

*Full Length Research Paper*

# Benefit-cost analysis and socio-economic considerations of trypanosomiasis control and treatment in Northern Ghana

Abdul-Wahab Salifu<sup>1\*</sup>, Samuel Asuming-Brempong<sup>2</sup> and Ramatu Alhassan<sup>2</sup>

<sup>1</sup>1600 Franklin Road Apartment 8C, Tuskegee University, Tuskegee, AL 36088, U. S. A.

<sup>2</sup>Department of Agricultural Economics and Agribusiness, University of Ghana, Ghana.

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The paper estimated the cost of tsetse control and treatment of trypanosomiasis and the benefits involved, using benefit-cost analysis. It also estimated 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 showed that farmers will benefit if they invest in control and treatment of the disease. We found 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 were 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 should be provided to livestock farmers to help them derive maximum benefit from disease control practices.

**Key words:** Savelugu/Nanton, socio-economic, trypanosomiasis, tsetse fly, benefit-cost analysis.

## BACKGROUND

Tsetse-transmitted trypanosomiasis is one of the most ubiquitous and important constraints to agricultural development in the sub-humid and humid zones of Africa. Reid (1995) estimated that about 46 million cattle in an area of about 8.7 million km<sup>2</sup> 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*, *Palpalis*, 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.

The control of African trypanosomiasis in domestic animals is accomplished either by controlling the vector (tsetse fly) or by treating animals with trypanocidal drugs. The use of trypanocidal drugs is the most widely accepted means of controlling the disease. However, the drugs available are relatively expensive. In some African countries, sales of trypanocides account for more than half of the total sales of veterinary pharmaceuticals. In spite of

\*Corresponding author. E-mail: [wahab242001@yahoo.com](mailto:wahab242001@yahoo.com).  
Tel: (334) 552-1960. Fax: (334) 727-8816.

this, the development of new trypanocides appears to be economically unattractive. Each diagnosis for animal trypanosomiasis costs about US\$4.0 to \$5.0, which African livestock owners cannot afford. Consequently, more than 90% of the doses are applied without a reliable diagnosis (Bauer, in press). The indiscriminate and under dosed use of the few compounds developed for use against the trypanosomes has led to increasing resistance (Afewerk et al., 2000). In spite of the increasing number of case reports on trypanocide resistance, Geerts and Holmes (FAO, 1998) highlight the lack of reliable data at the regional or national levels on the true prevalence and impact of drug resistance. They urge the development of measures to manage resistance to trypanocides, if possible, and the provision of guidelines to delay the development of resistance. It is alarming that fake drugs with little or no therapeutic effect account for an estimated market portion of up to 60% in developing countries (Holmes, 1997).

Studies on the benefits and costs of tsetse control have been conducted extensively in other African countries (for example, Itty, 1992; Itty et al., 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 fertilize 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:

1. To estimate the financial profitability of preventing and treating trypanosomiasis with available drugs.
2. To identify and quantify the factors that influence the likelihood that farmers will use preventive trypanocidal drugs.
3. 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

**Table 1.** Definition of variables.

Variable	Description	Measured in
P0	Whether farmer accepts the challenge that the tsetse fly is a threat to cattle production.	1 = Yes; 0 = No
NOD	The number of dependents of the farmer.	Numeric
BCT	Whether the farmer agrees that the bite of the fly causes the nagana disease.	1 = Yes; 0 = No
EDU	Educational status of farmer.	1= JSS and above; 0 = no
P3	Whether the farmer's perception of the challenge of the nagana disease is that it is God sent.	1 = Yes; 0 = No
Prob (Yes)	The probability that the farmer uses trypanocidal drugs.	1 = Yes; 0 = No
$\mu_i$	Independently distributed random variable with 0 mean.	

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:

$$Y = \beta X_i + \mu_i, \text{ Such that } Y = 1 \text{ if } X_i > X_i^* \text{ and } 0 \text{ if } X_i < X_i^*$$

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:

$$\text{Log} \frac{\text{Pr ob}(Yes)}{1 - \text{Pr ob}(Yes)} = \beta_0 + \beta_1 P0 +$$

$$\beta_2 NOD + \beta_3 BCT + \beta_4 EDU + \beta_5 P3 + \mu_i$$

There are the coefficients of the independent variables (Table 1).

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

Where;

$P$  = Mean dependent variable.

$A_i$  = Mean of the  $i$ th independent variable.

The model was estimated with E-views 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-Nanton 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.

**Table 2.** Benefit-cost ratios of treatment and prophylactic control.

Herd range	# of cattle	Revenue (000'¢)	Treatment costs (000'¢)	Prophylactic costs (000'¢)	B/C treatment	B/C prophylactic
0-19	142	8,316,800	1,586,000	6,168,000	5.24	1.35
20-29	247	13,821,600	2,468,000	10,636,000	5.60	1.30
30-39	102	6,472,000	947,000	4,188,000	6.83	1.55
40-49	259	15,896,000	2,661,000	11,364,000	5.97	1.40
50-59	159	8,100,000	1,564,000	6,712,000	5.18	1.21
60+	260	15,387,200	2,683,000	11,276,000	5.74	1.37
Total	1,169	67,993,600	11,909,000	50,344,000	199.11	47.27
Average	33	1,942,674	340,257	1,438,400	5.71	1.35

**Table 3.** Net benefit and financial rate of return (FRR).

Herd size	Revenue gain (000' ¢)	Prophylaxis cost (000' ¢)	Net benefit (000' ¢)	FRR (%)
0-19	8,316,800	6,168,000	2,148,800	34.84
20-29	13,821,600	10,636,000	3,185,600	29.84
30-39	6,472,000	4,188,000	2,284,000	54.54
40-49	15,896,000	11,364,000	4,532,000	39.88
50-59	8,100,000	6,712,000	1,388,000	20.68
60+	15,387,200	11,276,000	4,111,200	36.46
Total	67,993,600	50,344,000	17,649,600	1227.23
Average	1,942,674	1,438,400	504,274	35.058

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 2 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 losing 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 and 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 3 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 (FRR) are ¢504,274 and 35.06%, respectively. Thus, on average, a farmer will generate a return above the

**Table 4.** Private level financial analysis (with and without disease cases).

Herd size	Cost (mill. ¢)	Revenue with disease	Revenue without disease	B/C with disease	B/C without disease	NB with disease	NB 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 +	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
Average	23.42	23.04	24.18	0.96	1.01	-0.644	1.28

assumed opportunity cost of capital.

### Financial profitability of the cattle enterprise

Table 4 presents results of the financial analysis, that is, 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 (¢198.46 m) and (¢207.85 m), 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. Furthermore, 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 mean from the model estimates. About ten independent variables were included and finally only five were used, as the rest created near

**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.

singular mat-rices. Appendix 1 contains the full regression results.

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 trypanosomiasis 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 - 0.40 (Sonka et al., 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 trypanosomiasis 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 (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; and 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 results 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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**APPENDIX 1.** Regression results. (Dependent variable: UOTD, method: ML -Binary logit, Date: 10/16/05 Time: 16:23, Sample: 135, included observations: 35, Convergence achieved after 24 iterations. Covariance matrix computed using second derivatives.

<b>Variable</b>	<b>Coefficient</b>	<b>Standard error</b>	<b>z-statistic</b>	<b>Probability</b>
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 variable	0.800000	S.D. dependent variable		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 criterion		0.787204
Restr. log likelihood	-17.51408	Average 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			