inputs. However, as Sargent et al. [1981] found in a review of 125 projects involving ANTRAC in francophone West Africa, there is very scant evidence on two questions: (1) the performance of ANTRAC under farmer conditions; and (2) the effect of animal-powered tillage separate from locational factors or other elements of the package such as improved seeds, fertilizer, etc.

This paper presents evidence on both questions, based on a comprehensive farm survey conducted in eastern Upper Volta in 1978/79.[1] In particular, the paper examines the impact of ANTRAC on area cultivated, crop mix, yields, labor use, income, and cash flow. The paper also summarizes an analysis of potential returns under different levels of adoption and utilization of ANTRAC over a 10-year horizon. Finally, a discussion of reasons for the gap between current

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[1]A full report is contained in Barrett et al., 1981.

performance levels and potential benefits of ANTRAC is presented, along with recommended improvements in project design.

Background

The Eastern Region of Upper Volta is a largely Sahelian zone covering 49,992 km^2 with a total 1979 population of about 440,000 [Mehretu and Wilcock, 1979]. The predominantly small farms are sorghum/millet based with family labor the key agricultural input. Most rural households raise some small stock, and less frequently cattle. One of the U.S. Agency for International Development's first medium-term Sahelian drought recovery projects was initiated in the Eastern Region in early 1975. The project aimed to improve the institutional capacity of the Eastern ORD (Regional Development Organization), and to promote agricultural development through the introduction of animal-powered crop production technology. A technical assistance and applied research team was provided by the Department of Agricultural Economics, Michigan State University, beginning in May, 1977.

Most of the results presented in this paper are based on analysis of data from a farm survey conducted in 1978/79 by the Bureau of Economic Analysis and Planning of the Eastern ORD, together with the MSU team. Farm families were interviewed regularly on a wide range of farm, off-farm, and household activities. One-third of the sample was interviewed weekly to obtain information on labor use and other inputs and outputs on all farm fields of the household.

The sample consisted of 355 randomly selected traditional hoe farming households and 125 ANTRAC households, distributed across 27 villages and 12 agro-climatic zones in the Eastern Region. The 125 ANTRAC households were purposively selected as relatively successful adopters in order to indicate the potential performance of this new technology. Our analysis compares ANTRAC farmers with hoe farmers in the five zones where animal traction is used, allowing an assessment of ANTRAC impact controlling for zonal factors. Three of the zones represent primarily donkey traction and two are primarily oxen traction.

The ANTRAC Farming System

In the literature on technical change, mechanization is considered to be labor-saving rather than land-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 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 crop mix; and often (5) substantial borrowing to finance purchase of the ANTRAC package. ANTRAC adopters also become more dependent

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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.

on outside institutions for inputs supply, repair and maintenance, animal health services, credit, extension advice, etc.

Utilization of ANTRAC Techniques

The agronomic and economic benefits of ANTRAC depend on the extent of adoption of the technology, and on the intensity of animal traction use. Given the importance of the weeding constraint, it is critical for animal-drawn weeding to be adopted along with plowing. All ANTRAC farmers in the 1978/79 sample owned plows, and over 90 percent used them. However, only about one-sixth of donkey farmers and one-fifth of oxen farmers owned and used weeders. While oxen farmers plowed an average of 60 percent of their total cultivated area, they weeded only 14 percent. Donkey farmers plowed 85 percent but weeded only 10 percent of their cultivated area. Thus, in eastern Upper Volta to date, adoption of ANTRAC has been confined largely to plowing.

Impact of ANTRAC at the Farm Level

1. Area Expansion. ANTRAC households cultivate larger absolute areas than hoe farmers, primarily because of larger household size (11.2 versus 7.8 persons in traditional households) and larger farm holdings. Nonetheless, area cultivated per active worker (persons age 15-54) was 10 percent higher for ANTRAC households (1.39 ha.) than for hoe farming households (1.25 ha.), significant at the .05 level. The effect was greater for donkey farmers (18 percent) than for oxen farmers (4 percent). For oxen farmers, greater area cultivated per worker is associated with use of weeding and experience with ANTRAC.[1]

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[1] Oxen farmers who weeded cultivated 1.60 ha./worker, versus 1.31 ha./worker for non-weeders. Only 10 percent of those with two years or less experience with ANTRAC weeded, versus 56 percent of those with seven or more years of experience.

2. Changes in Crop Mix. There are few differences between the cropping patterns of ANTRAC and hoe farming households. Both devote 75 to 80 percent of cultivated area to sorghum and millet, and about 10 percent to peanuts. ANTRAC farmers grow proportionally more cotton, peanuts, soybeans, and rice. The average area in these four crops is twice as great for ANTRAC as for traditional farmers, although the absolute areas are small (1.2 ha. for ANTRAC and 0.5 ha. for hoe farmers).

3. Yield Increases. Crop yields per hectare are higher for ANTRAC farmers than for hoe farmers, for all crops except soybeans.[1] Because of small sample size for minor crops, these yield increases are not statistically significant except for maize (686 kg./ha. for ANTRAC and 425 kg./ha. for hoe farmers in all zones) and peanuts (179 kg./ha. for ANTRAC and 59 kg./ha. for hoe farmers in oxen zones). Yield levels are generally low even for ANTRAC farmers: 468 kg./ha. for sorghum/millet, 465 kg./ha. for rice, and 171 kg./ha. for cotton. Yields in donkey traction zones are especially low due to a severe drought experienced in two of the three zones during the survey period.

These survey estimates of current on-farm yields may be compared to the potential yield effect of ANTRAC as suggested by field trials conducted under controlled conditions in 1979/80. Three treatments were applied: plowing, plowing plus 150 kg./ha. of local rock phosphates, and hand hoe land preparation plus phosphates. The control was a hoe-prepared plot with no phosphates. Trials were conducted on 19 peanut fields and 24 sorghum fields covering the five ANTRAC zones and a representative sample of oxen and donkey traction. The plowing treatment resulted in a 16.7 percent increase in yield per hectare for sorghum/millet and an 18.2 percent increase for peanuts, significant at

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[1]The yield effects cited here are based on the farmer's year-end recall of his harvest. These estimates are slightly higher than those based on aggregated weekly recall of crop off-take by field. They are substantially lower than estimates based on yield plot measurements.

the .05 level. The combination of plowing and phosphates gave 65.0 and 26.8 percent increases for sorghum/millet and peanuts, respectively, which is twice as high as the results of the hoe cultivation and phosphates treatment.

4. Impact on Household Labor Allocation.[1] The principal finding here was that on average ANTRAC households devoted 132 hours less per hectare in family labor inputs than hoe farmers, representing an 18.5 percent reduction.[2] Of the decline in labor inputs, 82 percent came in the category of soil tillage. The average labor reduction was greater in oxen zones (26 percent) than in donkey zones (12 percent). These results are statistically significant at the .01 level.

What adjustments in labor allocation are associated with the reduction in overall field labor inputs? First, the proportional savings in labor time is slightly greater in the peak season than at other times. The peak season for ANTRAC farmers (late June to late August) occurs one month later than for hoe farmers. Second, it appears that lower family labor inputs are partially offset by increased use of hired labor. Third, ANTRAC households do not differ substantially from hoe farming households in allocation of labor among farm, non-farm, and leisure activities. ANTRAC households devoted slightly more labor to field activities (44.1 vs. 40.5 percent), livestock raising (8.6 vs. 6.9 percent), and agricultural trading (4.4 vs. 1.8 percent), and slightly less time to household tasks (22.0 vs. 27.7 percent) and crop processing (8.9 vs. 10.4 percent).

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[1]Family labor inputs on farm fields were collected weekly for 43 ANTRAC and 36 hoe farming families. Labor hours were converted to standard worker equivalents using weights obtained from farmer interviews.

[2]Shulman [1979: 7] reports evidence from Mali that oxen traction saves 140 hours/ha., a 40 percent reduction. Data from northern Nigeria indicate that oxen traction leads to per hectare labor savings of 16-17 percent for sorghum, 17-28 percent for cotton, and 33 percent for maize [Norman, Pryor, and Gibbs, 1979: 100].

5. Impact on Income. As shown in Table 1, the value of crop production contributes at least 70 percent of net household income for hoe and ANTRAC farmers alike. It is higher for traction farmers than for hoe farmers--149,356 FCFA per year for oxen ($679 at 220 FCFA/dollar) and 94,012 FCFA for donkey farmers versus about 84,500 FCFA for hoe farmers--but these figures reflect the larger farm and family size of traction households. Relative to traditional farmers, oxen farmers have a 4.5 percent higher value of crop production per capita, and donkey farmers an 11.9 percent lower value.

Other components of household income--livestock production and trading, crop trading, crop gathering and processing, and "other" (artisan and retail trades)--generally are quite small. For example, revenues from custom plowing

Table 1 FARM HOUSEHOLD CHARACTERISTICS AND INCOME MEASURES, EASTERN UPPER VOLTA, 1978/79[a]

	Oxen Zones		Donkey Zones	
Item	Hoe	ANTRAC	Hoe	ANTRAC
1. Number of Households Surveyed	36	72	72	53
2. Persons per Household	6.67	11.14	8.83	11.27
3. Workers per Household	3.04	5.27	3.96	4.14
4. Total Area Cultivated (ha.)	3.96	7.13	4.64	6.04
5. Major Net Income Components		(FCFA)		
a. Crop Production	78,622	146,220	75,572	71,099
b. Livestock Raising	-1,970	5,135	5,818	1,396
c. Crop Trading	175	930	942	1,922
d. Crop Processing	528	3,178	702	-1,420
e. Other Income	36,359	12,543	511	20,042
6. Net Farm Income (NFI)[b]	77,355	155,463	83,026	72,997
a. NFI per Worker	25,446	29,450	20,968	17,632
b. NFI per Hectare	19,534	21,804	17,894	12,085
7. Net Household Income (NHI)	113,714	168,006	83,537	93,039
a. NHI per Worker	37,406	31,879	21,095	22,473
b. NHI per Hectare	28,716	23,563	18,003	15,404

Source: Barrett et al., 1981: 15, 117.

[a]Households using hand hoe and animal traction (ANTRAC) technology.

[b]Net Farm Income is the sum of net income components (a) through (d). Approximately 220 FCFA = one U.S. dollar.

or carting amounted to only 660 FCFA on average for oxen and 1,705 FCFA for donkey farmers. However, a few donkey farmers earned high revenues from carting.

Adoption of ANTRAC brings higher production costs. The 1978/79 survey showed that ANTRAC-related variable costs (feed grain, salt, medicines) were 5,544 FCFA for oxen and 4,134 FCFA for donkey farmers.[1] Average annual variable costs were therefore 59 percent higher for oxen and 44 percent higher for donkey farmers by comparison to hoe farmers. Fixed costs (excluding change in value of animals) were 8,224 FCFA for oxen and 6,243 FCFA for donkey farmers, resulting in total fixed costs that were 154 and 127 percent higher than those of hoe farmers, for oxen and donkey farmers, respectively.

Appreciation in oxen value is quite significant. It was estimated at 20,000 FCFA per pair of oxen per year, which more than covered all ANTRAC-related costs in 1978/79.

Looking at net returns on a household basis, Table 1 indicates that oxen farmers in 1978/79 had higher crop and livestock revenue, and higher net farm and household income, by comparison to hoe farmers in the same zones. Donkey farmers on the other hand generally had lower incomes than their hoe farmer counterparts.[2] On a per person, per worker, and per hectare basis, oxen farmers had higher crop revenues and net farm incomes (NFI) but lower net household income (NHI). Donkey farmers had lower incomes by each measure except NHI per worker.[3]

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[1]Many farmers did not repay their ANTRAC loans on schedule during 1978/79. These figures therefore include an underestimate of normal interest payments.

[2]The drought may have affected donkey traction farmers disproportionately. Plowing before planting can take longer than planting directly. The timing of the drought prevented plowing in one donkey zone, and penalized late planting in all zones.

[3]Two of the 36 hoe farmers in the oxen zones had exceptionally high incomes from artisan and retail trade activities, leading to high NHI. For donkey farmers, high levels of NHI also result from such "other" income.

6. Cash Flow Pattern. The agricultural economy in eastern Upper Volta is largely non-monetized. Only a minor proportion of net cropping revenues (less than 7 percent (9,680 FCFA) for oxen farmers) is realized in cash. In hoe farming, the level of cash inputs is low (less than 3,000 FCFA per year) but large in proportion to cash revenues, absorbing 26 to 30 percent of cash inflows in the five ANTRAC zones. Cash costs are 70 percent and 32 percent of the level of cash sales of crops and custom services for oxen and donkey farmers, respectively.

Given rudimentary rural markets, it is difficult for farmers to increase their cash earnings substantially. This poses a problem in meeting the large cash requirements of ANTRAC-related production costs, animal maintenance, and loan repayment. Seasonal cash flow profiles for ANTRAC farmers indicate that they rely on non-cropping activities and sale of assets to offset their sporadically heavy cash expenditure needs.

Potential Long-Term Benefits from ANTRAC

Based on these empirical estimates of production effects and costs and returns, and the results of the field trials in 1979/80, the potential farm-level benefits of oxen and donkey traction were evaluated over a 10-year horizon. Three levels of adoption were examined: (1) plowing alone; (2) plowing and weeding; and (3) plowing, weeding, and application of 150 kg./ha. of local rock phosphate. Based on analyzing the effect of experience with ANTRAC, it is assumed that area and yield increases are attained gradually over a two- to six-year period, longer for oxen than for donkeys. Internal rates of return over the 10-year period ranged from 14 to 34 percent for oxen and from 4 to 35 percent for donkey traction. Except for the plowing-only case, donkey traction brings somewhat higher rates of return than oxen traction despite its lower area and yield increases. 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.[1]

Despite positive rates of return, net returns earned in the first four years following adoption are substantially lower than pre-adoption levels, especially for oxen traction. For the plowing-only package, average annual net returns for Years 1-4 are 27,640 FCFA below the pre-adoption level; for plowing and weeding, the shortfall in annual returns averages 32,370 FCFA. Corresponding figures for donkey traction are 8,160 FCFA and 10,660 FCFA, less than one-third of those for oxen. This suggests the probability of severe cash flow problems, a factor likely to discourage farmer adoption of ANTRAC. Also, the prevalence of erratic rainfall introduces substantial financial risk. Poor crop yields would worsen the cash flow problem and reduce long-run profitability still further. Farmer recognition of these risks no doubt detracts from the acceptability of ANTRAC technology as currently designed.

Discussion of Results

From 1974 to 1979, the number of farmers using ANTRAC in the region rose from 180 to 1,740. Nonetheless, despite considerable variability, the survey results indicate limited impact of ANTRAC at the farm level. This is noteworthy, given the deliberate sampling of "best" adopters. Based on farm trials and the 10-year cost and return calculations discussed above, it appears that production and income benefits achieved to date are low relative to what could be attained with moderately expanded equipment purchase and utilization,

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[1]The costs of donkey equipment, animal purchase, and loan interest are less than half those for oxen (65,665 FCFA versus 138,945 FCFA). Other variable costs of donkey traction are less than 40 percent of those for oxen (5,320 FCFA versus 13,735 FCFA). Lastly, the benefits of donkey traction are assumed to be realized by Year 2 for plowing and by Year 4 for weeding, compared to Year 4 and Year 6 for oxen plowing and weeding.

especially for weeding. What explains current performance levels, and how can they be improved? Several factors stand out:

1. Although ANTRAC is not new in the area, many farmers have adopted it recently and partially. Animal plowing is accepted widely, but less than one-fifth of traction farmers own and use a weeder. Given the sweeping changes involved in the ANTRAC farming system, it takes a minimum of five to ten years for full benefits to be achieved. As Sargent et al. [1981] found, pre-project expectations of benefits from ANTRAC have often been wildly exaggerated.

2. As designed and promoted, the ANTRAC package calls for too many changes too soon. Farmers are pressed to buy a weeder immediately. However, many farmers are reluctant to undertake animal weeding until they have the trained animals and the experience to execute weeding without damage to crops. 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.

3. Other factors worsen the cash flow problem. High productivity bio-chemical technology for dryland food crop production is still unavailable, and opportunities for cash crop production are limited.[1] Attempts to introduce soybeans failed and were not followed-up. Market outlets are so sparse that disposal of surplus cereal or legume crops can be problematic. Finally, the loan repayment period (4 years for donkeys and 5 for oxen) is too short.

4. Biological and mechanical aspects of the package have not been well adapted to diverse local conditions in the region. There is a particular need

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[1]ANTRAC has been most successful in Upper Volta in areas with strong cotton programs. Dedougou and Bobo-Dioulasso produce 80 percent of national cotton output and have over 50 percent of the country's working oxen [Republique de Haute Volta, 1979].

for improvement in design of weeding equipment. The quality of locally manufactured equipment is improving, however.

5. Inadequate supporting services have been a major bottleneck. The extension service, supply of inputs, credit supervision, repair, maintenance and animal health services, and market outlets all need strengthening. Continued efforts over a 10- to 20-year period are required. Substantial progress in adoption and effective use of ANTRAC may depend on establishing a "critical mass" of adopters in a given area where services can be provided on a cost-effective basis.

6. Overall, limited earnings opportunities, uncertain supporting services, and a highly variable climate combine to confront the adopter with substantial financial risks. For oxen traction, 30,000 to 35,000 FCFA of the farmer's initial investment is not covered by loans, over ten times the level of annual cash costs typically incurred by traditional farmers. Animal insurance may not cover the full replacement price of an animal if it dies, and replacement takes time. 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. Whether for oxen or donkey traction, adoption is safest for larger farmers who have outside income or assets which constitute a reserve to meet the heavy periodic cash requirements associated with effective utilization of the ANTRAC technology.

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