Benefit-Cost Analysis and Socio-Economic Considerations of Trypanosomiasis Control and Treatment in Northern Ghana

Wahab, S and S. Asuming-Brempong

Tuskegee University, USA

Abstract

The paper estimates the cost of tsetse control and treatment of trypanosomiasis and the benefits involved, using benefit-cost analysis. It also estimates the extent to which socio-economic characteristics of farmers affect the use of tsetse control techniques, using a maximum Likelihood-Binary Logit model. The results show that farmers will benefit if they invest in control and treatment of the disease. We find that the farmer accepting the challenge that the tsetse fly is a threat to cattle production, the number of dependants the farmer has, and the farmer agreeing that the bite of the tsetse fly causes the nagana disease are significant factors that affect adoption of control practices including the use of prescribed drugs. Our findings suggest that there is potential for farmers' response and participation in tsetse control activities in Northern Ghana. What seems to be lacking is the relevant information that farmers need to encourage them to participate. We recommend therefore that more extension services be provided livestock farmers to help them derive maximum benefit from disease control practice

Background

Tsetse-transmitted trypanosomiasis is one of the most ubiquitous and important constraints to agricultural development in the sub-humid and humid zones of frica. Reid (1995) estimated that about 46 million cattle in an area of about 8.7 million Km^2 in Africa are at risk of contracting the *nagana* disease. The tsetse, about the size of a housefly, is the carrier of the trypanosome parasite, which attacks the blood and the nervous system of its victims, causing sleeping sickness in humans and nagana in livestock. The impact of the tsetse on livestock, a disadvantage unique to African farmers, is worsening as the fly's range expands and the resistance of the parasite it carries strengthens.

It is estimated that over 60% of the land cover of Ghana is infested with tsetse flies of three main groups: *Fusca, Palppalis,* and *Morsitans*, classified according to the type of vegetation in which they occur. The forest regions do not normally present suitable grazing environment for livestock, hence little attention has been paid to the *fusca* group of tsetse flies, whose habitat is the forest. Ruminant production is largely concentrated in the Guinea Savanna areas of the Northern and Coastal parts of the country, and to a lesser extent in the derived Savanna of the middle belt, commonly known as the transition zone. Although about 85% of Ghana's cattle are assessed as being trypano-tolerant (FAO, 1994) further development of cattle is constrained because improved breeds of cattle that are not trypano-tolerant cannot thrive well in Ghana.

Studies on the benefits and costs of tsetse control have been conducted extensively in other African countries (for example, Itty, 1992; Itty, Swallow, Rowlands, Agyman and Dwinger, 1993; Swallow, 2000; Kuzoe, 1991). In 1997, the Tanzanian Island of Zanzibar was declared free of tsetse after conventional methods reduced its numbers, and the release of infertile male flies into the wild sustained the success of the population control. The impact of the tsetse control has included tripled milk production, doubling of beef production, a five-fold increase in the number of farmers who use manure to fertilise crops (Kabayo, in IAEA press release, 2002). Fears that tsetse elimination would have a harmful effect on the Islands' biodiversity have been unfounded. A return on investment of 33%-34% has been estimated for the removal of the tsetse from Ethiopia (IAEA, 2002).

Extensive work has been done on the socio-economic analysis and sustainability of tsetse control in neighboring countries. Studies on use of trypanocidal drugs conducted in Burkina Faso found differences in the use of drugs. In the Samorogouan area, more farmers (94%) preferred using curative trypanocidal drugs than using preventive trypanocidal drugs (54%). During the previous year, an average household treated about 40 cattle with preventive drugs at a cost of about 360 CFA per animal and about 64 cattle with curative drugs at a cost of about 820 CFA per animal. In the Satiri-Bekuy area, equal numbers of households

used preventive and curative treatments of trypanocidal drugs (ILRI, 2000).

For many years, the Veterinary Service Department (V.S.D.) has relied on use of trypanocides and the exploitation of trypano-tolerance to improve livestock productivity in trypanosomiasis-endemic areas of Ghana. In all these efforts, control has not been effective since only government is the implementer (Tsetse Control Unit, Pong-Tamale). Due to government budget constraints of late, there is the need for farmers to get involved in the control of the disease through cost recovery mechanisms.

For effective involvement of farmers in the disease control, farmers have to be convinced about the financial benefits from adopting prescribed control measures and drugs. This paper presents estimates of financial profitability of preventing and treating trypanosomiasis with available drugs. The study was conducted in the Savelugu-Nantong District of Northern region, Ghana. In addition to assessing the technical feasibility of control methods, it is important to assess the socio-economic factors likely to influence farmers' participation in tsetse control and adoption of trypanosomiasis disease control methods. The objectives of the study may therefore be summarized as:To estimates the financial profitability of preventing and treating trypanosomiasis with available drugs.

- To identify and quantify the factors that influence the likelihood that farmers will use preventive trypanocidal drugs.

- To determine the attitudes of farmers towards the use of preventive trypanocidal drugs.

Theoretical Framework for Benefit/Cost Analysis

At the time of this study, use of prophylactic drugs and treatment of diagnosed cases were the two main trypanosomiasis control methods available to farmers in Northern Ghana. Cost of prophylactic treatment includes all costs related to the use of trypanocides to treat all animals in the herd as a measure against contracting the nagana disease. Each animal in the herd is treated twice in a year. The cost components of prophylactic treatment include unit cost of prophylactic drugs; quantity of drugs given each animal; number of animals dosed; number of times of dosing per season per year and wages paid. Cost of treatment consists of all costs incurred in the diagnoses and treatment of only clinically affected cattle suffering from symptoms of the *nagana* disease. The

cost components in this category are: unit cost of trypanocidal drugs; number of cases/animals diagnosed for treatment; quantity of drugs administered per animal; number of treatments per year and cost of veterinary services provided per animal treated.

Benefits were estimated using gains from effective disease control and revenues from production as enumerated below. The cost of the disease was estimated by quantifying the direct losses due to the disease. The cost of the disease represents the level of revenue forgone due to the disease (or revenue gained as a result of the control of the disease). Direct losses caused by trypanosomiasis are due to the presence of the disease in livestock population, and they include production and reproduction losses resulting from mortality, morbidity and infertility, and the cost of implementing and running trypanosomiasis control operations. Benefit/cost of the disease was thus determined by estimating the impact of trypanosomiasis, which consists of estimates of the prevalence and incidence of infections and disease, and the effects of the disease on key livestock production parameters such as mortality, milk yield and draught power (Putt *et al* 1987).

Econometric Model

A binary choice model is applied to identify the factors that influence farmers' choice of treatment. The decision to adopt an innovation is dichotomous between two mutually exclusive alternatives. The individual chooses either to adopt or not to adopt. This implies that there exists a threshold in the dimension of the explanatory variable(s) below which a stimulus elicits no observable response. Only when the strength of the stimulus reaches the threshold level does a reaction occur. Additional increases in the strength of the stimulus results in no effect on the observed response. Behavior of this nature are handled using a general model of the form:

$Y = \beta X_i + \mu_i$, Such that $Y = 1$ if $X_i > X^*_i$ and 0 if $X_i < X^*$.

Such a model is called a linear probability model (LPM). A given farmer will adopt the use of trypanocidal drugs only when the combined effects of all the socio-economic factors are able to offset the inherent tendency of the farmer to resist change. In fact, a farmer adopts only when he assesses the

consequences of adoption to be favorable when weighted against the economic, social and technical feasibility (Goldberger, 1964). Based on this, a regression was run using the maximum Likelihood-Binary Logit Model to determine the extent to which some of the socio-economic factors can affect the use of trypanocidal drugs by farmers. The method of ML-Binary Logit model was chosen because; i) it restricts the expected value of Y to lie between 0 and 1, ii) it resolves the problem of heteroscedasticity, iii) it gives consistent estimates of the standard errors (Hill and Kau, 1973), unlike the Binary Least Square Model (Pindyck and Rubinfeld, 1991). The regression equation is specified as:

$$Log\frac{\text{Pr}ob(Yes)}{1-\text{Pr}ob(Yes)} = \beta_0 + \beta_1 P0 + \beta_2 NOD + \beta_3 BCT + \beta_4 EDU + \beta_5 P3 + \mu_i$$

The β's are the coefficients of the independent variables.

The following equations were used to calculate the marginal effects (M.E.) and the elasticity (E):

$$M.E. = P\,(1-P)\beta$$

$$E = (1-P)\beta A_i$$

Where;

P = Mean dependent variable.

A_i = Mean of the ith independent variable.

The model was estimated with EViews 3.1 software.

Sources of Data and Sampling Technique

The primary data was collected using structured questionnaires, from a random sample of thirty-five farmers in the Savelugu-Nantong district of Northern region, Ghana. The tsetse control unit at Pong-Tamale provided information on the cost of the components of treatment and prophylactic dosing as well as number of animals at risk. Information from studies conducted in neighbouring countries (Burkina Faso and Cote d'Ivoire) was used as proxy to estimate morbidity and mortality losses from the *nagana* disease.

The Savelugu/Nanton district is noted for its medium (10-19%) to high (>20%) prevalence levels of trypanosomiasis. A list of villages in three sub-districts namely Savelugu (28.5% prevalence), Pong-Tamale (22.5% prevalence), and Diari with 53.5% prevalence level of the disease was obtained from the Tsetse Control Unit at Pong Tamale, and survey villages were randomly selected from each sub-district. Respondents from the survey villages were randomly picked for interviewing.

Estimates in this section were based on mean economic values for cattle production parameters generated through a set of questionnaire. Based on this, monetary values were quantified for the determination of the private financial profitability level of the cattle enterprise to their owners

Benefit-Cost ratios of Treatment and Prophylactic control

Table 1 presents results of the benefit-cost ratios of treatment and prophylactic control of the *nagana* disease for each of the 6 groupings of herds based on size. The third column of the table presents information on revenue gained from the control of the disease. This gives an indication of the amount of revenue the farmers will be loosing each year if nothing is done to control the disease. The results show that the revenue gained is highest for herd group 40-49 (¢15,896,000) and lowest for herd group 30-39 (¢6,472,000). The largest component of revenue gained for several of the herds was beef (final herd). The lowest component of revenue gained was milk off-take. This is largely because most of the breeds were the West African Short Horn (WASH) that has low milk yields.

Columns 4 and 5 present the cost of treatment and prophylactic dosing, respectively. Generally the cost of treatment is lower than that of using chemotherapeutic drugs for almost all the herd groups. This is so because for the dosing almost all cows in each herd are administered and this is repeated twice a year unlike treatment. The highest cost of treatment is herd group 60 & over (¢2,683,000) and that for prophylaxis is herd group 40-49 (¢11,364,000).

The last two columns present the benefit-cost ratio for treatment and prophylactic control. For all the herd size groupings, the benefit-cost ratios of treatment are greater than benefit-cost ratio of prophylactic control. The benefit-cost ratios are higher for treatment costs than for prevention for all herds; but the ratios for prophylaxis are above 1.0. The averages of B/C ratios for treatment and prevention are 5.71 and 1.35 respectively, showing net financial gains from investing in either treatment of diseased animals or prophylactic treatment of herds but that the gains are

much larger with treatment than from prophylactic treatment.

Net Benefits and Financial Rate of Return of Using Prophylactic Control

Table 2 presents both the net benefit and the financial rate of return to the 35 herd owners, grouped in 6 size categories, using only the cost of prophylactic control. All the 6 groupings are able to generate returns that exceeded the assumed opportunity cost of capital of 10%. The average net benefit and financial rate of return (FRR) are ¢504,274 and 35.06%, respectively. Thus on average, a farmer will generate a return above the assumed opportunity cost of capital.

Financial Profitability of the Cattle Enterprise

Table 3 presents results of the financial analysis, i.e., the cost, revenues and financial returns generated from the herds. The cost and revenue values were all compounded at 10% rate for a period of five years backwards (2003-1999). In other words, the value estimates are based on 1999 prices. The chosen discount rate falls within the range of discount rates usually chosen for projects in developing countries. The second column gives the compounded cost per herd.

The largest component of cost is herd purchase, this is because in addition to the high value of animals, herd purchase costs are incurred at the beginning of the first year and therefore are weighted more heavily than operating costs. The next largest cost component is herding cost (calculated in terms of the opportunity cost of labor per year), followed by cost of tethering ropes and lastly, costs of veterinary treatments (zero cost in most cases).

The third and fourth columns present information on revenue gained, with and without disease cases. The largest component of revenue in both cases was beef (final herd) and the smallest was milk off take. The largest revenue in both cases was obtained within herd group 40-49 (¢198.46m) and (¢207.85m), respectively. Columns 5 and 6 present information on the net benefit-investment ratios, with and without disease cases respectively. In the case of net benefit without disease cases, almost all the herd size groupings have positive net benefits whereas in the case of net benefit with disease cases, only three herd size groupings have positive net benefits. This indicates that the absence of the disease is more beneficial to farmers; therefore farmers should show interest in controlling the tsetse

fly population. Further more, the average B/C ratio is greater than one and the average net benefit (without disease cases) is positive (1.01 and 1.28), whereas that for with disease cases is less than one and negative, respectively (0.96 and –0.64).

Socio-economic characteristics of Farmers

A survey was implemented at the individual herd level to assess farmers' perception of the problem and their attitudes towards tsetse control. This statistics reinforces the effects of the independent variables on use of trypanocidal drugs. For example, majority (74%) of respondents attributed the bite of the tsetse fly to be the cause of the nagana disease, and this variable is equally significant at the 5% level in determining use of trypanocides to control the disease. The characteristics of the sampled farmers are presented in this section.

The most frequent age was 48 years. The ages ranged between a low of 28 to a high of 74. Out of the 35 sampled, 33 (94.3%) have never been to school and only 2 (5.7%) had (up to nine years of) basic education. All of the farmers (100%) said they could identify a tsetse fly. With regard to knowledge of the links between the bite of the tsetse fly that causes the nagana disease in their herd, 25.7% did not agree and the remaining 74.3% agreed. Only 8.6% were engaged in trading as an additional income source after farming, the rest (91.4%) did not engage themselves in any other non-farm income generating activity.

With regard to their perception of the causes of the disease, 17% did not know, 6% said is God's will, 3% said it was an unknown disease, and 74.3% knew it is caused by the tsetse fly. Only about 3% of farmers had been encouraged by veterinary staff to control the disease. All the 35 (100%) were willing to contribute both money and labour towards the control of the tsetse fly. But this does not reflect actual contribution commitment.

Econometric Results with the use of Trypanocidal Drugs

The results of the regression analysis using the ML-Binary Logit model are presented in table 4. The marginal effect and the elasticities were calculated using the coefficients and means from the model estimates. About ten independent variables were included and finally only five were used, as the rest created near singular matrices. Appendix One contains the full regression results.

Table 1: Benefit-Cost Ratios of Treatment and Prophylactic Control

#	Herd size	Revenue (000'¢)	Treatment cost(000'¢)	Prophylaxis cost(000' ¢)	B/C treatment	B/C prophylaxis
1	0-19	8316800	1586000	6168000	5.24	1.35
2	20-29	13821600	2468000	10636000	5.60	1.30
3	30-39	6472000	947000	4188000	6.83	1.55
4	40-49	15896000	2661000	11364000	5.97	1.40
5	50-59	8100000	1564000	6712000	5.18	1.21
6	60 & over	15387200	2683000	11276000	5.74	1.37
Total	1169	67993600	11909000	50344000	199.11	47.27
Average	33	1942674	340257.1	1438400	5.71	1.35

Table 2: Net Benefit and Financial Rate of Return (FRR)

Herd	Herd size	Revenue gain (000' ¢)	Prophylaxis cost(000' ¢)	Net benefit (000' ¢)	FRR (%)
	0-19	8316800	6168000	2148800	34.84
	20-29	13821600	10636000	3185600	29.95
	30-39	6472000	4188000	2284000	54.54
	40-49	15896000	11364000	4532000	39.88
	50-59	8100000	6712000	1388000	20.68
	60 & over	15387200	11276000	4111200	36.46
Total	1169	67993600	50344000	17649600	1227.23
Average	33		1942674	1438400 504274.3	35.058

Table 3: Private Level Financial Analysis (with & without Disease cases)

Herd size	Cost (mill. ¢)	Revenue with disease (mill. ¢)	Revenue without disease	Benefit-cost with disease	B/c without disease	Net benefit with disease	Net benefit without disease
0-19	104.64	93.79	98.24	0.90	0.94	-18.38	-10.84
20-29	169.83	162.44	170.60	0.96	1.00	-12.52	1.30
30-39	75.10	72.87	76.69	0.97	1.02	-3.78	2.69
40-49	197.07	198.46	207.85	1.01	1.05	2.35	18.26
50-59	96.52	96.64	101.42	1.00	1.05	0.20	8.30
60>60	176.62	182.26	191.35	1.03	1.08	9.55	24.95
Total	819.8	806.5	846.2	5.86	6.15	-22.54	44.67
Aveg	23.42	23.04	24.18	0.96	1.01	-0.644	1.28

The results show that farmers who have perception that the tsetse fly is a threat to cattle (P0 variable) are about 10% more likely to use prophylactic drugs against the disease, *ceteris paribus*. Consistent with the a priori expectation, the number of dependents (NOD variable) has a negative effect on the likelihood of use of trypanocidal drugs. It means that a 1% increase in the number of dependants will lead to about -0.5% decrease in the likelihood of a farmer using trypanocidal drugs, all things being equal.

The knowledge that the tsetse fly bite causes trypanosomosis is significant at 5% level and bears the expected a priori sign; those who know the link between the tsetse fly and trypanosomiasis are 0.2% more likely to use trypanocidal drugs. Though the effect of the education variable on the likelihood of use of trypanocidal drugs is unexpectedly negative, it is statistically significant at 10% level. Though theoretically, the effect of the education variable is unrealistic, literature suggests that most of the parasites have developed resistance to most of the drugs used against them, so that a highly educated farmer will switch to new technologies of control if available than use trypanocidal drugs (Rowlands et al., 1994). The farmers' perception that the *nagana* disease is God sent is highly insignificant and bears the unexpected a priori sign.

A McFadden R squared value of 0.648 implies that about 65% of the total variation in the use of trypanocidal drugs is explained by the explanatory variables included in the model consisting of P0, NOD, BCT, EDU, and P3. It is acceptably high, particularly for logit models where evidence of goodness of fit points to a range of 0.20 to 0.40 (Sonka, Hornbaker, and Hudson 1989; Harper et al.1990). The probability that the independent variables jointly explain the total variation in the use of trypanocidal drugs (represented by LR Stat 0.00038) is highly significant at the 1% level.

Conclusions

This study has shown that there are net financial gains from investing in either treatment of diseased animals or prophylactic treatment of herds. Almost all (34) herd owners generated returns that exceeded the assumed opportunity cost of capital of 10%, using only the cost of prophylactic control.

This study has also revealed that despite the high level of trypanosomosis risk, the prevalence of drug

resistant trypanosomes, and the resultant relatively low productivity, cattle production can generate attractive economic returns for individual herd owners and the overall Ghanaian economy, as more farmers will improve their earnings from disease absence.

From literature (see for example Swallow, 2000), it is noted that actual use of trypanocidal drugs by farmers depends mostly on: a) the breeds of cattle that they raise; b) whether or not they practice transhumance; c) their knowledge of the disease and its treatment; d) their ability to pay. The main determinants of the likelihood of a farmer using trypanocidal drugs were: farmer accepting that the tsetse fly is a threat to cattle production, the number of dependents of the farmer, and the knowledge of the farmer that the bite of the tsetse fly causes the nagana disease.

The key conclusion from the study is that increased knowledge of farmers about the cause of the disease will improve the chances of farmers' use of preventive trypanocidal drugs. The recommendation is therefore to improve supply of information on the disease to farmers through the veterinary services. This is especially important because only 3% of the sampled farmers reported having been encouraged by veterinary technicians to control the disease.

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Dependent Variable: UOTD				
Method: ML -Binary Logit				
Date: 10/16/05 Time: 16:23				
Sample: 1 35				
Included observations: 35				
Convergence achieved after 24 iterations				
Covariance matrix computed using second derivatives				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
P0	6.861594	2.773362	2.474107	0.0134
NOD	-0.168707	0.091139	-1.851094	0.0642
BCT	4.282357	2.143342	1.997981	0.0457
EDU	-6.872480	3.567626	-1.926346	0.0541
P3	41.92359	1.18E+08	3.54E-07	1.0000
C	0.147250	1.500540	0.098132	0.9218
Mean dependent var	0.800000	S.D. dependent var		0.405840
S.E. of regression	0.262995	Akaike info criterion		0.695163
Sum squared resid	2.005822	Schwarz criterion		0.961794
Log likelihood	-6.165348	Hannan-Quinn criter.		0.787204
Restr. log likelihood	-17.51408	Avg. log likelihood		-0.176153
LR statistic (5 df)	22.69747	McFadden R-squared		0.647978
Probability(LR stat)	0.000386			
Obs with Dep=0	7	Total obs		35
Obs with Dep=1	28			

Table 4: Results of the Econometric Analysis

Variable	Coefficient	Probability	Mean	Marginal effect	Elasticity
P0	6.862	0.0134**	0.743	1.098	1.019
NOD	-0.169	0.0642*	14.571	-0.027	-0.492
BCT	4.282	0.0457**	0.257	0.685	0.220
EDU	-6.873	0.0541*	0.057	-1.100	-0.079
P3	41.924	1.000+	0.029	6.708	0.240
C	0.147	0.922+			

McFadden R-squared = 0.648, S.E. of Regression = 0.263 Probability (LR Stat) = 0.000386 ** = Significant at 5% * = Significant at 10% + = Not significant