Profitability assessment of animal traction investment: the case of northeastern Ghana

by

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Abstract

The cautious attitude of farmers in many parts of sub-Saharan Africa towards the adoption of animal traction for crop cultivation raises the crucial question of whether animal traction investment is profitable at farm level. Financial analysis based on farm management data from northeastern Ghana revealed that animal traction investment over short (5 year) and medium (10 year) term periods was profitable. The analysis produced internal rates of return (IRR) with equity financing of 46% and 54% for short- and medium-term periods, respectively. With debt financing (credit) the figures were 79% and 90% respectively. Further, it provided moderate increases in average annual income over hoe farming of 10% for the short- and 17% for the medium-term period. However, sensitivity analyses showed that the investment, particularly over the short-term period, was highly vulnerable to variations in the value of production. The early years of animal traction use represent a substantial financial burden on the farmer. These coupled with the other risks involved in rain-fed agriculture, may inhibit the adoption of animal traction by farmers in the region.

Introduction

Based on farm-income analyses, the comparison of the economic performance of households using animal traction for farming and those using hand hoe shows that the animal traction technology is superior to the hand-hoe technology (Barrett, Lassiter, Wilcock, Baker and Crawford, 1982; Panin, 1988). Nevertheless, animal traction adoption by farmers has been disappointing in most of sub-Saharan African countries despite the considerable efforts of both governments and donor agencies to promote its use following the 1973 oil crisis (Eicher and Baker, 1982). This situation raises the crucial question whether the investment is economically profitable at the farm level. The answer to this question cannot be derived from the results of farm-income analysis based on single year cross-sectional data. The use of such data fails to elaborate the investment outlays on the farm by overlooking the critically important learning period required before new adopters can use the technology efficiently. Furthermore, in cross-sectional analysis, the impact of animal traction on the farming systems studied, can only be inferred from differences between the animal traction households and the hoe households.

This paper provides a 10-year income projection for the change-over from the hoe to animal traction, using coefficients derived from a 1982/83 farm management survey in Northern Ghana. The income projections evaluate the animal traction package only for ridging, since ridging is the only farm operation for which the technology is used in the survey area.

The study area and data collection

Data for this analysis were obtained in a study of three villages in northeastern Ghana from April 1982 to March 1983 (Panin, 1988). Data on various aspects of farming were collected

* Position at the time of the 1988 workshop. A subsequent address may be found in the workshop participant address list.

Table 1: Cultivated area and total crop output of hoe and animal traction sub-samples in northeastern Ghana 1982/83.

Household (hh)	Area cultivated per hh member (ha)	Average yield[a] (C ha^{-1})[b]
Hoe	0.35	23 613
Animal traction sub-sample with:		
1-3 yrs. exp.[c]	0.52	25 561
3-10 yrs. exp.	0.42	31 347[d]
10 yrs. exp.	0.31	33 980[d]

Notes:
a) Yield is expressed in monetary value to provide a common measure for different crops grown on a plot.
b) C = Cedi. In 1982, C2.75 = US$1)
c) yrs. exp. = years of experience with AT)
d) P significance level of mean value which differs from that of hoe household

from 42 randomly selected farming households, of these 12 mainly used hoes for cultivation and 30 used animal traction. The animal traction sample which was deliberately over-represented, was divided into three groups according to their experience with the technology so as to evaluate the impact of this experience on farmers' performance. Data were collected through direct measurement, observation, and formal and informal interviews. The frequency of the interviews depended on the nature of data required.

At the beginning of the growing season, each plot was mapped, measured, and its crops recorded. Personal and demographic data of the farm family, livestock holding and farming equipment were registered for each household. All inputs and outputs of each plot were monitored. Household income and expenses were obtained through weekly records of sales and purchases.

The economy of northeastern Ghana is predominantly agricultural and it is dominated by smallholders using traditional farming technology. Most farmers till their land with the hand hoe, but the use of animal traction is common in the area. About 20% of the farming population uses animal traction albeit only for ridging. Bullocks are the main draft animals used by the farmers. Chemical fertilizers are known to the farmers but play no significant role in crop production, because supplies are both inadequate and irregular.

The main food crops, which are usually grown in mixtures, are millet (early and late), maize, and sorghum. Groundnut is the main cash crop. Crop production in the study area, and throughout Northern Ghana, is mostly for home consumption (World Bank, 1978; Tripp, 1982; NORRIP, 1982), about 10% of the farm produce is sold (Panin, 1988).

All households in the sample had livestock of which sheep, goats and fowls were the most common. The distribution of cattle ownership was skewed: only 25% of the hoe households owned cattle (the average holding being 1.5 per household), while every household in the animal traction sample possessed cattle, averaging 17.3 per household.

Animal traction investment analysis

The analysis of the animal traction investment was carried out under the key assumption that animal traction leads to increases in the value of the total crop output through increased yields, but not through increases in the area cultivated. Table 1 shows a small increase in yields in years one to three of animal traction adoption. However, since these were not statistically significant, the assumption is made that there is no yield effect from animal traction in the first three years: these years are hence assumed to be a learning period for the farmer. Significant yield increases are obtained following the fourth year and are maintained thereafter. Yields shown in Table 1 for the years four through to 10 represent the mean expected yield over that period. Based on the data in Table 1, the annual gross

Table 2: Capital and annual costs of animal traction investment in northeastern Ghana in 1982/83.

Investment item	Initial price (C)[a]	Estimated working years	Salvage value (C)	Annual rate of depreciation (C)[b]
Pair of draft animals (including training costs)	18 000	5	25 000	(1400)[c]
Ridger	1 728	15	0	115
Accessories (yoke, bolts and nuts, nose ring and rope)	820	3	0	273
Animal shelter	5 000	10	0	500

Notes:
a) C = Cedi (in 1982, C2.75 = US$1)
b) Straight-line depreciation schedule is used for the estimation. The estimated salvage values are based on the subjective valuations of animal traction farmers.
c) The value in parentheses represents appreciation. Due to extra feed given to the draft animals they gain more weight than other non-traction cattle and hence at the end of their lives they ottract higher prices than were originally paid for them.

revenue per hectare cropped is assumed to be 33% higher on the animal traction farms than that of hoe farming during the years 4 to 10.

It is difficult to sort out the animal traction effect on total crop revenue, since there are other factors, such as labour and fertilizer use, which influence crop yield. However, the results of a regression analysis (carried out to estimate factors influencing crop yields) clearly indicate that the animal traction effect on total crop output is relatively greater than any other factor included in the model; the respective production elasticity for the use of animal traction, labour and fertilizer inputs was 0.32 (P), 0.18 (P) and 0.01 (P) (Panin, 1988). Through its labour-saving effect animal traction enables households to improve on agronomic practices (such as timely and deeper ridging, mulching and thorough weed control) which are crucial to improving the crop output of a given unit of land. Further assumptions made were that each pair of draft animals is replaced every 5 years, the main traction equipment (ridger) is replaced every 15 years, and the various traction accessories (yoke, rope, bolts and nuts and nose ring) are replaced every 3 years. The residual values of draft animals and equipment are realised in the year of replacement. It is assumed that the draft animals are sold after the fifth year. In the tenth year, the figures provided for the draft animals and the traction equipment represent their respective salvage values. An animal insurance scheme is incorporated in the model to cover fully the loss of an animal through death. However, the model does not consider any risk factor for animal sickness. Thus, the analysis is conservative with regard to this particular issue. Credit is also considered in the analysis: it is assumed that the smallholder has access to financial institutions and can finance the purchase of draft animals and equipment from institutional loans. The interest rate on loans is 19%, which was the rate charged on credit by commercial banks in 1982 (IMF, 1986). Loan repayment is spread over the economic life of the draft animals, with a one-year grace period which is to take care of the time lag between costs and benefits (Gittinger, 1982). The replacement of the draft animals is financed by the farmer.

Cost of animal traction investment

The capital and annual costs of the animal traction investment are presented in Table 2. The purchase prices of traction equipment and accessories are taken from the 1982 records of the Ministry of Agriculture (Nakpanduri Station). Both the purchase (including training costs) and the subsequent sales prices

of a pair of draft animals are derived from estimated 1982 market prices. The replacements of animals and traction equipment follow a straight-line depreciation schedule. All values are estimated at constant prices, based on prices in the study period.

The farm model

The model projects budget development over a 10-year period for a typical 11-person hoe household comprising four working adults and cultivating an area of 3.85 ha, but which has not adopted animal traction. The figures for the pre-investment year are estimated by projecting the per head values found among hoe households in the 1982/83 farm management survey (Table 3). Yearly values serve as a benchmark against which the costs and returns of animal traction are compared over the investment period. Profitability analysis of the investment is based on financial estimates of the internal rate of return (IRR), net incremental benefits (NIB) and net present worth (NPW) of NIB. To test the effect of cost and yield variations on the magnitude of IRR, NIB and NPW, sensitivity analysis was conducted. Assumptions for the sensitivity analysis include 10% decrease in output, 10% decrease in costs, 20% decrease in output and 20% decrease in costs.

Results of the analysis

The benefit streams of animal traction over the 10 year period are measured as the value of increase in farm output over hoe farming. The benefit streams are presented in two ways, NIB without financing and NIB with financing (Table 3). The NIB stream without financing shows the financial rate of return to resources, while the NIB with financing assesses the return to the farmer's equity or the increase in his net income.

Under the main assumption of yield increase only, the 10-year income projections reflect a substantial increase in performance for animal traction. It produces an IRR of 51% (without financing). The total NIB (without financing) over the life of the investment amounts to C 177,719, providing an average annual increase of 21% over the income from hoe farming (assuming that the net benefits from hoe farming would be constant throughout the period of analysis). The estimated returns to the investment with financing are also substantial: total NIB is C 165,018; the annual increase in income is 20%, and the IRR is 85%.

To account for the timing of costs and benefits over the investment, the respective NPW of the NIB without and with financing is discounted at a rate of 11.5%. The selected discount rate represents the interest rate paid on deposits in 1982 (IMF, 1986), and therefore reflects the opportunity cost of the investment. The discounted NPW, which amounts to C 73,271 (without financing) and C 69,798 (with financing), gives an average annual increases of 15.2% and 14.5% over the discounted NPW of income from hoe farming. Notwithstanding the overall positive NIB of the investment, the farmer faces financial difficulties during the first year of adoption as a result of the high initial investment cost, C 31,523 compared with C 575 under hoe farming. By financing the investment through institutional loans (Table 3), the initial burden of the farmer is reduced from C 22,926 to C 2,926, but the meagre positive benefit streams for the second and third year tend to be negative due to both annuity payments and lack of increased crop yields. The investment becomes unprofitable when output decreases more than 11% over the investment period (Table 4). With a 10% decrease in output, the IRR drops from 51% to 14% and the NPW from C 73,272 to C 5,731 (without financing) producing an average annual increase of only 1% over income from hoe farming. By financing the investment through an institutional loan, a 10% decrease in output brings down the IRR from 85% to 10% and reduces the NPW by 97% (from C 69,798 to C 2,257), yielding an average increase in income of 0.5%. With a 25% increase in costs the investment is still profitable.

Table 3: Projected statement for animal traction in northeastern Ghana 1982/83.

	Year of investment. *All values in Ghana currency, Cedi (C)*[b]										
	0[a]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross value of production											
Crops	90910	90910	90910	90910	120729	120729	120729	120729	120729	120729	120729
Contract ridging	0	5040	5040	5040	5320	5320	5320	5320	5320	5320	5320
Sale + residual value of animals	0	0	0	0	0	0	25000	0	0	0	23600
Residual value of equipment	0	0	0	0	0	0	0	0	0	0	1919
Total revenue	**90910**	**95950**	**95950**	**95950**	**126049**	**126049**	**151049**	**126049**	**126049**	**126049**	**150668**
Variable costs											
Seed	2148	1829	1829	1829	2900	2900	2900	2900	2900	2900	2900
Fertilizer	1658	780	780	780	2334	2334	2334	2334	2334	2334	2334
Hired labour	1877	643	643	643	2737	2737	2737	2737	2737	2737	2737
Power hiring	928	0	0	0	0	0	0	0	0	0	0
Feed	0	38	38	38	53	53	53	53	53	53	53
Animal care	0	340	340	340	578	578	578	578	578	578	578
Total variable costs	**6611**	**3624**	**3624**	**3624**	**11336**	**11336**	**11336**	**11336**	**11336**	**11336**	**11336**
Investments costs											
Hand tools + maintenance	575	575	575	575	775	775	775	775	775	775	775
AT equipment + maintenance	0	2548	0	910	570	910	3810	1030	450	910	570
Animals + training	0	18000	0	0	0	0	18000	0	0	0	0
Animal insurance	0	5400	5400	5400	5400	5400	5400	5400	5400	5400	5400
Animal shelter	0	5000	0	0	250	0	0	250	0	0	250
Total invest. costs	**575**	**31523**	**5975**	**6885**	**6995**	**7085**	**27985**	**7455**	**6625**	**7085**	**6995**
Total expenses	**7186**	**35152**	**9604**	**10514**	**18331**	**18421**	**39321**	**18791**	**17961**	**18421**	**18331**
Without financing											
Net benefit	83725	60798	85346	85436	107718	107628	111728	107258	108088	107628	132337
Incremental net benefit	-	(-22926)	2622	1712	23993	23903	28003	23533	24363	23903	48613
With financing (credit)											
Loan for animals and equipment	0	+20000	0	0	0	0	0	0	0	0	0
Loan repayment	0	0	-6541	-6541	-6541	-6541	-6541	0	0	0	0
Net benefit	83725	80798	79805	78895	101176	101087	101187	107258	108088	107628	132337
Incremental net benefit	-	(-2926)	(-3919)	(-4829)	17452	17362	21462	23533	24363	23903	48613

Notes:

a) Figures for the hoe farming are compared to animal traction figures over the same investment period.

b) In 1982, C. Cedi 2.75 = US$1. The net present worth of incremental benefits (discounted at 11.5% interest rate): without financing = C73271; with financing = C69797.

Internal rate of return of incremental benefit: without financing = 51%; with financing = 85%.

Table 4: Sensitivity analyses of animal traction investment in northeastern Ghana 1982/83

Assumption	Without financing		With financing	
	IRR (%)	NPW (C)[a]	IRR (%)	NPW (C)[b]
Base	15.2	73 272	85.4	69 798
10% decrease in output	14.1	5 732	10.0	2 257
10% increase in costs	42.0	61 349	58.0	57 875
20% decrease in output	-18.5	-61 809	-22.6	-65 283
20% increase in costs	34.9	49 427	42.6	45 953

Notes:
a) C = Cedi (in 1982, C2.75 = US$1)
b) Discount factor is 11.5%. Estimated switching value of output is 11%. This is the proportionate fall in output that will make the NPW equal zero at 11.5% opportunity cost.

Conclusion

The analysis shows that investing in animal traction in northeastern Ghana is profitable. The investment gives a high IRR and considerably increases annual average incomes over those from hoe farming. The farmers are subjected to a substantial financial burden during the early years (1-3 years) of the adoption of the technology. Furthermore the risk due to the death of animals in the first or second year was not modelled because of lack of data. The investment is highly sensitive to variations in crop yields. 11% decrease in output renders the investment unprofitable. Most peasant farmers neither own cattle nor have cash to purchase a pair of draft animals (the main cost component of the investment). This, combined with the risk involved in rainfed agriculture may explain why the adoption of animal traction by farmers in this area in particular, and in many other areas in sub-Saharan Africa, has not lived up to popular expectation. It is recommended that access to credit and appropriate repayment conditions should be instituted for the farmers in northeastern Ghana. This should enhance the adoption of animal traction in the area and contribute to a sustainable increase in agricultural production.

Résumé

Les réserves communément émises par les paysans de la plupart des régions de la zone sub-saharienne à l'égard de l'adoption de la traction animale pose la question fondamentale de sa profitabilité au niveau de la ferme. L'analyse financière basée sur la gestion des exploitations septentrionales du Ghana montrent que les investissements à court (cinq ans) et moyen termes (dix ans) sont rentables. L'analyse a établi des taux de rendements internes de 46% et 54% pour les périodes à court et moyen termes, respectivement; et 79% et 90% dans le cas d'un financement par emprunt. En comparaison avec la culture manuelle, l'augmentation des revenus annuels en traction animale s'est révélée modérée, soit 10% à court terme et 17% à moyen terme. L'analyse des facteurs d'instabilité montre que l'investissement est très sensible aux variations des prix, surtout à court terme. Aussi, les premières années d'utilisation de la traction animale exercent une pression financière considérable sur l'exploitation. Ceci, en plus des risques inhérents aux variations climatiques, peut freiner l'adoption de la traction animale chez les paysans de ces régions.

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References

Barrett V., Lassiter G., Wilcock D., Baker D. and Crawford E. 1982. Animal traction in eastern Upper Volta: a technical, economical and institutional analysis. International Development Paper No.4. Michigan State University, East Lansing, Michigan, USA. 118p. (E,F).

Eicher C.K and Baker D.C. 1982. Research on agricultural development in sub-Saharan Africa: a critical survey. International Development Paper No.1. Michigan State University, East Lansing, Michigan, USA. (E).

Gittinger J.P. 1982. Economic analysis of agricultural projects (2nd Edition). Johns Hopkins University Press, Baltimore, USA. (E).

IMF 1986. International financial statistics Vol.39. International Monetary Fund, Washington DC, USA. (E).

NORRIP 1982. Draft report Regional development strategy for the Northern Region. Technical Unit, Northern Region Rural Integrated Program (NORRIP), Tamale, Ghana. (E).

Panin A. 1988. Hoe and bullock farming systems in Northern Ghana: a comparative socio-economic analysis. Nyankpala Agricultural Research Report 1. TRIOPS Verlag, Langen, F.R Germany. (E).

Tripp R.B. 1982. Time allocation in Northern Ghana: An example of the random-visit method. Journal of Developing Areas 16: 391-400. (E).

World Bank 1978. Ghana agricultural sector review: West Africa Country Programs 1. World Bank, Washington DC, USA. (E).

Title photograph (opposite)
Plows manufactured by a village blacksmith in southern Mali, using components and steel provided by the Compagnie Malienne pour le Développement des Textiles, CMDT (see paper by K. B. van Dam)
(Photo: Paul Starkey)