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Studies on cattle Trypanosomiasis in the coastal savannah of Ghana: A policy guide

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Abstract

The control of Trypanosomiasis is complex and multifaceted, necessitating a holistic approach for a full understanding of the disease and its control. This study is an example of such a strategy and adopts various approaches. This research seeks to identify and explain the perceived problems of cattle farmers associated with trypanosomiasis control and to suggest the appropriate strategies for planning and control of animal trypanosomiasis in the study area. A Participatory Rural Appraisal (PRA) involving 850 cattle farmers (drovers, herdsmen, owners) adopted a technique known as preference ranking of production objectives to determine the relative importance of trypanosomiasis in the Coastal savannah. A survey, using a structured interview of 250 herdsmen focused on constraints encountered by herdsmen in the use of Berenil® for trypanosomiasis control as well as the quality of drug services provided. A multiple regression equation was run on PC-SPSS Programme [version 16] by the Ordinary Least Square (OLS). The findings indicate that, milk production, the most dominant production objective of farmers, was most affected by trypanosomiasis. Some of the constraints identified with trypanosomiasis control were inappropriate dosages of Berenil® used by farmers, inappropriate pour-on techniques and lack of extension training. Recommendations were targeted at removing these constraints.

Keywords: Triangulation; Tsetse; Trypanosomiasis; Berenil®; Dosage, Parasitology; Drovers; Herdsmen; Owners; Landuse

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1. Introduction

The presence of tsetse flies (*Glossina* spp) and tsetse-borne trypanosomiasis has been a major constraint to health, socio-economical, agricultural and livestock development in Africa. Indeed, the disease is known to disrupt the development of sustainable mixed farming in potentially productive areas (Swallow, 2000) rendering the region one of the most agriculturally impoverished in the world (Hursey, 2001). Despite almost a century of research on the subject, and considerable investments, little impact has been made on its control (PAAT, 1998). African trypanosomiases are caused by species of trypanosomes, protozoan parasites that are transmitted by tsetse flies. The disease (both human and nagana) is distributed over about 10 million square kilometres in the humid and sub-humid region (Jahnke, 1982; Rogers and Randolph 1986; Connor, 1992; Chadenga, 1994) of the sub-Saharan African countries between latitudes 14° North and 29° South (Dolan, 1987; Hursey and Slingenbergh 1995). It is estimated that only 5% of the tsetse-infested area in Africa has been cleared during the last 50 years (Brady, 1991); and even trypanotolerant breeds do not appear to represent a comprehensive answer to the problem (Meltzer, 1990; Meltzer, 1992) because they succumb to intense tsetse challenge (ILCA, 1979; Itard, 1989; ILRAD, 1989).

In Ghana, the presence of tsetse flies (Gyening, 1969; Mahama, 1988; Marchot, Leroy *et. al.* 1989; Gouteux, 1990; Doku and Mahama, 1992; Turkson, 1993) and trypanosomiasis are known to be the major factors limiting the performance of livestock production as well as limiting the optimal utilisation of land (Ghana, 1996). Recognizing its importance, trypanosomiasis was included as one of the important animal diseases in “the Diseases of Animals Act 83 section 22” of 1961. In response to this problem, the Government developed a policy for its control under the National Livestock Services Project (Tsetse and Trypanosomiasis Control Unit of the Veterinary Services Department). Available records (Turkson, 1993; Ghana, 1996) show that prior to and after the introduction of Government’s policy on tsetse and trypanosomiasis control, livestock owners have relied unsuccessfully on the *ad hoc* use of trypanotolerant breeds of livestock and especially on chemotherapy.

Recognizing the shortcomings of the approach adopted hitherto for the control of tsetse flies and animal trypanosomiasis in the country, it is imperative that before embarking on a trypanosomiasis control programme, detailed epidemiological studies should be undertaken. Specifically, there is the need for a better understanding of farmers’ production objectives and the ways they use trypanocides; also appropriate information and maps on *Glossina* and trypanosomiasis risk areas, and epidemiological models as guidelines for animal trypanosomiasis control and forecasts of the disease for accurate targeting of resources.

The Standardised Nomenclature of Animal Parasitic Diseases (SNOAPAD) of the World Association for the Advancement of Veterinary Parasitology now refers to trypanosomiasis as "trypanosomosis." However, because the term "trypanosomiasis" is still very widely used by field veterinarians and WHO for human sleeping sickness, it is used in this study.

1.1. Objectives of the Study

The objectives of this research are to:

- Rank the importance of trypanosomiasis in relation to the production objectives of farmers and in relation to other animal diseases among cattle, sheep, goats and pigs
- Ascertain the measures taken to control the disease according to type of farmer
- Identify and explain the perceived problems of the farmers associated with trypanosomiasis control
- Determine the distribution of trypanosomiasis of livestock and *Glossina* in the study area.
- Develop an epidemiological model for trypanosomiasis monitoring, prediction and control and
- Suggest the appropriate strategies to control animal trypanosomiasis in the study area.

2. Literature review

2.1. Animal trypanosomiasis

The disease has both direct and indirect economic impacts on livestock production. The direct impacts are associated with losses in milk and meat production as well as mortality and morbidity (Agyemang et al., 1997), poor animal growth, reduced fertility and poor carcass quality (Connor, 1993). The indirect impact is related to the opportunity cost of land and other resources currently not used for livestock production owing to the presence of tsetse flies (Agyemang et al., 1997).

Losses of livestock and agricultural production as a result of animal trypanosomiasis (nagana) are around US$ 5 billion annually (ILRI, 1995). Of the 165 million cattle in sub-Saharan Africa, 60 million are at risk of trypanosomiasis (Chadenga, 1994), 10 million are located in tsetse infested areas, while the remainder are distributed in periphery of habitats (Hursey and Slingenbergh, 1995). It is estimated that the annual direct production losses from cattle alone ranges from about US$ 6,000 million to $12,000 million. The disease severely constrains farming activities in sub-Saharan Africa, causing approximately 3 million livestock deaths each year (Hursey and Slingenbergh, 1995; PAAT 1998); and 10, 000 cattle daily (Hursey, 2001). Other constraints include a 20% loss in calving through abortion, 25% reduction in milk yields, 50% reduction in herd numbers and a 50% reduction in food production (PAAT, 1998). Where agriculture and trypanosomiasis do coincide, livestock production is reduced by 20-40 % (Swallow, 2000). Murray et al. (1991) considered that if losses such as in milk and manure production and tractive power could be prevented, the benefit from livestock and mixed agricultural development in tsetse infested Africa could amount to US $50 billion annually. Indeed, the disease arguably represents the most debilitating limitation on agricultural production (Winrock, 1992).

Despite many attempts, an effective vaccine is unlikely to be developed in the near future (Williams et al., 1992; Keiser et al., 2001). Currently, the only effective treatment is the continuous dosage of trypanocidal drugs such as Diminazene aceturate (Berenil®) and Isometamedium chloride (Samorin®). A single treatment of Diminazene aceturate costs between US$ 0.50 and US$ 1.00 per animal (Williams et al., 1993). In an area of intensive tsetse challenge, each animal may need several treatments per year. However resistance of trypanosomes to the available trypanocide is a constant and, in some areas increasing threat (Connor, 1992; Agyemang et al., 1997; Geerts and Holmes, 1998). Although a sterile-male fly release technology has been developed (IAEA 1972) and demonstrated in some African countries including Tanzania (Dame et al., 1980), Burkina Faso (Politzar and Cuissance 1984), and Nigeria (Takken et al. 1986) and successful in Zanzibar (Saleh et al. 1997; Saleh et al. 1999), it is expensive and unlikely to have a significant impact except on small isolated tsetse populations (Williams and Williams, 1992; Williams et al., 1993) whilst new approaches such as "pour-ons" and traps need to be implemented and sustained.

The importance of trypanosomiasis is emphasized by its inclusion as one of the target diseases of the WHO programme for Research and Training in Tropical Diseases (TDR) sponsored by the World Bank during the 28th World Health Assembly (WHO 1975). For similar reasons, the FAO, in accordance with Resolution XI of the World Food Conference of the United Nations in 1974, initiated a long-term programme for the prevention of animal trypanosomiasis in a large area of Africa (WHO 1975; Hursey and Slingenbergh, 1995).

Several other International Organisations have incorporated the control of trypanosomiasis as a top priority. For example, during the 24th meeting of the International Scientific Council for Trypanosomiasis Research and Control (ISCTRC) on the 3rd October 1997 in Maputo Mozambique, the following international organisations: OAU/IBAR, EU, WHO, ILRI, CIRDES, IAEA, ICIPE and RTTC discussed the control of *Glossina* and Trypanosomiasis as their main objective. An important recommendation that emerged was the integration of efforts to control human and animal trypanosomiasis in common endemic areas which cross international boundaries.

It is therefore not surprising that the Programme Against African Trypanosmiasis (PAAT) secretariat commissioned the drafting of guidelines for the use of trypanocidal drugs. The aim was to help manage the problem of resistance, and the need for a more systematic approach to drug use. Other issues discussed were the privatisation of the vector and disease control, and socio-economic factors of trypanosomiasis control. Indeed it was a strategy to ensure trypanosomiasis control in endemic areas in Africa. In line with this plan, the WHO suggested a target of 70% of the risk population under surveillance by the year 2000 (PAAT, 1998).

In sub-Saharan Africa, some strategies have been adopted to combat the spread of sleeping sickness. For example, a number of countries have attempted to co-ordinate surveillance and control of tsetse and Trypanosomiasis. In Central Africa, National Control Programme Projects are being implemented under an initiative involving 10 countries. In West Africa, there is a plan for surveillance within the framework of the Onchocerciasis Control Programme transfer process and "Centre Internationale de Réchérche Dévéloppement sur l'Elevage en zone subhumide CIRDES", has targeted certain risk areas in Francophone countries in West Africa for Trypanosomiasis control. In south-east Africa, surveillance and control involving 8 countries has been promoted through a Regional Tsetse and Animal Trypanosomiasis Control Programme (RTTC) supported by the European Community (WHO 1994).

2.2. Statement of the problem

The presence of tsetse flies and trypanosomiasis in Ghana is well-established (Gyening, 1969; Assoku, 1979; Mahama, 1988; Doku and Mahama, 1992; Turkson, 1993). Despite the inclusion of tsetse and trypanosomiasis control as an integral part of animal and public health programmes by past and present governments in Ghana, sustainable control has not yet been achieved. Several unsuccessful attempts have been made in the past to control the disease (Stewart, 1937; Stewart, 1946; Stewart, 1954; Nowosielki-Splepowron, 1962; Ghana, 1996). Currently in Ghana, about 60 % of the country is still infested with various species of tsetse flies (Ghana, 1996).

Although farmers have used trypanocides regularly for nearly two decades, the disease still remains a problem (Turkson, 1993; Ghana, 1996). The importance of the disease to the farmer's production objectives requires that the impact of such intense trypanocide control measures presently unknown is evaluated. What is more, the procedure for trypanocide use by these farmers is not understood and has not been investigated. The constraints affecting the current control measures need to be identified to assist livestock owners and policy makers in planning.

3. The study area

Ghana lies on the West Coast of Africa between latitudes 5° and 11° north of the equator; longitudes 1° east and 3° west of zero meridians. A coastline of 537 km in the south borders it by Gulf of Guinea, Togo in the east, La Côte d'Ivoire on the west and Burkina Faso on the north. It covers an area of 238,540 km^2. Ghana is a lowland country except for a range of hills on the eastern border. A coastal plain that is crossed by several rivers and streams, generally navigable only by canoe backs the sandy coastline. In the west, the terrain consists of heavily forested hills and many streams and rivers.

There is an undulating savannah in the north. The Black Volta and White Volta rivers that join to form the Volta River drain this area. The Volta then flows south to the sea through a narrow gap in the hills. The most important river, the Volta, has been dammed at Akosombo to form a lake that extends 540 km long and covers an approximate area of 8000 km^2, one of the largest artificial lakes in the world. The country's highest point, in the eastern hills is about 876 metres above sea level.

The climate is tropical, but temperatures vary with season and elevation. Generally the temperature ranges from 18° to 32° C. Two main seasons (wet and dry) occur from April to June and from September to November.

In the north, the rainy season lasts from May to August, and the dry season is from September to April. In the South, the wet season lasts from April to November and is interrupted by a short dry spell in August. The annual rainfall ranges from 70 cm annually in the coastal area and the north to over 200 cm in the forest belt, delineates the country climatologically into 4 ecological zones.

Several rivers flow from north to south. The north, where the land is flat, is subject to flooding in the rainy season. The average annual temperature is 26° C.

The country is divided into 10 administrative regions and 110 districts. Each district elects its own district assembly representatives that assume responsibility for local government. The population is 20,244,154 (2007 estimates), and the growth is 3 per cent per year (Ghana 2008). On average, there are about 73 persons per square kilometre. About 36.3 per cent of the area are urban and 63.7 per cent rural. Most of the rural population is engaged in peasant farming. The major cash crop is cacao. Other principal crops are rice, coffee, cassava, groundnut, corn, shea nuts. Timber is one of the main exports. There is a cattle rearing in the north, and in some other parts of the country such as the coastal areas. Tourism is on the increase, and important game reserves are the Mole Game Reserve in the north and the Kakum National Park in the south. The eleven districts under study are represented in Fig 1.

3.1. The coastal savannah zone

The study area (Figure 2.1) is the southeast coastal plain. The physical and human geography of this region differs in several important respects from that of the rest of the country's coastal plain. This area has the oldest as well as the youngest rock formations in the country. The land is remarkably flat and dotted with inselbergs, the majority of which are found in the Accra plains and west of the Volta River. The drainage pattern in the zone is fairly simple; the principal river is the Volta, which enters the sea at Ada. The coast is fringed with lagoons into which flow a number of streams independent of the Volta.

The rainfall regime is equatorial, but the mean annual rainfall is about 72 centimetres. The vegetation is short grass with clumps of bush or with a few trees. The pattern of population shows concentrations around lagoons, along the Volta, and close to the border with Togo. The interior of the coastal zone has low population density. Except for the Greater Accra Region, the majority of the population in the zone lives in rural areas. The overwhelming majority of the inhabitants of the plains are Gas, Adangmes and Ewes for whom the plains are traditional homes. Other groups include Fulani and others from Northern Ghana, are relatively few.

The primary occupations are farming, livestock rearing, fishing and salt mining. Farming is the most widespread of the primary occupations. There are two systems of farming: bush fallowing, which produces mainly food crops for home consumption or for the markets and permanent cultivation which produces crops mainly for sale. The principal food crops produced by the bush fallow system include cassava, maize, yam, okra, groundnuts, sweet potatoes, and in the forested areas around the foothills of the Togo-Attakora mountains, plantains and cocoyam. Permanent cultivation is practised on peasant farms and includes crops like shallots, maize, sugar cane and tomatoes, lettuce, cabbage and other vegetables, oil palms and coconut.

Livestock (mainly cattle) rearing is important, particularly in the Accra plains. Some of the cattle are reared on state farms or ranches where low-level earth dams have been built to provide water for animals. But the majority of the cattle are reared outside the state farms on unimproved natural pasture and in the dry seasons some of the animals trek long distances in search of water. Others obtain water from nearby streams.

Some of the largest and most important towns in the southeast coast are Accra, Tema, Ashiaman, Ada, Keta, Denu and Aflao. The city of Accra, (population of about 1,500,000) is the largest urban settlement in the country. It is also the country's capital.

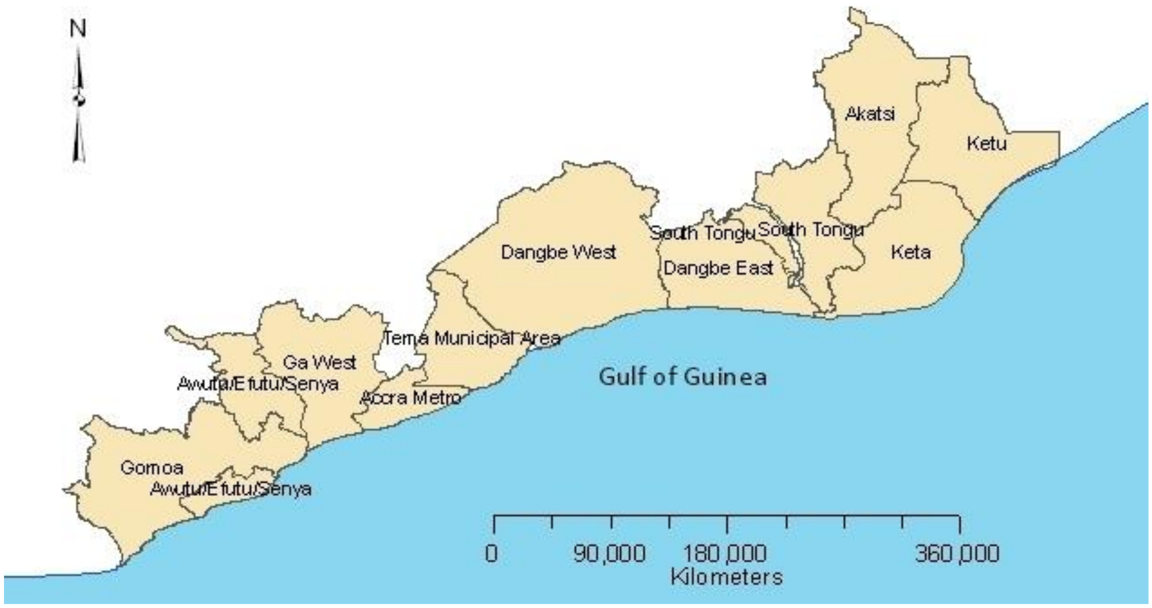

Figure 1. The study area – Gomoa, AES, Ga, AMA, Tema, Dangbe West, Dangbe East, Sogakope (Tongu) Akatsi, Keta and Denu (Ketu)

4. Research methodology

4.1. Population and sample

The respondents consisted of 250 herdsmen representing 15.14% of the total population of herdsmen in the study area [Figure 1]. The number of cattle farms owned in the study area is 1651 (McCracken et al., 1988; Ghana, 1999). They were grouped into various Districts as follows:

In the Central Region there are 112 farms at Awutu-Efutu-Senya (AES) District and 139 in Gomoa District. In the Greater Accra Region, there are 20 in the Accra Metropolitan Assembly (AMA); 185 in Dangme East 429 in Dangme West and 205 in Tema District. In the Volta Region, 198 in Akatsi District 33 in Keta District 46 in Ketu and 119 in Sogakope (South Tongu) District. Of this total number of farms, 250 were selected for the study and the respective herdsmen were identified as respondents and interviewed. In a survey design, a sample of 10 to 20% of the accessible population is enough to generate confidence in the data collected and the subsequent generalization (Ary et al., 1979). It was noted that 30 cases is minimum for statistical data analysis (Bailey, 1982) and some techniques can be used with fewer than 30 cases (Champion, 1970). For the Participatory Rural Appraisal (PRA) technique, 850 farmers comprising drovers, herdsmen and owners were interviewed for matrix-scoring of the production objectives and the effect of animal diseases on livestock and their products.

For the purpose of trypanosomiasis prevalence studies a current cattle population census of the various districts was obtained from Records of the respective Veterinary Offices. A minimum sample size of all herds (kraals) was chosen at a 95% confidence level, an assumed (estimated) prevalence of 20% (Ghana, 1996) and within a precision (margin of error) of 5% (Lemeshow et al., 1990; Lwanga and Lemeshaw, 1991).

In each herd (within the kraals) the required number of animals was selected by simple random sampling so as to ensure that each animal had an equal chance of being selected.

In this survey, 1,830 cattle were sampled. But the research also adopted a total of 6,902 samples for analysis as secondary data from the Tsetse Control Unit (Veterinary Department of the Ministry of Food and Agriculture) to strengthen the validity of the research findings.

4.1.1. Farmer types

Categories of farmers (drover, herdsman, herdowner) are defined as follows as categorized by the Ministry of Health (Ghana 1998) are as follows:

- **Drovers** are "cow boys" (aged 10-16 years) who are local children employed to assist herdsmen in the daily management and grazing of cattle. They ran errands for herdsmen on cattle farms. Herdsmen normally remunerate them with milk, cash, beef and sometimes calves for their services.
- **Herdsmen** are pastoralists who are employed by cattle owners to manage their farms. They are normally remunerated with milk, cash and sometimes with calves.
- **Owners** are herdowners (or cattle owners); normally absentee farmers. They employ the services of herdsmen to manage their farms. This is normally done with certain agreements involving remuneration with milk, cash or cows.
- **Small-Scale Farms** are farms where cattle numbers range from 1 to 49.
- **Medium-Scale farms** are farms where cattle numbers are between 50 to 99.
- **Large-Scale farms** have 100 or more cattle.
- **Sole Ownership** Ownership of cattle farm by an individual.
- **Family Ownership** Ownership of cattle by a family.
- **Communal Ownership** Ownership of cattle by a group of farmers in some form of partnership whereby the farm is under the supervision of only one farmer who owns the largest proportion of cattle in the herd.

4.2. Procedure

4.2.1. Participatory Rural Appraisal Surveys (PRA)

The PRA survey relied on a technique known as preference ranking of variables within a matrix (Kirsopp-Reed and Hinchcliffe, 1994). Participants were asked to rank the importance of different cattle production parameters and also their perceptions of the importance of livestock diseases. Parameters included hide, beef, milk, manure as well as customary and ceremonial uses. The criteria were listed in the rows of a matrix with the classes of livestock in columns. Within each cell of the matrix, participants could specify the relative importance of every category by placing between zero and ten maize seeds within the matrix. The production objectives, farmer's perceptions of the importance of livestock diseases, livestock disease types in relation to trypanosomiasis and cattle diseases affecting productivity (i.e. the rows of a matrix) were determined after discussion and pre-testing with farmers.

The survey was carried out in 75 villages within 11 districts as follows: 5 districts in the Greater Accra Region, 4 districts in the Volta Region and 2 districts in the Central Region.

In each village, participants were asked to divide themselves into groups according to their ethnic origin and wealth relative to cattle herd size: small < 50 head, medium 50-99 head and large > 99 (Ghana, 1999). Each completed the matrix separately. Contract herdsmen completed the matrices as groups separate to the owners of the herd. Herders were also asked to complete the matrices according to herder types and the type of ownership (sole ownership, family ownership and communal ownership). Prioritization process was followed by informal discussions to clarify issues relating to the matrices, cattle disease, treatment and constraints for each type of livestock.

4.2.2. Ground surveys: tsetse surveys

Glossina spp. Tsetse fly sampling was done in the study area (where PRA surveys and parasitological studies were conducted) using 20 unbaited biconical traps (Challier and Laveissière, 1973) in each area for 24 hours. The species, sex and numbers of tsetse were identified (WHO, 1988; Geoffroy et al., 1993), recorded and stored in the database as flies per trap per day. The data were supplemented with those of the National Livestock Survey Project.

4.2.3. Land use and climatological data

It is important to examine the interaction between trypanosomiasis risks and agricultural activities such as crop and livestock production. To achieve this, digitized land use maps of the study area were obtained from the Department of Geography and Resource Development (University of Ghana, Legon), while Climatological data (from 1980 to 1999) were obtained from the Ghana Meteorological Headquarters (Accra) for analysis.

4.2.4. Satellite data

Normalized Difference Vegetation Indices (NDVI) (Rouse et al., 1974) derived from the Advanced Very High Resolution Radiometer (AVHRR) on board the National Oceanic and Atmospheric Administration (NOAA) satellites were obtained from the following sources for 1999 Satellite images: USGS website, African Real Time and Environmental Monitoring Information System (ARTEMIS) and the MALSAT Research Group. These values were analyzed for predictions of Tsetse and cattle trypanosomiasis transmission risks areas in the coastal savannah.

4.2.5. Trypanosome identification in cattle

The techniques adopted (Murray et al., 1983) are based on the premise that following blood centrifugation, trypanosomes are concentrated mainly in the buffy coat zone. Each animal was bled from the jugular vein into a herparinized vacutainer tube (10 mls) and from the ear vein into a haematocrit capillary tube which were transported to the laboratory on ice at 4^{o} C. The capillary tubes containing blood were microscopically examined for trypanosomes using the Buffy Coat technique, BCT (Woo method). The buffy coat prepared in a microhaematocrit capillary tube and centrifuged as for measurement of Packed Cell Volume (PCV) was examined for trypanosomes as follows:

The capillary tube was cut with a diamond pointed pen 1mm below the buffy coat to include the upper layer of the red blood cells, and 3cm above to include the plasma. Using a microhaematocrit capillary tube holder, the contents of the capillary tube were gently expressed on a slide, mixed and covered with a cover slip (22 x 22 mm). The preparation was then examined using the following microscopic set up: A Leitz SM microscope, periplan GF x 10 eyepieces, P.V. 25/0.50m objective and Heine phase contrast condenser. The entire coverslip area was then examined for about 5 minutes.

The identification of trypanosome species were made on morphology of the parasites (Hoare, 1972; Itard, 1989) the behavioural pattern observed in the buffy coat dark ground illuminated preparations, and mensural characteristics: The species identified were: *Trypanosoma. congolense*, *T. vivax and T. brucei.*

4.2.6. Trypanocide usage and the constraints in the control of trypanosomiasis by livestock keepers

Knowledge of diagnosis and treatment procedures of trypanosomiasis by herdsmen was assessed by questionnaire. Respondents were interviewed on the use of trypanocides to treat cattle trypanosomiasis. Records included the volume of Berenil® administered to cattle. The data were supplemented by relevant records and information from the following sources: Department of Veterinary Services, Veterinary Technical officers (Community Animal Health Officers/Frontline Staffs), District veterinary doctors and the National Head of Tsetse and Trypanosomiasis Control Unit.

4.2.7. Quality of care of veterinary drug services

Farmers were asked to rank quality of drug services using Likert scale. The farmers' views of drug services were presented in tabular form and ranked as follows: excellent, good, fair, undecided and poor. The qualities (variables) used were: general satisfaction, coverage of needs, satisfaction of needs, presentation of treatment methods, effectiveness of treatment, information given, understanding of drugs, language gap, seller's follow up and regularity of follow up.

4.3. Data processing and analysis

4.3.1. Participatory Rural Assessment (PRA)

The data were analyzed using a linear-mixed-model that included the effects of Regions, Districts, and Villages within districts, ethnic groups, herd size and whether the respondents were cattle owners or herdsmen, Business-Ownership of cattle (sole, family, communal) and Vegetation type of each study site.

$$Y_{ijklmno} = Region_i + district_j + village_k + ethnic\ group_l + herd\ size_m + ownership_n + vegetation_o + e_{ijklmno}$$

Regions, Districts, Ethnic Group, Herd size and Vegetation were regarded as fixed factors, whereas village within district was regarded as a random factor. The data were standardized to ensure that relative ranking of objectives and disease type by different groups of respondents was similar. For example, one group of farmers might only use a range of zero to 5 maize seeds, whereas another group the full range of zero to 10. In the first group, a trait with a score of 5 is the most important, although it will be an intermediate score in the second group. The data for each herd and animal group were transformed using the formula:

$$Y_{std} = Y_{org}/(n/\Sigma Y_{org})$$

where Y_{org} = original score of trait n = number of recorded traits

Thus the standardized trait measures the importance of this trait relative to all scored traits within each herd. An F-test was used to test the significance of the various factors and the LSD-test to investigate the differences of levels within a factor.

4.3.2. Constraints associated with the control of trypanosomiasis by herdsmen

To empirically estimate the marginal effect of constraints affecting the control of trypanosomiasis, multiple regression equations were run on the PC-SPSS programme by the Ordinary Least Squares (OLS) analysis. In this analysis, the “general to specific” approach of Hendry (Kousoyiannis, 1971; Zar,1984; Thomas, 1993; Johnson and Di Nardo, 1997; Kennedy, 1998) was adopted in order to arrive at coherent regression results.

4.3.3. Quality of care of drug services

The data were transformed semi-quantitatively by assigning values to the variables. The qualities of the likert-scale were assigned values as follows: excellent = 5, good = 4, fair = 3, undecided = 2 and poor = 1. The PC Programme SPSS was used to run multiple regression to test the significance of the impact of the farmers’ view of the qualities of drug services.

Furthermore, the Spearman’s rho (ρ) was used for a two-tailed test for possible correlations between the variables.

4.3.4. Cryopreservation of trypanosome-infected blood samples for future drug (trypanosome) susceptibility analysis

This section was conducted at The Noguchi Memorial Institute of Medical Research (Legon-Accra, Ghana) as follows: Trypanosome-infected blood samples from cattle in selected areas were treated with anticoagulant, heparin (0.005%). One volume of dimethylsulfoxide (DMSO) sterilized stock (20%) solution was added to 3 volumes of blood, to give a final concentration of 5% and mixed well. The samples were aliquoted in 0.8mls cryotubes, screwcapped, labelled with stabilate codes and frozen in liquid nitrogen by progressively sinking the tubes in the vapourphase of the liquid nitrogen container.

5. Discussion and policy implications of study

5.1. Primary findings

5.1.1. Demographic characteristics of cattle farmers

The survey produced 10,832 completed matrices, and a total of 850 appraisals of cattle farmers. This includes 2,250 matrices for production objectives, 5,582 for farmer perceptions of animal diseases and 3,000 for impact of animal diseases on productivity. The percentage breakdown of the different groups of participants is presented in Table 6.1. Analysis of the herdsize (farm size) shows that there were 275 (32.3 %) small scale farmers, 383 (45.1 %) medium scale farmers and 192 (22.6 %) large scale farmers. Among these farmers, there were 116 (19.5 %) drovers 346 (40.7 %) herdsmen and 338 (39.8 %) herd-owners. Medium scale farmers (50-99 cattle) dominate (45.1 %) among these farmers. The farming system is mainly communal ownership (47.3 %) whereby cattle farms are under the care of only one farmer (cattle owner). Most of the farmers (88.5 %) are males and mainly from the Dangme West District (26.0 %) of the Greater Accra Region (60.7 %). The proportion of male farmers is (88.5%). The bulk (89.5%) of farmers comprises Fulanis, Ewes and Adangmes.

The study has shown that males dominate in the farming system. This issue of male dominance in enterprises in general and livestock keeping in particular has been noted by (ILO/JASPA, 1993) and (CSIR, 1997) respectively that explained this gender differential as the inadequate overall attention given to women in the country. The fact that as many as 45.1% of the farms are medium scale (50-99 cattle) and 32.3 % are small scale farms (1-49 cattle) shows that probably there is still a considerable amount to be done to improve the efficiency of the farming system. So far, only 22.6% of the farmers are categorized as having obtained a large scale (> 99 cattle) status. Average herd size in the study area was 87 and varied from 8 herds to 600. This finding is at variance with the findings (Ghana, 1996) in Dangme East and Dangme West where farmers were known to have herds ranging from 30 to 200 cattle.

The study further shows that the herd size in the study area ranged from 11 to 450 and not 30-200 cattle as previously known. In an explanation to differences in farmers' choices about farm size, it (PAAT, 1998) was clarified that the existence and severity of trypanosomiasis may have influenced it. Another possible reason for the small herd size as observed is the prevailing economic conditions that may not allow farmers to afford many cattle. These changes could also be explained by migrations and cattle offtake (Koney, 1992).

Contrary to expectations, the current study found only 47.3% of communal ownership of cattle in the study area as compared to a previous report (Ghana, 1996) which indicated that as much as 80% of cattle farms in Dangme East and Dangme West were communally owned. MOFA further explained that 40% of livestock owners are not resident in the communities concerned, but have contracted herdsmen and relatives who look after their stock (Ghana, 1996). This decrease in communal ownership may be explained by current interest of farmers in sole and family ownership and for mixed farming. Interview on with farmers shows that they preferred mixed farming (associated with sole and family ownership) to communal ownership because it gives them independence.

5.1.2. Production objectives of Cattle Farmers

5.1.2.1. Drovers

It was observed from the regression analysis that the significant factors ranked by farmers were their cattle products ($p < 0.01$). The orders of importance were: Milk, Beef, Cattle acquisition, Manure and Hides. The importance of milk to drovers may be explained by its immediate use for consumption and as a cash commodity. A further explanation may be that milk is the main source of remuneration from the herdsmen who employ services of drovers. The next commodity of importance is manure. The importance of manures over hides may be the recognition for farming purposes of manure in enhancing crop productivity as the trend to mixed farming increases. Mixed farming has become important in the study area and drovers get involved in farming at an early age in the Coastal Savannah.

It is important to note that in the case of usage of the above commodities, these farmers ranked cash highest. This is followed by “own consumption” of these commodities and for “ceremonial uses” respectively.

5.1.2.2. Herdsmen

Among herdsmen, the descending order of importance of the products is milk, the acquisition of cattle, beef, manure and hides. This order of importance to herdsmen is not surprising as milk is their main source of remuneration and in certain instances, cattle. In general, Milk is the primary production objective of herdsmen. This has some implications on how herdsmen are remunerated in the farming system. The importance attached to milk by herdsmen in general may have motivated them to control trypanosomiasis by themselves without technical guidance. The importance of milk as a top priority to herdsmen has also been noted elsewhere (South Africa) by (Dreyer et al., 1999).

In this research, the farmers have indicated that beef is normally for sale and to a lesser degree for their own consumption. The herdsmen ranked manure more important than hides because of mixed farming activities and as manure is sold in certain localities in the coastal savannah.

5.1.2.3. Owners

Cattle owners have different preferences for products from drovers and herdsmen. They ranked the acquisition of additional cattle as the highest priority. This has implication for the way animals are managed within the herd. Specifically, cattle owners aim to maximize numbers, even if individual productivity is low (Bennison et al., 1997). Invariably, technical (or veterinary) guidance is lacking with herdowners. Indeed production parameters favoured by government and development agencies are not those perceived by cattle owners and even herdsmen as being of primary importance. To herd owners, cattle are kept primarily as an investment and also as a symbol of wealth.

The importance of cattle to owners is followed by beef, milk, manure and hides. However, milk is of limited importance to cattle owners compared with drovers and herdsmen. The next commodity of importance is manure, which are used by all farmers for farming purposes or for sale.

5.1.3. Farmer's perception of the importance of animal trypanosomiasis in relation to other livestock diseases

The findings of this study show that the severity and impact of diseases on different groups of livestock varies. Farmers held similar views that the impact of a disease (e.g. trypanosomiasis or mange) on cattle may be most severe. These observations varied between villages in the Coastal Savannah.

Tick infestation was viewed as the most serious constraint by herd owners but drovers and herdsmen rank it as the second most important constraint. The importance of ticks to "farmers" in the study area has been observed earlier by Okantah et al*.* (1998). In this study, it was also observed that of all the diseases affecting cattle, diarrhoea was classified as the most important to Drovers and herdsmen respectively. In contrast, Diarrhoea was mentioned (Okantah et al., 1998) as the third most important disease. Using raw (unstandardized values) findings from Dangbe East and Dangbe West (Ghana 1996) however indicated that the following diseases were in priority of identified importance: helminthiasis, dermatophilosis and FMD and trypanosomiasis.

Diseases, particularly those associated with tick and worm infestation have been reported on sites in selected areas of the coastal savannah as major constraints to dairy production (Okantah et al*.,* 1998). The importance of ticks on cattle and other livestock as a constraint to livestock development has also been noted by herdsmen in other parts of Africa (Dreyer et al*.,* 1999). Mattioli et al. (2000) believe that tick infestation and tick-borne infections together with tsetse-transmitted trypanosomiasis constitute the main parasitological disease complex constraining livestock production in Africa.

5.1.4. Farmer's perceptions of the effects of livestock diseases on cattle productivity

This study has shown that the effect of diseases on products varies between districts and villages. The majority of farmers held similar opinions about the impact of diseases on their production objectives. The important animal diseases on products (commodities) in a descending order of importance were: Trypanosomiasis, Tick infestation, Helminthiasis (worms), and skin diseases (mange, lumpy skin and Dermatophilosis). Others were Foot and Mouth Diseases (FMD), T.B. and Diarrhoea.

The key result linking cattle productivity and animal diseases is that milk production, is the most important production objective of herdsmen and is most adversely affected by trypanosomiasis. It is therefore not surprising that herdsmen focus considerable attention and efforts on its control. Milk is the main remuneration system for herdsmen (Koney 1992; Dickson and Benneh, 1995), constitutes a major source of their own diet (Okantah et al., 1998) and an obvious economic incentives. Okantah et al. (1998) demonstrated that in selected areas in the coastal savannah (AES, Dangme West, Ga, Tema and North Tongu) herdsmen considered the loss of milk associated with disease more important than the loss of a calf. These findings of the effect of trypanosomiasis on milk production supports that of other researchers (Ikede et al., 1988; Agyemang et al., 1997) who explained that trypanosomiasis causes not only clinical disease but also productivity losses, including reduced milk yield, stunted growth, infertility and abortion. Agyemang et al. (1997) explained that the productivity of cattle kept under traditional management condition in Africa are adversely affected by several diseases. These diseases are prevalent to varying degrees in village production systems (Agyemang et al., 1997). For example, the University of Berlin studies in 1993 indicated that trypanosomiasis reduces milk offtake by 12% in sedentary herds and 8% in transhumance herds in Northern Côte d'Ivoire. Furthermore, trypanosomiasis decreases offtake in sedentary herds by 4% and 10% in transhumance herds.

With a few exceptions (Jahnke, 1982; De Leuw and Ray, 1995) studies on the direct impact of trypanosomiasis on livestock communities themselves is lacking. Regardless of the scanty information, it has been demonstrated that trypanosomal infections affect the level of nutrition and body conditions in cattle (Little et al., 1990). It is also known that much of the variation in health and productivity of cattle are attributable to differences in prevalence of trypanosomiasis and helminthiasis (Agyemang et al., 1988). A deleterious effect of trypanosome infection on productivity (oestrous activity) has been experimentally demonstrated among Boran and N'Dama heifers (Lorenzini et al., 1988) whilst others (Dwinger et al., 1994) demonstrated that the productivity per 100 kg cow maintained per year varied from 37.2 kg in low tsetse challenge to 21.4 kg for cattle kept in high tsetse challenge. Under ranching conditions, calving intervals for cows infected with trypanosomes was 68 days (14%) longer than that for uninfected cows (Trail et al., 1990).

5.1.5. Trypanosomiasis prevalence and distribution

Trypanosoma vivax is found in 60.5 % of those cattle with trypanosomiasis. The predominance of *T. vivax* infection in livestock as compared to other trypanosome species is known from other studies (Ford, 1964; Folkers and Jones-Davies, 1966). This predominance of *T. vivax* in livestock has been explained by mechanical transmission (Leak, 1999). Furthermore, it is observed that *T. vivax* correlates best with heifers ($p < 0.05$), and cows ($p < 0.05$). Mixed infection are more frequently encountered in Young bulls ($p < 0.050$), and cattle ($p < 0.07$). There was no apparent relationship between trypanosome prevalence and the smaller ruminants (sheep, goat) and pigs. Similar observations were made (Snow et al., 1996) to explain that in the traditional husbandry practice, sheep and goats remain close to villages while cattle forage widely into tsetse infested habitats.

5.1.6. Tsetse density and distribution

The Challier-Laveissière trap was used for sampling tsetse flies (Challier and Laveissière, 1973). In this research, *Glossina palpalis* was the only tsetse species found in the area and its distribution (0.55-0.71 catches/trap/day) of *G. palpalis* were in Dangme East (0.71catches/trap/day), Ga (0.37 catches/trap/day) and Gomoa (0.33 catches/trap/day). Medium risk areas (0.21-0.54 catches/trap/day) were Ketu (0.30 catches/trap/day) and Akatsi (0.28 catches/trap/day). As the analysis shows, flies are least abundant in Dangme West (0.101 catches/trap/day) and AES (0.088 catches/trap/day).

Comparing current tsetse distribution results to earlier findings (Offori, 1963; Offori, 1964; Kuzoe, 1971) shows that, there have been significant changes in distributional patterns of *Glossina* species in the areas. For example *Glossina* species such as *G. longipalpis*, and *G. medicorum* (Edwards, 1959; Chapman, 1960; Offori, 1963; Offori, 1964) that were previously found and recorded in the coastal savannah were not identified in this survey. *G. morsitans* was once widely distributed in Ghana (Morris, 1946) but was not found in this study.

It was found however that between 1995 and 1999, there has been a change (increases and decreases) in tsetse density (catches/trap/day) in the study area. Several authors have suggested reasons for changes in numbers and patterns of tsetse populations. Some of these factors in the study area include hunting and reduction in cattle numbers along the former cattle routes (Offori, 1964). It is also known that the creation of the Volta lake led to changes in tsetse population (Kuzoe, 1971). Another artificial lake created in the coastal savannah at Kpong could be a probable reason for changes tsetse density and distribution. Other probable reasons for this change were result of land use (Kuzoe, 1971), control procedures or cattle movements. Williams et al*.* (1992), suggested that fly population and densities may also be dependent on movement patterns of the flies.

5.1.7. Animal trypanosomiasis control by cattle farmers and diseases patterns in the coastal savannah

Analysis of the survey indicates that only two districts (Akatsi and AMA) adopted the recommended dosages (3.5-7.0 mg/kg wt.). However, apart from farmers in the two districts (Akatsi, AMA) there were individual farmers 55 (22.0 %) in all districts who used the appropriate dosages. Education of herdsmen and the type of farming practiced influence it. Thus farmers with higher education tend to use the appropriate dosage of Berenil.

Proportions of cattle breeds (zebu, sanga, N'dama and WASH) and total herd density per district shows that the average number of cattle was 7.42/km^2 in high risk areas such as Gomoa and Ketu, 18.8/km^2 in medium risk areas (Tema, Akatsi). In the low risk areas, (Awutu, Dangme East, Dangme West) cattle density was 21.17/km^2. Overall, the cattle population density in the study area is 15.81 per km^2 and ranges between 0.78 per km^2 in some areas (Keta) to 34.34 per km^2 in other districts (Dangme East).

5.1.8. Relationship between trypanosomiasis and mixed farming practices

The relationship between trypanosomiasis and the intensity of mixed farming (crop-livestock) and mixed-arable crop indicates that trypanosomiasis prevalence has a strong correlation with mixed farming (crop-livestock) activities. In high trypanosomiasis risk areas, mixed farming intensity (% land use) is 2.3 %. At medium and low risk areas, farming intensities are 17.7 % and 19.1 % respectively.

5.2. The impact of AVHRR on Glossina palpalis and cattle trypanosomiasis: Predictions for trypanosomiasis risk areas

Normalized Difference Vegetation Index (NDVI) derived from the Advanced Very High Resolution Radiation (AVHRR) on board the National Oceanic and Atmospheric Administration (NOAA) satellites were used for the period 1999. The use of these indices is the simplest and most convenient way to monitor vegetation cover, and allow rapid estimation of vegetation cover properties from remotely sensed data (Rouse et al., 1974).

Results from this study shows that the significant ($p < 0.05$) NDVI band affecting tsetse distribution is the RANGEDVI and the equation may be represented as:

$$TSETSE_{Distribution} = -3.097 + 0.33\ RANGEDVI \qquad (1)$$

The equation shows that for a unit (1.0 %) increase in RANGEDVI, Tsetse density increases by 0.0033. This is represented as a relationship between NDVI and tsetses are shown and may be represented as in the following equation:

$$LogTRYPS_{Risks\ areas} = 0.993 + 1.186\ RANGEDVI - 1.364\ MINNDVI \qquad (2)$$

Equation 2 shows relationships between RANGEDVI, MINNDVI and trypanosomiasis prevalence. It indicates that a unit increase (1.0 %) of RANGEDVI increases trypanosomiasis risk by 0.0186 and with a 1.0 % decrease in MINNDVI decreases Trypanosomiasis risk by 0.01364.

5.3. Policy recommendations

This research explores the production objectives of three categories of farmers (drovers, herdsmen, and owners) as a new approach to analysing their views on production priorities. It also explains farmers' perceptions of diseases affecting livestock and production and why they control the diseases themselves without technical guidance.

The key finding of this research is that milk production is the most important production objective of the farmers, and that milk production is most affected by trypanosomiasis. Because Milk is the main source of remuneration of herdsmen, they focus considerable attention on trypanosomiasis and its control. It is therefore important that the views of cattle farmers must be included in the planning of livestock projects because they have different priority outputs.

5.4. Livestock patterns and landuse in relation to trypanosomiasis risks

The monitoring and evaluation of the effects of trypanosomiasis on land use change and livestock densities is relevant for planning control operations and this has policy implications. In particular this is applicable in assessing the impact on the intensity of cultivation and mixed farming in traditional husbandry systems.

Mixed farming systems predominate in the coastal savannah zone of Ghana and this has some significant relationship with trypanosomiasis prevalence as demonstrated in this research. Trypanosomiasis affects the suitability of areas for livestock keeping and limits the utilization of land to the extent that livestock keeping is restricted only to certain areas of the coastal savannah and very relevant for policy implications in livestock farming areas.

In the traditional sector, livestock keepers in rural areas in Africa can be broadly classified into two groups: pastoralists who depend mainly on livestock and the second group who adopt mixed farming (crop-livestock) practice.

Specifically, there are constraints associated with cattle trypanosomiasis control approaches by cattle farmers with trypanocides. These limit the expansion of livestock production in the coastal savannah. Removal of these constraints will enhance the expansion of livestock and quality of their products. This could then enhance livestock productivity in terms of meat, milk, hides and manure in the study area.

5.5. Drug classification and accreditation system:

Apart from Berenil® other types of trypanocides (such as Samorin®, Veriben®, Ethidium®, Diminaveto®, and Sangavet®) were used by farmers and there was no control of drug use by these farmers. There is therefore the need for a trypanocide classification system as a tool for performing comparative studies of supply/marketing and use. Such a system will provide a solid basis on which to compare trypanocidal drug use among farmers in the various locations in study area. Furthermore, the MOFA and the Ghana Standards Board in consultation with the Government should promote the accreditation of Veterinary drug stores at national, Regional and District levels.

5.6. Test for trypanosome resistance

This study indicates that there is a significant rate of underdosing among the cattle farmers. The fact that most of the farmers underdosed their cattle with Berenil® shows the risk of increasing selection pressure on trypanosome populations (Geerts and Holmes, 1998). To address this problem, there is the need to test for resistance of trypanosomes to trypanocides such as Berenil® in the study area. Some parasite isolates have been made and stored at the Noguchi Memorial Institute in Accra, Ghana. Further studies should elucidate the level of trypanocidal drug resistance in the study area.

5.7. Community participation and involvement in trypanosomiasis control programmes

There is a growing awareness of the need for trypanosomiasis control to be considered an integral component of rural development as demonstrated in this research. It is therefore not surprising that current control of the disease is carried out in many rural areas to facilitate the expansion of livestock-based production systems. The use of trypanocidal drugs generally administered by livestock owners themselves is the method by which animal trypanosomiasis is controlled in most African countries (Leak, 1999). Indeed this is the method adopted in Ghana (Turkson, 1993; Yahaya, 1996) because there is limited application of tsetse control in the country. But this method of dependence on drugs for the control of animal trypanosomiasis has become alarming often under inadequate supervision. Because farmers take direct responsibility of controlling typanosomiasis, it is important to take into account their (especially the Cattle Farmers' Association) in decision making and developing policies on drug use.

The Veterinary Department and the Ghana Standards Board have a role to play in monitoring the use of trypanocides in accordance with good standards of pharmaco-vigilance. This will allow for data on rare and unexpected effects on livestock to be recorded and analysed with the co-operation of farmers. This is important as drug utilisation studies can make an important contribution by striking a balance betweenthe benefits and the risks of drug use. In this context, the implementation of appropriate drug policies with farmers' involvement should be re-addressed.

5.7.1. Training Programmes

5.7.1.1. Cattle farmers

Extension training has been identified as a constraint to productivity among cattle farmers. Extension systems and public education constitute important tools to improve the agro-economic situation, especially livestock production. There is therefore the need to introduce basic training programmes for farmers specifically on the use of veterinary drugs and trypanocides in particular. This training may include the implications of buying drugs from Veterinary stores without prescription form the Veterinary Doctor.

In this research, certain factors were identified as affecting cattle production. They are, inappropriate dosage of Berenil® used by farmers, selective treatments adopted, pour-on techniques and lack of extension training. Others were the criteria for treatments and inappropriate treatment intervals. These are factors that affect productivity and need to be addressed by policy makers especially by the Veterinary Department to improve drug use by herdsmen. Currently, farmers are not trained on the use of these drugs but they undertake their own treatment as the cattle belong to them and directly responsible for the animal health of their livestock.

5.7.1.2. Drug sellers

The constraints associated with the quality of care of drug services by drug sellers are: inadequate information is provided, language gap, there is an inability of drug sellers to follow up and inappropriate presentation of treatment methods. Extension training among drug sellers will be appropriate to address these problems. Specifically, drug sellers should be trained on the implication of drug abuse (overdose and underdose).

6. Conclusion

Milk is the main source of remuneration of herdsmen, and a motivating factor for farmers and their views are crucial in directing policy. It is therefore important that the views of cattle farmers must be included in the planning of livestock projects because they have different priority outputs. It is clear from this study that a mixed-method approach is crucial for a full understanding of trypanosomiasis control and for policy analysis. Thus, in this study, it has been possible to identify the production objectives of cattle farmers, the rationale for trypanosomiasis control, constraints associated with the use of trypanocides, vector distribution, prediction of trypanosomiasis risk areas, land use in relation to trypanosomiasis. All these information have been appropriately used to inform decision on targeting trypanosomiasis control.

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