ISSN 1020-7163

PAAT TECHNICAL AND SCIENTIFIC SERIES 5

ECONOMIC GUIDELINES FOR STRATEGIC PLANNING OF TSETSE AND TRYPANOSOMIASIS CONTROL IN WEST AFRICA

A PAAT INFORMATION SERVICE PUBLICATION

Abstract

This paper seeks to address the issue of how to integrate economic criteria into the strategic planning process for tsetse and trypanosomiasis control in West Africa. Brent Swallow's paper (PAAT, 2000) on the impacts of trypanosomiasis on African agriculture is taken as a starting point. This has provided both an excellent summary and a discussion of the current state of knowledge on the economic impact of trypanosomiasis on livestock and of its wider impacts on agriculture.

First, the methodological issues involved in the economic appraisal of potential projects to control the disease are discussed in some detail here. The various approaches can have profound implications for the type of strategy adopted. This discussion is particularly timely in the light of the current Pan-African initiatives, which reveal a need both for the wider scientific community and for planners to understand the implications for policy- and decision-making of the economic techniques used. One of these is "discounting". The literature on the economic appraisal of livestock projects universally advocates putting some value on the use of money over time, reflecting its opportunity cost in terms of resources diverted from other projects and the need to fix some minimum acceptable rate of return on public and private investments. The use of "discount" rates is thus recommended here, while applying low discount rates in the examples used, so as to lessen the effect of deflating benefits occurring in the distant future as compared to present costs. The terms of reference for this work were to produce economic guidelines for planners in the tsetse and trypanosomiasis field. Accordingly, it is argued that in the current institutional context, each individual project or zone should be the subject of a separate benefit–cost analysis. This ensures that a project is assessed on its own merits, not on

its possible technical contribution to a potential continent-wide programme. This again is part of sound economic practice and also reflects current policy on dealing with the disease.

The setting out of benefits and costs according to the rules of partial analysis is explained for the case of tsetse and trypanosomiasis control. In particular, it is important to incorporate farmers' current strategies for controlling the disease in the economic analysis. Studies have shown that in many areas their use of trypanocides is effective; this means that a proportion of disease losses are already being successfully avoided. The benefits from introducing tsetse control in such situations would not be the elimination of all possible losses due to trypanosomiasis, but would consist of savings in the use of trypanocides plus a further reduction in the losses due to the disease. A dynamic herd model, which includes animal traction among herd outputs, is used to simulate the benefits and costs of tsetse eradication, trypanocide use, and the switch from one to the other. This implies that farmers' current strategy of targeting productive animals brings high returns. Enabling farmers to reinforce their efforts by implementing low-cost tsetse control would also bring very high returns. Where technically feasible, area-wide tsetse control or localized eradication becomes more profitable if sufficiently large cattle populations exist to make up the "benefit units" per km^2 and where there is evidence of drug resistance.

Second, from this discussion on methodology, it is argued that there is a need for planners to adopt a standardized and transparent approach for assessing tsetse and trypanosomiasis control schemes. The approach used would itself need to be cost-effective. It would need to use a standard methodology to produce consistently calculated results that could be used for ranking and priority setting. In this context there is an urgent need for updated and fully comparable costings on the various forms of tsetse control. To be of use in project planning, these costings would need to be applicable to West Africa and a standardized approach, which includes overheads, would need to be adopted.

Third, this paper tries to complement the GIS work on the spatial distribution of the factors influencing the economics of trypanosomiasis in livestock and their expected changes over time. The dynamics of benefits and costs over time are examined, especially in relation to the densities of human and cattle populations. A conceptual model shows tsetse control costs falling with rising human populations. Benefits, however, initially rise and then peak when mixed farming is well established but tsetse challenge persists. Lastly, benefits tend to fall when human populations rise to a level where the fly's habitat becomes eroded and/or high cropping intensity means that fewer cattle are kept. This points to the existence of two turning points in the economics of area-wide, long-term tsetse control or elimination: below a certain cattle or human population density there are insufficient benefit units to make it profitable; above a certain human population density fly challenge is reduced, losses due to the disease decline, and cattle numbers may also be lower as the amount of grazing land is reduced. This model is used to characterize situations where controlling the disease may or may not be profitable. These situations and the profitability limits, or turning points identified, coincide to a large extent with those emerging from the GIS priority-setting exercises. The two approaches thus very much complement each other, suggesting that the economic appraisals should focus on those zones that emerge as priority areas from the GIS filtering process. Following this, the tsetse and trypanosomiasis situation in the areas identified can be studied, using sound economic methods to investigate how different interventions can improve on what the farmers are already doing, how they can involve farmers and how they fit into the broad sweep of development in that area.

Contents

Acknowledgements

The author would like to thank FAO for commissioning this work, in particular Prof. Raffaele Mattioli for his encouragement and support, as well as other friends and colleagues for taking the time to discuss the issues involved, especially Dr David Bourn for allowing the author access to his working library and for his editorial comments, and Dr Issa Sidibe and Dr Victorin Codjia for providing the author with up-to-date price information.

Acronyms

BCR	Benefit–Cost ratio
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CIRDES	Centre International de Recherche-Développement sur L'Élevage en Zone Subhumide
DFID	Department for International Development, UK
ERGO	Environmental Research Group Oxford
EMVT	Elevage et Médecine Véterinaire (CIRAD-EMVT)
FAO	Food and Agriculture Organization of the United Nations
FITCA	Farming in Tsetse Controlled Areas (project covering Ethiopia, Kenya, Tanzania and Uganda)
GIS	Geographic Information Systems
IAEA	International Atomic Energy Agency
IIED	International Institute for Environment and Development
ILCA	International Livestock Centre for Africa, Addis Ababa, Ethiopia (now ILRI)
ILRAD	International Laboratory for Research on Animal Diseases (now ILRI)
ILRI	International Livestock Research Institute, Kenya and Ethiopia
IRR	Internal Rate of Return
ISCTRC	International Scientific Council for Trypanosomiasis Research and Control

ITC	International Trypanotolerance Centre
NGO	Non-Governmental Organization
NPV	Net Present Value
OAU/STRC	Organization of African Unity – Scientific, Technical and Research Commission
PAAT	Programme against African Trypanosomiasis
PAATIS	PAAT Information Service
PATTEC	Pan-African Tsetse and Trypanosomosis Eradication Campaign
PLA	Participatory Learning and Action
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
RTTCP	Regional Tsetse and Trypanosomiasis Control Project (covering Malawi, Mozambique, Zambia and Zimbabwe)
SAT	Sequential Aerosol Technique
SIT	Sterile Insect Technique
SITE	Method for project analysis based on Socio-economic, Institutional, Technical and Environmental criteria
US$	United States Dollar
WHO	World Health Organization

Chapter 1

Introduction

> One result of the analysis is that it is not so much the costs of tsetse and trypanosomiasis control but the benefits from animal production which determine the overall economics of any approach. Another result is that the relative economic preferential of the different approaches changes according to their natural potential, the trypanosomiasis challenge and other specific characteristics of an area. This is in contrast with the common strategy of rolling up the country irrespective of differing conditions.
>
> Hans Jahnke, 1974

> The sparsity of literature citations in this chapter is an indication of how little work has been done on the economics of trypanosomiasis control. Ten years ago even this incomplete account could not have been written. There is an urgent need for more hard facts.
>
> Tony Jordan, 1986

> Empirical evidence that has accumulated during the last ten years supports previous claims that trypanosomiasis is an important constraint on agricultural production in Africa.
>
> Brent Swallow, PAAT, 2000

It is three decades since the publication of Hans Jahnke's thesis in 1974, which was the first detailed study of the economics of trypanosomiasis in livestock in a particular area. Work in this area only took off slowly thereafter, as evidenced by the quote above from Jordan (1986), but during the last ten to fifteen years knowledge in this area has grown immensely (Swallow in PAAT, 2000). In recent years a significant volume of work has come to fruition, which has greatly enhanced our understanding both of the spatial distribution of the tsetse and trypanosomiasis problem through the use of GIS techniques, and of its socio-economic impact on livestock keepers and farmers in many parts of Africa. There is now an established and wide-ranging literature on the subject, which was reviewed and summarized by Swallow in PAAT (2000). There have been a number of studies which have tried to quantify the overall impact of the disease on a continental scale (Kristjanson et al., 1999; PAAT, 2000) and the review by Budd (1999) in particular has led to a revisiting of the concept of tsetse eradication. In addition to Swallow's paper (PAAT, 2000), two other papers in the PAAT Technical and Scientific Series deal first with the sociocultural aspects of livestock and agricultural systems of tsetse-infested areas in West Africa by Kamuanga (PAAT, 2003) and second with the use of GIS techniques to identify and select potential areas for tsetse control in West Africa by Hendrickx, de la Rocque and Mattioli (PAAT, in prep.).

The terms of reference for this paper were to review the economics of tsetse and trypanosomiasis control or eradication and to formulate economic guidelines for strategic planning in this field. This paper thus complements the studies cited above by approaching the problem more from the point of view of the economic methodology and going on to try to identify the key factors that influence the economics of the various measures used to control this disease. This means leaving aside some of the important issues which are often discussed along with the economic aspects, such as land-use issues, and how community participation and public/private good considerations can influence costs and sustainability. Again, in order to fit within its terms of reference, the paper does not include detailed discussion and comparison of the costs and sustainability of various methods of controlling tsetse – although more work on this subject is urgently needed. This paper also does not deal directly with the options for controlling sleeping sickness, which in many cases is not a major factor in the areas being studied. The reader is referred to WHO (1998), Cattand, Jannin and Lucas (2001), and Shaw and Cattand

(2001) for background on the economics of controlling sleeping sickness. There are three main areas that need to be addressed:

- determination of an appropriate analytical framework, this is a prerequisite for addressing the economic issues;
- identification of the key elements which make up the costs and benefits of interventions to control this disease;
- characterization of the situations where the different types of tsetse and trypanosomiasis control interventions are likely to be economically profitable – the purpose of the exercise.

Chapter 2

Current knowledge on the economics of tsetse and trypanosomiasis control

As outlined above, there is now an established body of knowledge about the economics of the tsetse and trypanosomiasis problem based on careful field work spanning the continent. Most of this has been very ably summarized in Brent Swallow's position paper for PAAT (PAAT, 2000), which concentrates on attempts to quantify the impact of the disease in economic terms. In particular, this paper provides a summary of the data that has been collected in the course of studies over the past two decades about the effects of trypanosomiasis on cattle production parameters (mortality, fertility, milk yield and draught performance) and discusses the methods used to collect this data. Two earlier reviews (Itty, 1991; Tacher et al., 1998) included more of the earlier studies and also covered benefit–cost studies. The most significant study to appear since Swallow's review is the socio-economic volume of the three-volume study produced in 2000 by the Regional Tsetse and Trypanosomiasis Control Project (RTTCP). This volume (Doran, 2000) is based on socio-economic surveys and studies done in all four RTTCP countries, and concludes: "The evidence available from these studies suggests that the continued use of trypanocides to control the disease is the most sustainable and transferable option available at present for Malawi, Mozambique and Zambia. In Zimbabwe, the logical strategy is to hold the target barrier which prevents the re-invasion of tsetse flies from neighbouring countries." The socio-economic study is based on a cost-effective and reproducible methodology and the survey questionnaires are included.

To the continent-wide studies reviewed by Swallow (Jahnke et al., 1988; Kristjanson et al., 1999; Gilbert et al., 2001) is added Budd's analysis of the potential benefits of tsetse eradication (Budd, 1999). This built on the suggestion made in Swallow's paper (PAAT, 2000) of using estimated elasticities which measure the change in total agricultural output occurring in response to a change in livestock numbers. This was used as a basis for capturing the likely indirect benefits to agriculture from the increase in cattle numbers that would be possible in a tsetse-free Africa. The other insight provided by Budd (1999) was an investigation of the economies of scale arising from very large tsetse control schemes due, not just to the usual factors that make for economies of scale, but also to an effect specific to tsetse clearance, that of needing less expenditure per km^2 on barriers to protect from re-invasion. Once the benefits were taken into account, the effect of these economies of scale was that the highest benefit–cost ratios were achieved, on the one hand by the very large projects (due to economies of scale), and on the other by the very small projects (which targeted problem areas and had high cattle population densities). The use of GIS systems (PAAT, in prep.), and specifically of PAATIS has made it possible to be more precise about the potential increase in cattle populations which might follow from the removal of tsetse flies (Gilbert et al., 2001).

These continent-wide studies clearly provide support for the many statements made over the years about the disease's impact and its importance in constraining development (e.g. MacLennan, 1980; Jordan, 1986; PAAT, 2000). This view is reinforced by the results of most of the project evaluations undertaken which have included a benefit–cost analysis. A full review of the many benefit–cost analyses undertaken is outside the scope of this paper. To list just a few (Putt et al., 1980; Brandl, 1988a; Putt et al., 1989; Shaw, Zessin and Münstermann, 1994; Blanc, Le Gall and Cuisance, 1995; Woudyalew et al., 1999; RTTCP, 1999), these typically come up with benefit–cost ratios between 2:1 and

5:1, using discount rates of 10 percent or more (see the section "Time value of money", page 11). The studies undertaken have included both appraisals or ex ante studies, which look ahead to try and estimate the potential benefits and/or costs of a project and evaluations or ex post studies, which examine the profitability of work that has already been undertaken. The continent-wide studies are, of necessity, all ex ante estimations of what the effects of controlling the disease throughout Africa might be.

The relative cost-effectiveness of the many approaches towards controlling tsetse and trypanosomiasis has also been looked at for many situations, the most comprehensive study to date being Barrett (1997). The costing out of different approaches towards controlling the disease has also been incorporated into most of the benefit–cost studies cited above. Thus, a hierarchy of costs has evolved – how this can be interpreted is discussed in Chapter 4, in the section "Cost side considerations", page 27.

We are, thus, in the happy position of trying to control a disease that everyone agrees is sufficiently important for virtually any intervention to be beneficial. However, there are some "clouds" on this horizon. First, most writers on the subject have identified situations where certain interventions are economically unjustifiable (and often also technically infeasible), for example tsetse control is less profitable where cattle and human populations are very low, since there are few units to build benefits on and keeping such an area free of tsetse is relatively more expensive. Second, the situation is changing over time, with expanding human and animal populations reducing the fly's habitat. This means that in some areas the problem is self-limiting, as originally stated by Nash (1948) and discussed in Bourn et al. (2001) and Reid et al. (1999). Third, the farmers themselves are not passive players in this game and they have developed strategies for dealing with the disease; it is only recently that we have achieved a better understanding of what these strategies are (Pokou, Swallow and Kamuanga, 1998; CIRDES, ILRI and ITC, 2000; Doran, 2000; Kamuanga et al., 2001a).

What is needed, then, is a generally accepted and consistently applied methodology for assessing the economics of controlling the tsetse and trypanosomiasis problem, with a view to establishing an economic "filter" or screening process, which, in an analogous manner to the GIS filters:

- makes it possible to reject control options or areas where interventions are not profitable;
- identifies situations where interventions could be profitable but depend on a number of uncertain factors; and
- flags up those situations where it is clear that a certain control strategy is highly cost-effective and has significant benefits to offer to livestock keepers and farmers – these would be the priority areas.

Chapter 3

Basic economic principles governing project appraisal and evaluation

Traditionally, the economic analysis of a project has been undertaken last in a series of studies covering the technical, institutional-organizational-managerial, social, commercial-marketing and financial aspects (Gittinger, 1982). For the tsetse and trypanosomiasis problem, this approach has recently been formalized with the development of SITE analysis (Doran and Van den Bossche, 2000); SITE is a process for screening strategy options by the four criteria on which the acronym is based:

- Socio-economic
- Institutional
- Technical
- Environmental.

The various options for intervention are then scored and ranked according to these criteria, and conflicts between the results for the different criteria explored. The remit of this paper obviously falls within the socio-economic component. There are a variety of techniques for analysing the economics of interventions in the field of agriculture and livestock production, which have been summarized in the animal health context by Rushton, Thornton and Otte (1999), the possible approaches are also discussed, with specific reference to parasitic diseases of livestock, in Perry and Randolph (1999). The technique that has been most used in the past, and which is favoured by many of the authors in Perry (1999) is some form of social benefit–cost analysis. This can be underpinned as appropriate by the use of a herd model simulating output from the livestock population with the project being implemented and consequently with improved production parameters, and comparing this to the situation in the absence of the project. Integrating epidemiological with economic models is also very helpful, particularly for a vector-borne disease such as trypanosomiasis (see McDermott and Coleman, 2001). Perry and Randolph (1999) emphasize the need to:

- "integrate the products of good epidemiological studies into economic frameworks";
- "integrate techniques for economic analysis and simulation models of animal production and health dynamics within a systems framework".

Published textbooks on the evaluation of animal health programmes, such as Putt et al. (1987) and Dijkhuizen and Morris (1997) also support this approach. It remains the most practical tool for analysing and ranking projects according to the relationship between their costs and their expected impact.

At this stage it is appropriate briefly to review some of the main techniques used in benefit–cost analysis which are particularly relevant in the field of tsetse and trypanosomiasis control. The main steps in benefit–cost analysis are:

- quantifying the expected benefits of an intervention over time;
- quantifying the expected costs of an intervention over time;
- comparing these, coming up with a standard measure (net present value, benefit–cost ratio or internal rate of return) that makes it possible to
  - assess the intervention's profitability
  - compare it, or rank it against other possible interventions with which it is competing for funds or which are alternatives for development in the same production sector;
- undertaking sensitivity analyses to examine how sensitive the result is to changes in key assumptions, such as the effectiveness of the disease-control measures, the rate of

adoption of an animal health intervention or the growth of human and livestock populations in the project area.

Social benefit–cost analysis studies the effect of an intervention, usually described as a project, on society as a whole, so it takes into account all the benefits and all the costs, regardless of who spends the money or to whom the benefits accrue. In the tsetse and trypanosomiasis field the benefits tend mostly to accrue to livestock and crop farmers, while the expenditures are usually shared between donors, government and local farmers. While many analyses focus on the total social costs and benefits, increasingly, studies are looking at the effect of interventions from the financial viewpoint of the livestock keepers. Thus, the studies by Woudyalew et al. (1999) and Blanc, Le Gall and Cuisance (1995) calculate benefit–cost ratios from the farmer's point of view. New ways of modelling benefits at farm level are also being developed (McDermott, Coleman and Randolph, 2003).

TIME VALUE OF MONEY

A key principle underlying the benefit–cost approach is assigning a lower weighting to future income/expenditure as against current income/expenditure.[1] The rationale for this can be presented in a number of ways.

- Using money has an opportunity cost, which banks acknowledge by paying interest to customers for using their money, and charging it when customers borrow the bank's money; in the public sector this opportunity cost exists because projects are competing for scarce public funds and allocating money to one project within a sector usually takes it away from an alternative use.
- In this case, we should select projects which provide a good return on money invested, as measured by the compound

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[1] This weighting is completely independent of inflation accounting, and applies to sums of money calculated at constant prices; readers should be aware of a common tendency to confuse the two processes.

interest which the benefits add to the costs over time.

- Finally, society places a relative valuation on present as against future income; this is the social time preference rate. This rate tends to be high in poor societies where current needs are urgent, and lower in wealthy societies where the future is more secure.

In benefit–cost analysis this relative weighting of present as against future income (the implied interest rate or minimum acceptable return on money invested) is undertaken by using a process called discounting. This process is not just applied in commercial business ventures, but is an integral part of the project analysis process in public sector projects in all areas (see Gittinger, 1982 on agricultural project analysis; Drummond et al., 1997 for human health projects; Putt et al., 1987; Dijkhuizen and Morris, 1997; Rushton, Thornton and Otte, 1999 for animal health projects and discussion in Kristjanson et al., 1999). Discount rates used in agricultural and livestock analysis generally range from 8 percent to 15 percent, and in the field of human health they range from 3 percent to 5 percent (Acharya and Murray, 1997). With the exception of Budd (1999), whose objective was to present the global magnitudes involved rather than undertake an analysis over time, the economic studies of the trypanosomiasis problem cited above, have applied discount rates of 8 percent or over in their analyses. Since the use of discount rates penalizes future benefits as against present costs, the use of high discount rates has been debated in projects that are expected to have very long-term benefits or many “intangible” benefits that are difficult to quantify, in particular in the field of the eradication of infectious diseases in humans (Acharya and Murray, 1997). The authors conclude that it can sometimes be argued that the selection of human diseases for eradication should be undertaken without discounting using other, very stringent, criteria, and that a proportion of global health funding be set aside for this purpose. Nevertheless, costs should be discounted in order to select the most cost-effective options. However, other writers, even in the field of human health, conclude “technically and theoretically there are good reasons for discounting benefits as well” (as costs) and “discounting health benefits has been advocated as good economic practice in all guidelines on economic evaluation” (Glydmark and Alban, 1997).

As a consequence, it is recommended here that, when dealing with a disease which:

- mainly affects livestock and agricultural production, and
- occurs in a continent where there are huge and urgent alternative demands on finance,

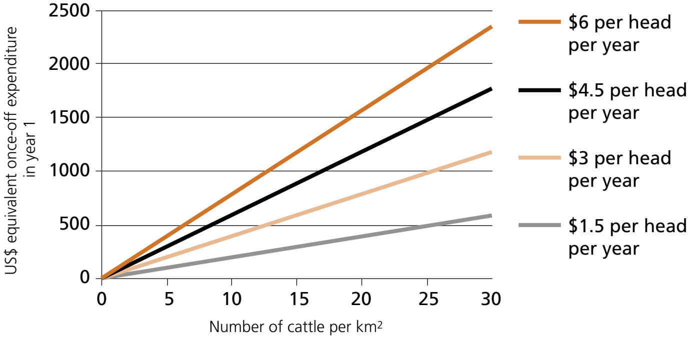
we maintain the convention of using discount rates. In view of the inclusion of tsetse elimination, which would have very long-term benefits, among the options for dealing with trypanosomiasis, the discount rate used in the analysis below was 5 percent rather than the 10 percent which would more usually be applied in the livestock sector.

Discounting has important implications in comparing control and eradication options. This is particularly so in the field of tsetse control where some techniques, such as targets or ground spraying, can be used for either control or eradication. Furthermore, eradicated areas may need to be treated repeatedly because of re-invasion or failure to completely eliminate a tsetse population.

Figure 1 illustrates some of the implications that discounting has for decision-making on options for tsetse and trypanosomiasis control. In this figure, annually recurring expenditures over 20 years are compared to once-off expenditures incurred at the start of a 20-year period. The example used is of expenditures on trypanocides, which are costed at US$1.50 a dose, and then multiplied by the number of cattle per km^2, in order to obtain an annual total cost per km^2 at different cattle population densities. The once-off expenditures could equally well refer to annual recurrent expenditure on tsetse control, for example using pour-ons.

The figures on the y-axis show what the equivalent amount

FIGURE 1
Comparing annual to once-off expenditure



Note: Calculated over 20 years at a 5% discount rate

spent per km^2 at the beginning of the period would be. Thus, at about 20 cattle per km^2, an annual expenditure of US$6, or four doses of trypanocide, would be equivalent to an initial outlay on tsetse elimination of US$1 500 per km^2. If tsetse elimination cost less than this, it would be the more attractive option, however if it cost more, a very clear argument would need to be presented to show that it was economically justified. Obviously this model simplifies the situation, for example:

- it does not take into account the fact that the cattle population might be increasing during the period;
- it only looks at cost-effectiveness, implying that the two options have equivalent benefits over time, whereas tsetse clearance may be subject to re-invasion, annual control usually does not totally remove the effects of disease, drug resistance can gradually appear;
- it is based on a 20-year time horizon;
- it assumes that tsetse clearance is a once-off expenditure occurring in year one of the project, whereas it may take several years to achieve and be followed by some ongoing

annual costs, for example the cost of barriers.

All of these factors could easily be taken into account in a comprehensive benefit–cost analysis, in particular the changes in cattle populations can be tackled using a herd model as outlined below.

Despite these limitations, the analysis is useful in illustrating the basic nature of some of the decisions which have to be made in the field of tsetse and trypanosomiasis control. Similar graphs could be constructed to show:

- the annual benefit per head of cattle which would be needed in order to justify a certain initial outlay on tsetse clearance – again using Figure 1, it implies that if the benefit is expected to be of the order of US$6 per year, the average cattle population per km^2 would have to be about 12.5 in order to justify a once-off expenditure of US$1 000 on tsetse clearance;
- the level of annual expenditure on tsetse suppression for which it would be more economic, if feasible, to switch to tsetse clearance – for example, if suppression costs US$30 per km^2, this would be equivalent to a once-off expenditure of just under US$400 per km^2; if suppression were deemed to be only 50 percent as effective in controlling the disease as permanent clearance, this figure could be adjusted to just under US$800 (400/0.5).

THRESHOLD VALUES

In economics, as in other disciplines, it is often useful for the decision-maker to be able to define threshold values or cut-off points, above which a certain decision is appropriate and below which another becomes valid. In economic and financial decision-making these are often referred to as break-even points. They define the point at which a project "breaks even", meaning that above this point the benefits exceed the costs; below this point the costs exceed the benefits. In the same way that the cut-off point for a diagnostic test can be adjusted to make it either more specific or more sensitive, in economics, the cut-off discount rate chosen can make it possible to give different weights to long-term benefits as against current costs. Also, as in other disciplines, the threshold value has to be interpreted by the decision-maker, and may often consist of a range of values within which it is felt that the result is doubtful. In project appraisal, these “doubtful” projects, are those which should be put at the “bottom of the pile” and only looked at when no better alternatives are found or when circumstances change, such as their score on another of the SITE criteria.

The threshold concept is particularly helpful in assessing the economic viability of different tsetse and trypanosomiasis control schemes. Some of the thresholds are:

- cattle population density at the start of a programme (as seen in Figure 1 this determines benefit levels and cost levels for “per head of cattle” control methods such as trypanocides and pour-ons);
- human population density at the start of the programme (influencing fly habitat and also helping determine benefit units, for example the potential for using draught power);
- for each area the cost of once-off tsetse clearance plus the ongoing cost of barriers, weighted by the risk of needing to re-treat the area;
- the cost of the technically feasible ongoing tsetse suppression techniques.

These thresholds can be defined with some accuracy for a particular area or region with similar areas – but as everyone who has worked on the tsetse and trypanosomiasis problem knows, generalizing is very difficult. There are other criteria to be included, in particular human and livestock population pressure in neighbouring areas. It should be noted at this stage that on the benefit side these thresholds are, to all intents and purposes, the

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[2] The two other standard measures can be used for ranking projects in this field but have some drawbacks: the Net Present Value (NPV) reflects project size as well as profitability and the Internal Rate of Return (IRR) has mathematical limitations which mean that, in particular, control using trypanocides can easily produce exaggerated IRRs of over 300 percent.

same ones that are used in the GIS filtering process in order to identify promising areas for intervention (e.g. Gilbert et al., 2001; Hendrickx, 2001; Hendrickx et al., 1999; PAAT, in prep.).

To complete this filtering process, benefit–cost analysis adds the possibility of summarizing much of this information in a single measure. The most practical for the purposes of this analysis is the benefit–cost ratio (BCR),[2] which is expressed as:

$$\frac{\text{sum of all discounted benefits over the time span considered}}{\text{sum of all discounted costs over the time span considered}}$$

Benefit–cost ratios have the added advantage that they can easily be adjusted from the above measure, which calculates the return on all monies invested, to measures that analyse the return to different groups such as farmers, livestock keepers or to investment, research, etc.

The following sections discuss how the information above can be treated to produce realistic and consistent estimates on the impact of the disease over time and in response to various interventions.

PARTIAL ANALYSIS – DEFINING THE “WITH” AND “WITHOUT” SCENARIOS

The basic tool used in farm management in order to quantify the costs and benefits of a proposed modification to the production system is partial analysis, which is also sometimes called partial budgeting. It provides a useful framework for categorizing benefits and costs, and when the framework is completed it acts as a checklist, which applies particularly well to disease-control interventions (e.g. Putt et al, 1987; Dijkhuizen and Morris, 1997; Rushton, Thornton and Otte, 1999).

For trypanosomiasis the main items to be included under the four headings that comprise the partial analysis framework are shown in Table 1.

TABLE 1
Partial analysis for tsetse and trypanosomiasis interventions

Costs	Benefits
a) Extra costs	c) Extra revenue
Extra cost of implementing the proposed intervention: • chemo-prophylaxis • use of pour-ons • traps and targets • ground-spraying, SAT, SIT, other forms of vector control. Extra costs associated with an increase in livestock production (more animals) and productivity.	Output from herd "with" intervention in place minus output from herd "without" intervention (output to include herd growth, animal traction and if possible a value for manure as well as milk and meat).
b) Revenue foregone	d) Costs saved
Negative side-effects of the chosen control strategy on land use, environment, and development of drug resistance (these are mostly difficult to quantify). Loss or reduction in a particular category of output, e.g. lowered rural meat consumption due to a reduction in emergency slaughter following from improved herd health.	Saving in trypanocide costs due to implementation of vector control options. Saving in cost of curative trypanocides if a successful preventive trypanocide regime is established.
Total costs	Total benefits

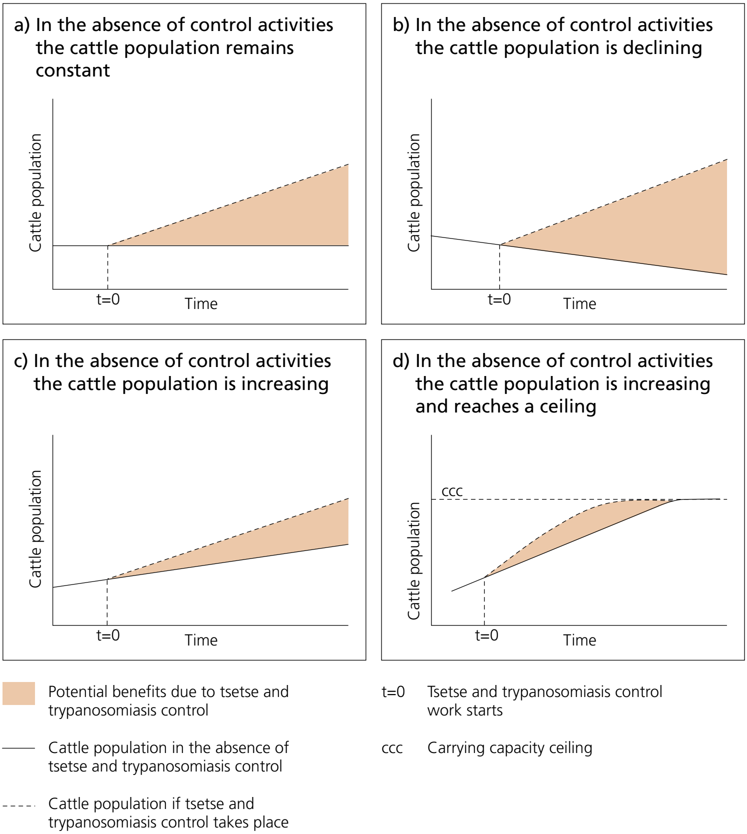
"With" and "without" project scenarios for benefits

Determining what the "with" and "without" project scenarios are is always difficult. On the benefits side, in terms of livestock productivity, it depends on studying before and after, or with disease and without disease situations, and should thus follow the same principles as an intervention trial in epidemiology. Swallow (PAAT, 2000), in his review paper, discusses the basis on which the production parameters with and without the disease were estimated in the various studies, distinguishing between the following approaches:

- longitudinal monitoring of herds, comparing parameters for individuals detected parasitaemic and those not detected parasitaemic;
- monitoring the health and productivity of cattle herds in similar areas distinguished by different levels of trypanosomiasis risk

FIGURE 2

Alternative “with” and “without” intervention scenarios for tsetse and trypanosomiasis control



a) In the absence of control activities the cattle population remains constant

b) In the absence of control activities the cattle population is declining

c) In the absence of control activities the cattle population is increasing

d) In the absence of control activities the cattle population is increasing and reaches a ceiling

or challenge;

- monitoring livestock before and after control measures were undertaken.

An analysis of these studies and discussion of the parameters obtained is outside the scope of this paper, however it will be important (see Chapter 5) to consider these issues when making recommendations on how to standardize the collection of data required for the economic analyses.

The importance of correctly assessing the "with" and "without" scenarios can be illustrated by following the series of graphs given in Figure 2. Taking the size of the cattle population as an indicator of benefit levels, Figure 2a shows the "null hypothesis" situation, i.e. that the cattle population would remain unchanged in the absence of interventions to control the tsetse and trypanosomiasis problem. This "no change" scenario is often unconsciously adopted in evaluations, forgetting that while the population growth rate might remain more or less the same for some years in the absence of interventions, the population itself is unlikely to be static.

Figure 2b illustrates the situation where interventions to control the disease yield the highest profits – where a population is declining in the absence of control, owing to the severity of the disease – but would increase if effective control measures were implemented. This was the case, for example, in the Yalé area of Burkina Faso (Kamuanga et al., 2001a) where there had been massive losses due to the disease, reflected in a huge decline in the population.

Figure 2c, however, illustrates a situation that is often encountered in West Africa's moist savannah zone, where even in the absence of interventions to control tsetse and trypanosomiasis, the cattle herds are still growing. This has been the situation in Côte d'Ivoire, due perhaps to farmers' use of trypanocides and to the presence of trypanotolerant cattle (Camus, 1981; Shaw, 1993; Pokou, Swallow and Kamuanga, 1998). A similar situation is found in parts of northern Nigeria (Shaw, 1986). In this situation, potential benefits are lower than under the previous scenarios.

Finally, Figure 2d can be seen as an extension of Figure 2c, showing what the situation would be if there were a production ceiling, usually imposed by an area's livestock carrying capacity limit, itself determined both by the quality of the natural forage and by the proportion of land taken up for farming. In this case, production under the "with" and "without" scenarios converges and the effect of disease control is to enable production from cattle to reach its ceiling earlier on. Benefits under this scenario, although lower than under the others, may still be significant.

An issue which further complicates assessments of the impact of tsetse control strategies, is the possibility of using pour-on preparations that also affect ticks, and thus produce a wider range of benefits whose impact is difficult to compare to those of other tsetse and trypanosomiasis control strategies.

This discussion has not directly mentioned the issue of cattle migration, and more specifically immigration into areas that have been cleared of tsetse. A method for dealing with this issue, which seems to work well, is to take the cattle population affected by the project as being:

- those animals present in the area at the start of the project,
- plus any animals that migrate into the area during the course of the evaluation period,

and assume that both groups benefit from improved productivity, since the immigrants presumably moved into the area because they hoped for better conditions – whether better grazing or less risk from disease. This approach produces realistic results for actual situations and can be integrated into a herd model (Putt et al., 1989; Shaw, 1990, 1993).

“With” and “without” project scenarios for costs

Identifying the “with” project costs is usually relatively straightforward, since these mainly involve direct expenditure on a new disease-control programme. However, if one of the impacts of the project is to increase livestock numbers and/or productivity, this may involve extra production costs for livestock keepers and these need to be included in the extra costs.

More difficult to assess are the “without” project costs. The main issue to consider here is “how are farmers now, and how will they continue to manage the problem of trypanosomiasis in the future?” More evidence of how they do this is slowly accumulating. CIRDES, ILRI and ITC (2000) comment on farmers’ expertise in

TABLE 2

Partial analysis for tsetse control in an area where farmers currently use trypanocides

Costs	Benefits
a) Extra costs	c) Extra revenue
Cost of the tsetse control strategy implemented. Extra costs for rearing more animals.	Output from herd under tsetse control minus output from that herd if the current use of trypanocides had continued.
b) Revenue foregone	d) Costs saved
As noted in Table 1, but difficult to quantify.	Saving in trypanocide costs due to implementation of vector control options. Reduced risk of drug resistance.
Total costs	Total benefits

“integrated disease management” and state “The strategies that livestock owners adopt for production under trypanosomiasis risk have elements that take effect over the long-term, medium-term and short-term. Choices with long-term effects, especially regarding livestock breed and type, condition choices with medium-term effects, especially regarding transhumance and use of acaricides for tsetse and tick control. Similarly, choices with long-term and medium-term effects condition choices with short-term effects, especially the use of trypanocidal drugs.” Looking at the RTTCP countries, Van den Bossche and Vale (2000) discuss the widespread use of trypanocides, and state that “preference is given to the treatment of oxen and cows, i.e. the productive animals in the herd” and Doran (2000) points out that in the surveys conducted, trypanosomiasis challenge seems to affect calving rates, but not cattle mortality rates which may be masked by the effects of curative treatment. This tendency to prioritize on cows and oxen is very sound in economic terms. Looking at the economics of traditional cattle-production systems in West Africa, most of the output by value either consists of milk and draught power or is linked to herd growth. These in turn are a function of the health of adult females and draught oxen. Thus, taking a herd model and simulating the results of removing the effects of the disease in these two groups of animals deals with around 75 percent of the losses due to trypanosomiasis in many situations.

Thus, taking into account “with” and “without” project scenarios in this way means that the relevant partial analysis framework for the introduction of tsetse control would be as given in Table 2.

In Table 2, the benefits under c) would be the added increase in output due to a switch from using drugs to tsetse control and under d) for the savings that livestock keepers would now be able to make on trypanocides. In this context, Pokou, Swallow and Kamuanga (1998) and CIRDES, ILRI and ITC (2000) did note that farmers in northern Côte d’Ivoire continued to use drugs in the tsetse suppression area, probably partly because they were not completely aware of the extent to which tsetse control has reduced risk, and partly because some risk was actually still present and animals were being sent outside the tsetse control area on seasonal transhumance. Other factors might be the usefulness of these drugs against babesiosis, and the fact that in many places, trypanocides are still among the few veterinary drugs which are widely available.

OTHER METHODOLOGICAL ISSUES

There are a number of other methodological issues in project analysis, which have relevance to the analysis of the tsetse and trypanosomiasis problem.

The distinction between financial and economic analyses should briefly be mentioned (see Gittinger, 1982 for a detailed discussion). This operates at two levels.

a) The viewpoint from which the analysis is made – an economic analysis usually embraces the benefits and costs to society as a whole, while a financial analysis tends more often to be undertaken looking at the costs and benefits to individuals, specific groups or organizations (e.g. crop farmers, livestock keepers, cattle traders, governments).
b) The prices used in the analysis – there is a convention of using “accounting” or “shadow” prices which attempt to adjust market prices so that they better reflect real resource

costs; this is particularly the case for some prices such as foreign exchange rates, or agricultural prices that are fixed by government, accounting prices have been used in looking at tsetse and trypanosomiasis control economics, for example by Jahnke (1974) and Itty (1992).

In practice, many economists end up producing a sort of "half-way house" midway between an economic analysis and a financial analysis, by making adjustments for over-valued exchange rates and taxes and subsidies while leaving most other prices at their current market values. The term "economic" tends to be used as the general term covering both approaches, and this convention is followed here. Most of the analyses conducted here are economic in the sense that they look at the benefits and costs to society rather than individual groupings, and financial in the sense that they are based on current market prices. However, as discussed at the start of Chapter 3, a number of studies have looked at the benefits and costs from the financial viewpoint of farmers and livestock keepers (Blanc, Le Gall and Cuisance, 1995; Woudyalew et al., 1999; McDermott, Coleman and Randolph, 2003). In addition, a number of studies have examined farmers' willingness to pay for tsetse control, these were studied for a West African situation by Kamuanga et al. (2001b) and the various studies were reviewed by Kamuanga in PAAT (2003).

Dealing with risk and uncertainty is obviously crucial when looking at the possible outcomes and costs of tsetse and trypanosomiasis control. Sensitivity analyses are an effective way to deal with this, by studying the effects of changes in key assumptions and seeing how sensitive the project's performance is to likely changes. As mentioned above, identifying the threshold at which a project becomes profitable, through some form of break-even analysis is another way of defining the project's limits (e.g. with respect to disease incidence in the absence of control or minimum human and cattle populations necessary to generate sufficient benefits to make the project economically feasible).

The time horizon selected is also important, especially when comparing control and eradication options, as mentioned above in the section on “Time value of money”, page 11. The figure conventionally selected in benefit–cost analyses is 20 years and this has been used in the model runs below. Sensitivity analyses looking at 30 and 40 years are desirable, particularly if eradication is being considered – however, these need to be very carefully interpreted, since looking that far ahead into the future involves considerable speculation, and the assumption that current trends will continue can be enormously misleading.

DEFINING THE PROJECT TO BE ANALYSED

Finally, against the background of discussions on huge area-wide programmes to eliminate the fly over large sections of the continent, what is the rationale for trying to prioritize and select intervention programmes to control the tsetse and trypanosomiasis problem? The terms of reference for this paper were to produce guidelines for prioritizing intervention programmes on the basis of economic criteria. In economics, decisions are made at the margin, that is by comparing the potential additional benefit from a proposed change to the likely additional costs as shown in the framework for partial analysis (see Tables 1 and 2). In looking at the tsetse and trypanosomiasis problem, it is essential that individual projects are defined, analysed and ranked using each of the SITE criteria (see beginning of Chapter 3). The size of such projects should take into account the following.

- The project must be technically feasible – the area must have a defined trypanosomiasis problem, be of a suitable size for the most cost-effective control technique (such as a fourth-level river basin for area-wide tsetse eradication, see Hendrickx, 2001; PAAT, in prep.) or the zone should be covered by a defined group capable of concerted action (such as farmers with a particular problem and outlook, a development project or an administrative or extension structure).
- Funding for the project must exist – there is no point in

analysing a project for which funds will run out half way through, since this will prejudice the outcome and render the initial appraisal invalid.

- The technical capacity to carry out the project must exist.

Thus, it is strongly argued that each individual project, of whatever size, needs to be assessed on its own merits, not, especially at this stage, for its contribution to a continent-wide super-programme. The issue of timing, in particular, is important here. It is recognized that, as stated by the PAAT Advisory Group at its 8th meeting in 2002, while we "resolve to reduce and ultimately eliminate the constraint of tsetse-transmitted trypanosomiasis in man and animals … progress towards the final objective is best achieved through concerted efforts towards intervention in a sequential fashion, with the focus on those areas where the disease impact is most severe and where control provides the greatest benefits to human health, well-being and sustainable agriculture and rural development". It follows that undertaking tsetse eradication work on the fringes of the tsetse distribution, where the tsetse habitat is already marginal, cannot be justified purely in order to accrue benefits which will only start very far in the future and in another part of the continent. However, as Chapter 4 shows, it is in some of these fringe areas in West Africa, that controlling trypanosomiasis in cattle does yield high benefits.

Chapter 4
Towards a dynamic economic theory of tsetse and trypanosomiasis control in West Africa

The epidemiology of a disease is traditionally analysed in time and space. The GIS-based analyses have provided an excellent basis for looking at spatial variables. They have also added a time dimension where they have looked at probable changes in the relevant livestock and human populations over time (e.g. Reid et al., 1999; Gilbert et al., 2001; Hendrickx, 2001). The discussion on methodology above showed how important the time frame is when comparing “with” and “without” project scenarios. Thus, from the economic point of view, there needs to be a parallel understanding of how the benefits and costs of controlling the disease evolve over time with changing human and livestock populations.

COST SIDE CONSIDERATIONS

Tsetse control

The wide range of currently available techniques for controlling tsetse will be known to most readers. Table 3 lists a selection of cost estimates made in the last decade. The most detailed study of comparable costs using different techniques was that done by Barrett (1997) based on costs in Zimbabwe and, to a lesser extent, Zambia. These have been updated to current prices by Budd (1999) and are summarized in Table 3. Figures per linear kilometre of barrier are also taken from Budd (1999). These provide an idea of the “hierarchy” of costs that might be expected – although their relative costs do, like everything else relating to tsetse and trypanosomiasis, vary from situation to situation. Recent experience in Botswana indicated that aerial spraying costs may

TABLE 3

Estimated costs of tsetse eradication or control

Technique	Costs per km^2 (US$)	Objective and location
Ground spraying[1,2]	265–315	Eradication, Zimbabwe and Zambia, flat terrain.
Targets[1,2]	220–290	
Aerial spraying[1,2] (SAT)	345–535	
Cattle treatment[1,2] (pour-on, 15 cattle per km^2)	50–120	
Linear km of barrier using targets[1]		Barrier, general, based on Zimbabwe and Zambia.
• barrier establishment	2 000	
• annual barrier maintenance	1 600	
Aerial spraying[3] (SAT)	265–275	Eradication, Botswana.
Sterile insect technique[4] (SIT)	800	Eradication, Eastern Africa.
	250–400	Eradication, Western Africa.
Low-density mono-pyramidal traps[5]	26	Annual cost of control, Côte d'Ivoire.
Cattle treatment[6] (pour-on, 44 cattle per km^2)	60	Annual cost of control, Ethiopia.

Sources:

[1] Budd (1999).

[2] Adapted from Barrett (1997), which included direct and indirect costs as explained in this text, but excluded management, administration, training, and research.

[3] Personal communication, R. Allsopp, 2002, includes full cost of insecticide and flying time, based on actual experience in Botswana.

[4] Personal communication, U. Feldmann, 2003, current estimate including all field, flying and rearing costs as well as depreciation but excluding administration and tsetse surveys, for SIT following suppression using pour-ons, targets or traps in Eastern Africa, and estimate for large-scale work in West African riverine basins, following suppression.

[5] Shaw (1993), excludes initial adaptive research phase, otherwise includes all costs, including overheads and donor inputs.

[6] Woudyalew et al. (1999), includes cost of pour-on, its application, tsetse monitoring, excludes research components.

be somewhat lower than in the estimates for Zimbabwe, with costs under US$300 per km^2, for insecticide and flying time alone (R. Allsopp, personal communication). Estimates for SIT costs range from US$250 to US$800 per km^2, depending very much on scale and local conditions (U. Feldmann, personal communication). In West Africa, an annual cost for tsetse suppression using mono-pyramidal traps at low density was US$26 (Shaw, 1993). This low figure reflects both the use of very cost-effective technology and the fact that the goal was suppression, so that traps were not serviced during the rainy season. In addition these costs are very realistic, since they include virtually all in-country overheads such as bank charges, expatriate salaries, depreciation, ongoing research and surveillance activities. This programme planned to gradually involve farmers in cost sharing and responsibility for tsetse control, with mixed results (Krüger et al., 2001). The cost of pour-ons currently ranges from around US$0.60 to US$1.50 per adult cattle dose, with prices varying from location to location, depending on the product and on whether they are sold directly to farmers or purchased in bulk by an organization. More importantly, from the cost point of view, the frequency with which cattle need to be dosed, and the number of cattle which need to be treated per km^2 varies greatly as well. The benefit–cost analysis undertaken on the pour-on trial in Ethiopia by Woudyalew et al., (1999) came up with a figure of US$60 per km^2 at 1996 price levels. Lastly, as readers will know, trypanocide prices currently also range between US$0.75 and US$2.00 a dose, depending on the type of drug and the cost of delivery.

The comparative figures given in Table 3 thus provide an initial insight into what the relative costs of the different tsetse control techniques might be. But, when interpreting these figures, it is necessary to realize that the table is not comparing like with like; to a lesser extent, however, than the comparison of “apples and oranges”, discussed in McDermott and Coleman (2001) when modelling the effects of tsetse control, trypanocide use and the potential impact of a vaccine. However, in Table 3, once-off “eradication” approaches are listed alongside annual expenditures on control. An effective comparison of these would involve using the approach described in Chapter 3, “Time value of money”, page 11, discounting all costs incurred over an appropriate time period to their present value and then weighting them by the relative effectiveness of each approach in reducing the impact of the disease.

Next, when comparing these figures, it is important to be very clear about what is included and what is excluded from these cost

FIGURE 3
Categories of tsetse control costs – included or excluded?

- Insecticide
- Flying time
- Vehicle running costs
- Salary top ups and travel allowances
- Depreciation on traps/targets/other tsetse control specific equipment
- Publicity, public awareness campaigns
- Depreciation on other equipment and vehicles
- Estimation of value of community/individual farmer labour inputs
- Access development (roads, air strips)
- Share of annual salaries for staff working on tsetse
- Specialist training
- Local/in-country administrative structure, dedicated tsetse control unit
- Tsetse surveys and mapping
- Environmental monitoring
- Expatriate salaries and project administration
- Feasibility/baseline studies
- Adaptive research
- Strategic research

estimates. Figure 3 illustrates the range of components that go to make up the full cost of tsetse control. This list may not be complete for every technique. However, it attempts to show a graduated list of cost items, ranging from those at the top – the variable, direct, field costs; to those at the bottom – the indirect, fixed costs. The items in the dark area at the top are nearly always included in costings of tsetse control, then moving down the list into the lighter area, the items listed are more and more likely to be omitted from cost estimates.

There are sound reasons for this. There has been a long tradition of including only what are called “field” or “direct” or “operational” costs when reporting costs of tsetse control per km^2. In economics these would mostly be categorized as variable costs and refer to the extra costs involved in mounting a particular control operation. These always cover the costs of insecticide, traps, targets and most of the aeroplane hire costs. Sometimes the costs of travel allowances for staff, field staff salaries and vehicle running are included. The salaries of senior staff, expatriates, of running a headquarters and of supervising the project are seldom included. Further down the list in Figure 3, mapping, monitoring and research, although costed independently are usually excluded from the per km^2 cost estimates. The reason for this is that the costs per km^2 were mainly worked out by scientists studying which of the various techniques being developed performed best in the field. The work was usually undertaken with an established tsetse control unit in the background. The existence of overheads was always acknowledged, but their relevance to field-level analyses of cost effectiveness was thought to be limited. Such costings were never designed to be used as a basis for planning large-scale operations in the absence of an existing tsetse control infrastructure.

Barrett (1997) is very clear about what has and has not been included in his costings:

- direct costs are for "primary field activity" and cover chemicals, human resources and equipment employed in the field, and relate directly to the costs of an operation;
- indirect costs "arise in secondary field activities" and cover camp and access provision, aerial spraying contractors' fixed charges, etc.;
- overhead costs consist of a share of the costs of running the tsetse and trypanosomiasis control programme (management, administration, training, surveys, research).

The figures on which the Zimbabwe and Zambia estimates in Table 3 are based include the direct and indirect costs but not overheads. Barrett thus explains that this makes it possible to compare different tsetse control strategies, but states that overheads would have to be included in order to compare tsetse control costs to controlling the disease using trypanocidal drugs. Doran (2000) gives costs for tsetse control and veterinary services in some RTTCP countries.

To look at the significance of overheads for a well-documented

West African example of tsetse eradication, in the course of their evaluation of the work in Nigeria, Putt et al. (1980) undertook a detailed analysis of the actual recorded costs of 65 spraying operations. In this analysis the field costs consisted of insecticide, labour, the direct costs of staff involved in the operation (allowances and their salaries during the spraying period), vehicle running, depreciation of equipment and helicopter flying time. A number of helpful conclusions can be drawn from the analysis.

- At the field level costs for ground spraying appeared much cheaper than helicopter spraying, this is partly because the helicopter flying charge already included quite a few fixed cost components, such as depreciation on helicopters (Barrett succeeded in adjusting for this in his analyses).
- Once all the overheads have been added, helicopter spraying appeared somewhat more expensive, but the difference had narrowed down a lot.
- The real cost per km^2 of ground spraying was four times its field cost (this was reduced to about three times, after adjusting to take into account several factors, in particular a dramatic reduction in the amount of work done during the last 2 years studied which increased the share of overheads relative to the low budget allocation for field work).

Thus, it is clear that, as well as the obvious adjustment for West African conditions, most of the eradication estimates presented in Table 3 would need considerable upward revision to include overheads before they could be used as a basis for planning the total costs of a real tsetse clearance operation. Often there are also overheads in the project preparation stage, involving applied research, pilot projects, surveys, etc. For the example of low-density trapping in Côte d'Ivoire, although the calculation per km^2 was the most comprehensive of those given in Table 3, this cost would still approximately double if the preliminary pilot adaptive research phase was included. The need to carefully consider overheads is all the greater if:

- the local institutional structure for undertaking this work does

BOX 1

Factors affecting the costs of tsetse clearance per km^2 reclaimed

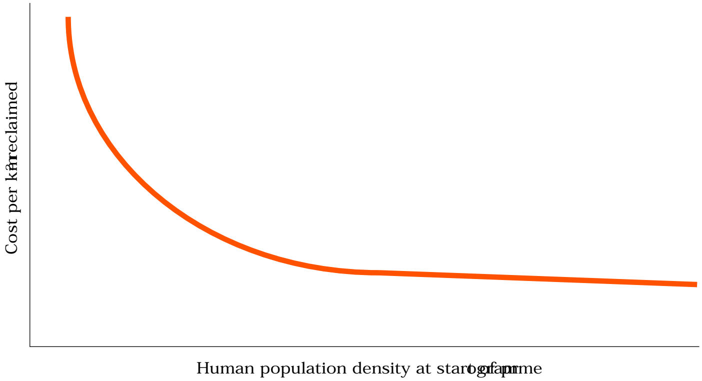
- Ecological zone – costs increase moving southward in West Africa, into areas of higher rainfall, reflecting vegetation changes, differences in the ratio between the area treated and the area reclaimed, etc.
- Terrain – costs are higher in more rugged terrain.
- Boundaries of the tsetse distribution – isolated tsetse populations can be cheaper to deal with.
- Human population density, especially for ground-based techniques – their cost is higher at lower human population densities because less land has been cleared for farming and there are fewer roads and paths so that more access provision is required. At higher human population densities costs are often lower since the fly distribution can be more patchy because of the vulnerability of savannah flies to vegetation changes, there is more local labour available to help with tasks and there is greater potential for community participation.
- Economies of scale – larger projects require proportionately fewer barriers, can make use of natural barriers and can spread the administrative and other overheads over a larger area.
- Dis-economies of scale – when they are set up large administrative super-structures add considerably to the costs of the clearance operation.
- Fly species involved – costs are generally higher for savannah and mixed infestations than for riverine flies.
- Technique chosen.

not exist (equipment is therefore needed for new offices, new field and administrative staff need to be trained, etc.);

- an international body is to be created in order to supervise and coordinate this work on an international scale.

There are important lessons to be learned here from analysing the real overheads involved in creating and running FITCA and RTTCP as well as those incurred by NGOs involved in this type of project. The potential for the existence of such “dis-economies”

FIGURE 4
Relationship between tsetse control costs and human population density



Source: Shaw (1986)

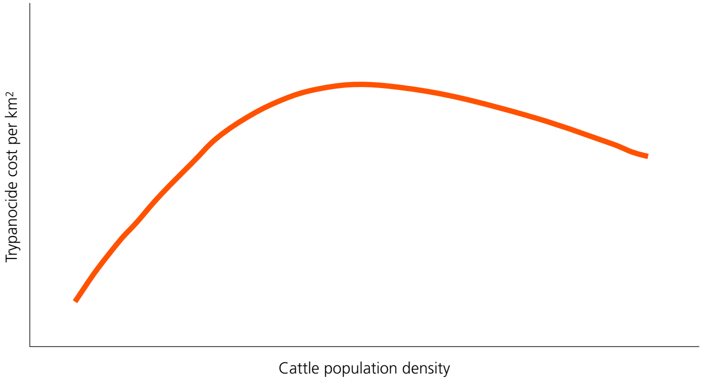
of scale due to the creation of international super-structures was discussed and recognized at a recent workshop (FAO and IAEA, 2002). These need to be balanced against the economies of scale discussed in Budd (1999). The need to find ways of avoiding incurring overheads associated with the larger scale, more top-down approaches, has been one of the main reasons for trying to develop farmer-based tsetse control methods over the last few decades.

There is thus a twofold requirement:

- to update current knowledge on tsetse control costs in the field, and do this for West African situations;
- to try to quantify likely levels of overheads associated with the different approaches.

From the discussion above, from established knowledge, and published detailed cost analyses (Barrett, 1997; Brandl, 1988b; Putt et al., 1980) the main factors that influence the costs of tsetse clearance have been summarized in Box 1. Obviously, there

FIGURE 5
Relationship between trypanocide costs and cattle population density



is variation according to the technique used, but these factors generally hold true.

In West Africa, it is likely that human population density is a key variable in determining the level of costs. A modelling exercise based on Nigerian data (Shaw, 1986) came up with a relationship such as that illustrated by the curve in Figure 4. The variables included in the GIS analysis (Hendrickx et al. 1997; PAAT, in prep.; Hendrickx, 2001) very much complement and reinforce this relationship and the selection of this parameter as a crucial one.

Trypanosomiasis control using drugs in cattle

Aspects of the use of trypanocides have been discussed in Chapter 3, "'With' and 'without' project scenarios for costs", page 21. In terms of how these costs behave, it appears that they:

- increase linearly with cattle population density (see Figure 1);
- increase with tsetse challenge (which tends to be higher at low human population densities).

In general the cattle population will increase as the human population increases, up to the point where cultivation density is such that the population of herd cattle (as against draught animals) that an area can support is reduced. Thus, the cost per km^2 of effectively controlling the disease with trypanocides could follow a curve such as that shown in Figure 5. It will increase in line with the cattle population and then could reduce slightly, as fewer doses per head of cattle would be required at high population densities, when tsetse challenge is likely to be lower. However, if drug resistance emerges over time, then the amount of trypanocide needed would increase, changing the shape of the curve, and making it time dependent. Thus, the form taken by the curve is likely to vary according to circumstances and should be modelled with respect to specific situations in order to illustrate the relationship more clearly.

Actual expenditure (as against the amount required to effectively control the disease) would depend on the extent to which cattle keepers use trypanocides, in turn reflecting their incomes, their knowledge of the disease and drug availability. As stated above, finding out about current levels of drug use and assessing what proportion of losses due to the disease are being prevented by the current use of trypanocides are crucial to understanding the economics of controlling the disease.

The issue of drug resistance and its current extent has been much debated, and falls outside the scope of this paper. Doran (2000) comments that the way in which drugs are being used in the RTTCP countries is, according to the guidelines given in Geerts and Holmes (PAAT, 1998), unlikely to cause resistance.

BENEFIT SIDE CONSIDERATIONS

As everyone who has grappled with the issue will be well aware, quantifying and analysing benefits is a far more complex issue than tackling costs. This is due to the need to integrate the following variables in any model of what level of benefits to expect:

- tsetse challenge;
- human and livestock, especially cattle, populations inside the

project area;

- human and livestock, especially cattle, populations outside the project area, a measure of land pressure in the surrounding region, and of potential immigration;
- breed of cattle likely to be affected;
- specific characteristics of the production system, i.e. crops grown, use of draught power and livestock management practices.

Techniques and approaches used in quantifying benefits

A very wide range of techniques has been used for quantifying actual or potential benefits in the economic analyses cited in Chapter 1.

Kristjanson et al. (1999) used an economic surplus model to analyse the potential benefits on a continent-wide scale if a vaccine were developed for trypanosomiasis. They looked at how demand and supply might shift in response to a greater availability of meat and milk (as calculated using a herd model) and at how this would benefit consumers and producers of these products once prices had adjusted in response to the new supply and demand situation.

As mentioned in the initial discussion in Chapter 1, the estimated elasticity[3] for the change in agricultural production with respect to a change in livestock numbers has been used by Swallow (PAAT, 2000) and Budd (1999) to estimate how agriculture would benefit from increased numbers of cattle following removal of tsetse from large areas of the continent. This attempts to capture, on a macro-economic scale, in addition to the increased output from livestock, the effect of the presence of livestock on crop farming, through greater availability of manure, use of draught animals and a more balanced portfolio of farm enterprises (crops and livestock) for

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[3] In economics, elasticity is a measure of the proportion by which one economic variable changes in response to a proportionate change in another.

farmers.

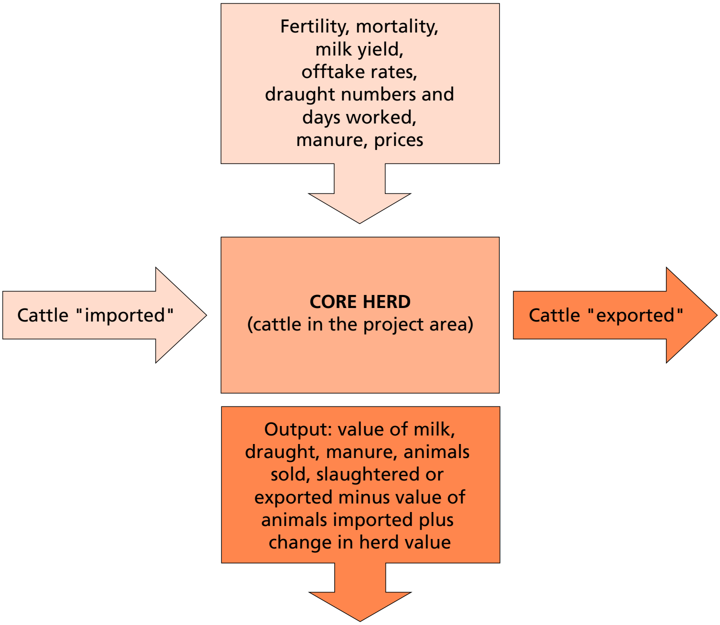
Contingent valuation saw, what was probably its first application to tropical animal health issues, through the work of Swallow and Woudyalew (1994) in Ethiopia and was used in West Africa in studies in Burkina Faso (Kamuanga et al., 2001b), Côte d'Ivoire and the Gambia which are all summarized in Kamuanga (PAAT, 2003). This technique, which has been extensively used in human health economics and environmental economics, was developed as an attempt to value goods such as human health or conservation goals by asking individuals affected by the issue what they were "willing to pay" for a specific outcome. In the field of tsetse and trypanosomiasis, a standardized approach has been developed and used to study people's willingness to contribute labour or money to actual control schemes and to see how their estimates varied over time, and were borne out by the contributions eventually made. The reader should consult PAAT (2003) for a detailed discussion of the issues involved.

The development of GIS has provided a powerful tool for identifying and prioritizing areas for tsetse and trypanosomiasis control (see, among many others, Gilbert et al., 2001; Hendrickx et al., 1999; PAAT, in prep.; Hendrickx, 1999, 2001.) The PAAT information system (PAATIS, see Gilbert et al., 2001) in particular has shown that GIS can focus on most of the issues that are essential in evaluating the economic impact of potential control and eradication schemes. It can highlight potential areas for livestock and crop development, as well as predicting tsetse distribution and identifying areas where the fly is vulnerable to habitat change (e.g. Reid et al., 1999). Indeed, much of what has come out of the GIS work is an answer to the prayers of economists and decision-makers trying to tackle the problem two or three decades ago.

The wide range of PRA and RRA techniques developed over the last 15 years have also contributed towards our understanding of the trypanosomiasis problem and farmers' and livestock-keepers' perceptions of how it affects them and how they deal with it. Techniques specific to the tsetse and trypanosomiasis problem have also been developed (Snow and Rawlings, 1999). These have made it possible to assess such situations in a structured way. They have been reinforced by the development of techniques specific to livestock keepers (e.g. IIED, 1994, 2002; Heffernan et al., 2003). The use of surveys and, in particular, recall data whereby farmers are asked to recall livestock events over a defined period, usually the last year, has been very helpful in enabling reasonably accurate information to be gathered at a moderate cost (e.g. Kamuanga et al., 2001a; Doran, 2000). When using these various tools, it is important to be aware of the strengths and weaknesses of different approaches, and of which elicit the best information in various circumstances (see Misturelli and Heffernan, 2003).

Herd models are mathematical simulations of livestock demographics, incorporating different production parameters (such as mortality and fertility rates) so as to simulate different health statuses of the populations, and thus the effects of disease, or of animal health control measures on disease. A wide range of herd models exists. These can be classified in various ways (Putt et al., 1987). They can be stochastic (incorporating values for the various parameters which follow probability distributions) or deterministic (where the variables take their average value). Static models illustrate the herd's productivity when it has reached its steady state; dynamic models trace herd output over a number of years, in response to changes such as the control of a disease. Herd models also differ in their emphasis, whether their main objective is to calculate the value of output from livestock (economic models) or whether they include a wider range of biological parameters, especially use of feed resources (bioeconomic models). The ILCA model (von Kaufman, MacIntire and Itty, 1990) is, as its name implies, a bioeconomic model, and was used in the analyses by Itty (1992), Kristjanson et al. (1999) and Woudyalew et al. (1999). Dynamic herd models have been used by Camus (1981), Habtemariam et al. (1983), Brandl (1985), RTTCP (1998) and Doran (2000) among others. Blanc, Le Gall and Cuisance (1995) used the FAO/EMVT livestock model. The Livestock

FIGURE 6
Structure of a tsetse and trypanosomiasis-specific cattle herd model



Production and Efficiency Calculator (LPEC) model produced by PAN Livestock Services at Reading University is a static bio-economic model (James, 1995). The model developed by Shaw (1986, 1990, 1992) is more simplistic in its assumptions, since it is deterministic and does not incorporate a direct link with feed resources. Nevertheless it was developed specifically to respond to the analytical requirements of the tsetse and trypanosomiasis problem and includes an option for valuing traction and manure outputs as well as milk, meat and herd growth. It attempts to combine “direct” impacts of controlling the disease on fertility, mortality and milk yield with “indirect” effects, through changes in the production of animal traction, in the number of draught animals kept, in offtake rates (sales and slaughter of animals) and in- and out-migration of animals. The way in which herd parameters change as carrying capacity ceilings are approached can be modelled by varying cattle offtake rates, to simulate animals leaving the area or being sold – the cattle “exported” function, compensating to a small extent for the lack of a bio-economic component. Alternatively, if no cattle are “exported” the effects of overgrazing could be reflected in fertility and mortality. Figure 6 illustrates the basic structure of this model.

Economic herd models such as this can be used to estimate the benefits of controlling the disease using any of the current technologies, by calculating the “extra revenue” in terms of the difference in output from the herd “with” project and from that “without” project. They can add to this any “costs saved” from a reduction in trypanocide use or the replacement of an earlier tsetse control strategy with a new approach. The model described in Figure 6 also has a benefit–cost analysis component in which the costs of a control strategy can be entered, and compared to the benefits as calculated above.

There are a number of methodological issues that are not altogether resolved. These have to do with pricing cattle, putting a value on herd increase and valuing of inputs made by livestock to agriculture. One issue is whether the value of stock adequately reflects their future ability to produce meat, milk and traction or whether these potential future impacts on agriculture should be calculated separately. Price changes to reflect the quality and weight of the animals produced are also difficult to incorporate. Another issue is how best to price manure and traction outputs. Fortunately, in many parts of West Africa herders are paid, usually in kind, for leaving their cattle on fields and thus manuring the land. There is also a hire market for animal traction. The amounts of such payments can be used in the model to approximate the value of these outputs.

In most cases these analyses of benefits have focused on cattle, their contribution to animal protein production and their impact on the rural economy. Whether or not this is justified is yet another debate. Donkeys are increasingly used for traction, while losses in small ruminants also occur. However, it seems likely that by analysing the impact of the disease on cattle a large proportion of its impact is captured.

The issue of whether or not tsetse control in itself leads to immigration by cattle herders and/or farmers has been much debated and is discussed in Swallow (PAAT, 2000). Reid and Swallow (1998) and Kamuanga et al. (2001c) found that where areas have been closed to settlement for institutional reasons (as in parts of Zimbabwe) the combination of the lifting of restrictions and tsetse clearance will lead to substantial immigration. In the areas studied in Ethiopia, some immigration pre-dated tsetse control, but there was some increase in immigration thereafter as well. However, in Burkina Faso and Côte d'Ivoire they found that migrants were not directly motivated by tsetse clearance. This supports the findings in Bourn (1983) that rates of land-use change in northern Nigeria were much the same in similar ecological zones, irrespective of whether or not tsetse clearance had taken place. Nevertheless, where new migrants or cattle keepers colonise an area and encounter tsetse, heavy losses can take place so that tsetse clearance or effective control of the disease in cattle using trypanocides can be seen as a "facilitating measure" enabling those moving into a new area to avoid heavy losses and be more productive (Kamuanga et al., 2001c). Also, in Zimbabwe Doran (2000) found that farmers moving into the cleared areas were motivated mainly by the greater availability of land and grazing, with 16 percent also mentioning the absence of tsetse. Thus, incorporating cattle immigration in the analysis can be a useful option, but allocating shares of benefits to tsetse control is less straightforward, as land shortage in other areas is a major motivator for emigration.

Another subject which has so far received limited attention is the issue of poverty and control of the tsetse and trypanosomiasis problem. Poverty-focused analyses, based on methodologies such as that developed by Heffernan et al. (2003), are needed here. Given the commitment of donor countries and African governments to the international goal of poverty elimination and the Millennium Development Goals formalized by the United Nations in 2000 (see www.developmentgoals.org) the impact of control strategies on poverty needs further analysis. As stated by Ashley, Holden and Bazeley (1999) the poor often do not benefit from livestock disease-control projects, because the benefits are captured by wealthier farmers, technologies are either not delivered or are difficult for the poor to sustain. There is, however, a growing consensus that many pastoralists can be classed as poor livestock keepers, so that any measure which reduces their vulnerability and improves their income would help reduce poverty. However, beyond this, there are a number of issues which need studying here.

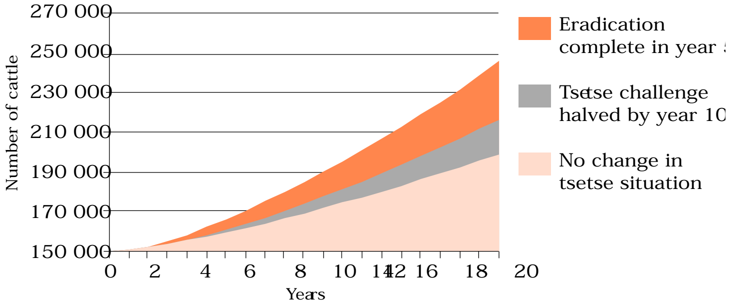
- Are trypanocides more or less accessible to the poor than other ways of controlling the disease?
- Is it possible to rank control strategies in terms of their pro-poor focus?
- Do poor people use animal traction?
- Will poor farmers benefit from the greater availability of animal inputs to agriculture?

How herd models can be used to simulate benefits over time

Figure 7 illustrates how herd models can simulate benefits over time. This is the result of a model simulation, based loosely on herds in northern Côte d'Ivoire, using production parameters from Shaw (1993) and current prices. This follows from the approach illustrated in Figure 2, this time illustrating numbers of animals as projected by the model. Three scenarios for the cattle population are analysed:

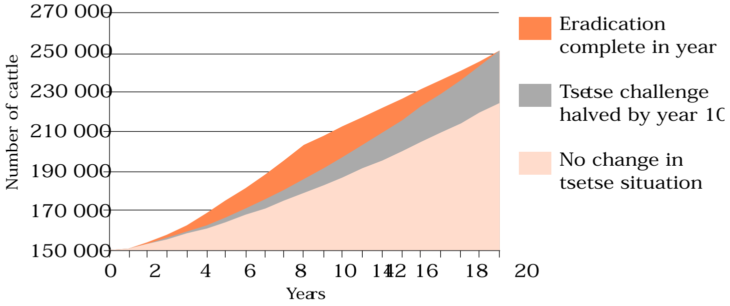
- no change in the tsetse situation, reflecting the “without project” scenario if the fly's habitat were maintained over the 20 years, with cattle population production parameters retaining their original “with trypanosomiasis” values;

FIGURE 7A
Cattle numbers with and without tsetse control



Note: Based on an area of 10 000 km^2 containing 10 cattle per km^2 at the start of the project.

FIGURE 7B
Cattle numbers subject to a carrying capacity ceiling
with and without tsetse control



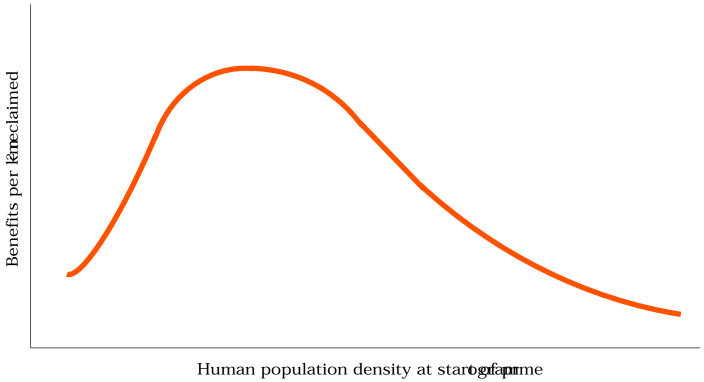
Note: Based on an area of 10 000 km^2 containing 15 cattle per km^2 at the start of the project.
Carrying capacity limit is assumed to be 25 cattle per km^2

- tsetse are autonomously disappearing, so that by year ten the effect of the disease is halved, reflecting the situation if, as shown in the Nash or Rawlings scenarios (see Reid et al., 1999; Nash 1948; Rawlings et al., 1993) human population growth was such that some tsetse populations

were reduced;
- tsetse are eradicated by year five.

In Figures 7a and 7b the potential benefits to the project, in the absence of any autonomous regression in the tsetse population, are approximated by the total of the two thin areas shaded dark orange and grey at the top of the graph. However, if tsetse are disappearing in the absence of intervention, then the area of benefit is only the small wedge at the top of the graph. This clearly illustrates how benefits are reduced (nearly halved in this case) if work to eradicate the fly simply accelerates an already ongoing process. However, this can still be highly beneficial, for example such a situation yielded high benefit–cost ratios in northern Nigeria (Putt et al., 1980). If it were assumed that tsetse would disappear altogether within the specified time horizon, the resulting reduction in benefits would be even more marked. The range of situations that could be simulated in this way is obviously very large (see below, "Results of simulations", page 50, for more examples).

FIGURE 8
Relationship between the benefits of tsetse control
and human population density



Source: Shaw (1986)

BOX 2

Factors linking the benefits from tsetse and trypanosomiasis control and changing human population density

- At low human (and cattle) population densities, although tsetse challenge is likely to be high, there are few people or livestock who will benefit from activities to control the disease, so that total benefits per km^2 are low.
- As people and their livestock colonize the area they suffer high losses, as numbers increase so potential benefits also increase.
- These benefits peak at a point when animal traction becomes fairly widely used and mixed farming is established in the area, which also sustains a substantial cattle population that benefits from the availability of crop residues.
- After a while, as the human population density increases, the savannah fly's habitat is reduced, and with its gradual disappearance tsetse challenge is reduced, also, as the area becomes more densely cultivated it may not be able to sustain the high numbers of herd cattle that it once did, so that potential benefits from controlling the disease begin to fall.

The size of the large triangle at the bottom of the graph reflects the extent to which existing herds are growing in the absence of control, in the case of the Côte d'Ivoire herds this was at over 2 percent per annum but, as illustrated in Figure 2, this is not necessarily the case.

Analysing the factors influencing the level of benefits obtained from tsetse and trypanosomiasis control

As the costs of tsetse control change with changes in human population density, so do the benefits. Figure 8 shows the curve that was derived by Shaw (1986), after modelling different categories of benefits from tsetse control, including herd cattle production, immigration by people, immigration by cattle and the

FIGURE 9
Relationship between tsetse control costs and benefits and human population density for long-term projects

Source: Shaw (1986)

Note: ▬ total discounted benefits over 20 years
▬ total discounted costs over 20 years
➡ possible turning points

use of draught cattle. The human population density at the start of the control programme is shown on the x-axis. The y-axis shows the discounted total value of benefits (valued over 20 years in this case). Thus, each point on the curve represents the telescoped sum of the potential benefits of controlling the disease over 20 years. (This is different from the approach used in Figure 7 where these were calculated on a year-by-year basis and in Figure 2 where the possible evolution of benefits over time was shown, both Figures thus tracing output obtained "with" and "without" a project over a number of years). Box 2 explains the process on which Figure 8 is based, by linking changes in human population density with potential benefits from controlling trypanosomiasis.

COMPARING BENEFITS AND COSTS

Having looked at the factors influencing the levels of costs and benefits over time and in different circumstances, the implications of comparing them, using the principles of partial analysis, need to be examined.

Basic relationships

Following on from the discussions underpinning Figures 4 and 8, the next step is to superimpose the graph for benefits on that for costs, as shown in Figure 9. This points to the likely existence of two turning points in the economics of long-term tsetse control operations:

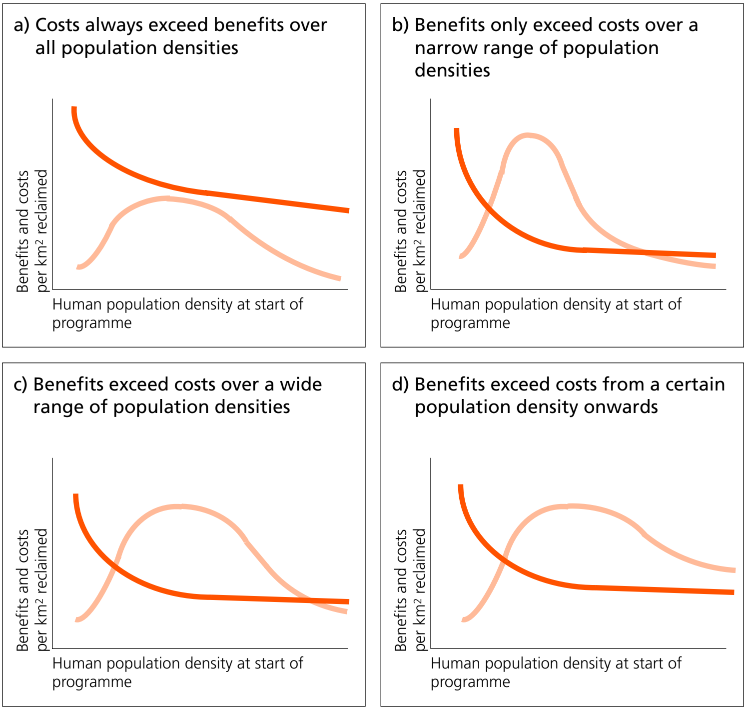
▯ when human population density and the associated cattle populations reach a critical size such that there are sufficient benefit units to justify tsetse control;

▯ when human population density has started to affect tsetse habitat so that challenge has been lowered, draught cattle numbers have reached their likely upper limit and herd cattle numbers have ceased to expand as they have reached carrying capacity limits.

However, short-term tsetse control operations may still be profitable beyond (that is to the left of) point ▯, on the assumption that they involve either lower costs and/or a shorter time period. Similarly, small-scale and much targeted control operations may sometimes be feasible beyond (that is to the right of) point ▯.

Translating this into real situations, what is implied is that in West Africa, there exists an area between these two limits where sustained control or elimination of tsetse is most likely to be profitable. The population limits are difficult to fix, and there is, as always with this disease and vector, a danger in generalizing the situation. The modelling for northern Nigeria (Shaw, 1986), based on cropping intensity and land use in the tsetse-cleared areas, indicated that the lower turning point was probably between 5 and 10 people per km^2, and the higher point between 40 and 70 people per km^2 (neatly spanning the limits proposed by Nash, 1948 and Rawlings et al., 1993, as used in Reid et al., 1999). However, although population expansion in northern Nigeria has

FIGURE 10
Variations in the relationship between costs and benefits of tsetse control over time with changing human population density



a) Costs always exceed benefits over all population densities

b) Benefits only exceed costs over a narrow range of population densities

c) Benefits exceed costs over a wide range of population densities

d) Benefits exceed costs from a certain population density onwards

Source: Shaw (1986)

Note: ▬ total discounted benefits over 20 years
▬ total discounted costs over 20 years

foreshadowed what might happen elsewhere in West Africa, this modelling exercise was undertaken some time ago, and may be fairly specific to the location and relate to somewhat more arid areas than those presently being considered. Nevertheless, it is worth recalling that Putt et al. (1980) and Bourn (1983) documented similar demographic and land-use changes in the Lafia region of the Nigerian subhumid zone.

For the purposes of the present exercise it is worth noting that:

- these turning points probably exist for most tsetse and trypanosomiasis situations;
- and, more importantly, while approaching the problem in a different way, they point to the same candidate areas as the GIS studies (Hendrickx, 2001), these being the locations in the moist savannah zone where agriculture and livestock production is expanding.

This analysis also introduces a time dimension over and above that provided by the herd model. With expanding human populations, the x-axis can be interpreted as not only showing at what starting point human population density intervention might be cost effective, but also when this is likely to be appropriate, since human populations are growing over time.

Obviously the shape and position of the curves will vary with different situations and long-term tsetse control strategies, some of these possible variations are illustrated in Figure 10.

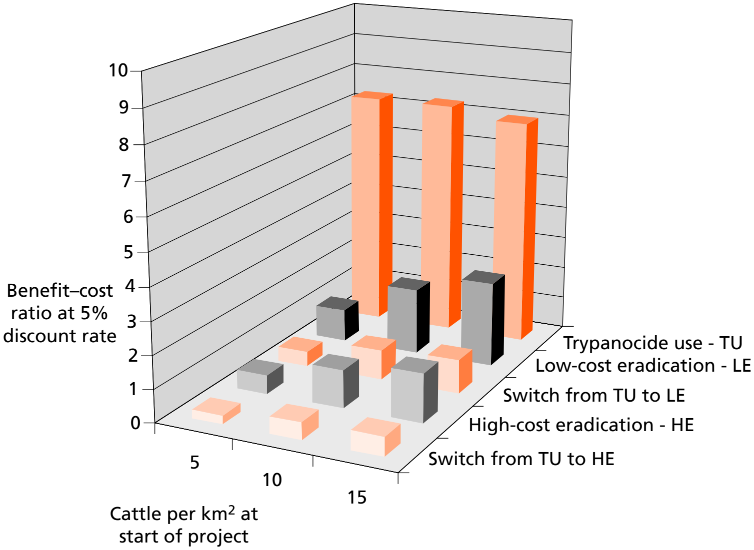
a) Some tsetse control strategies (high-cost eradication, ongoing barrier costs, an expensive control strategy) are so expensive that the costs will always exceed the benefits, or conversely the area being analysed offers little scope for rural development so that benefits will always remain lower than costs.

b) In some situations, the window of opportunity, or the range where benefits exceed costs, may be very narrow.

c) Conversely, the range where benefits exceed costs may be fairly broad.

d) Alternatively, it could be that above a certain human and livestock population density benefits always exceed costs, perhaps because without control riverine flies will remain to maintain the disease at high population densities, or because agriculture is dependent on traction and the control of the disease, or because of the presence of sleeping sickness. There would, however, need to be concrete evidence that a given area really falls into this category.

FIGURE 11A
Lower challenge situation: tsetse eradication versus trypanocide use



Note: Eradication is assumed to remove all effects of the disease from all cattle within five years, high cost is US$2 500 per km^2, low cost is only US$1 300. Trypanocide use targets cows and draught males and removes three-quarters of the disease effects from these animal categories. Trypanocide use = two doses a year for all cows and draught males, equivalent to 1 dose a year per head of the herd.
Time frame was 20 years.

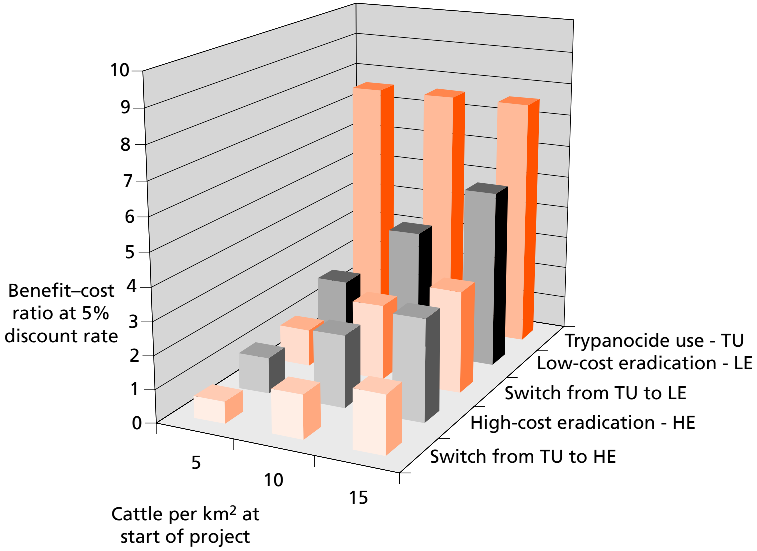
Results of simulations

To illustrate how the use of herd models in a partial analysis framework can inform some of the decisions to be made, the herd model described above in the section “How herd models can be used to simulate benefits over time”, page 43, was used in 48 runs to assess the profitability of tsetse eradication versus trypanocide use. As stated above, there are numerous possible combinations (cattle breed, starting human and livestock population densities, tsetse challenge, control strategy, time frame, etc.). Accordingly, for a hypothetical area of 10 000 km^2, this analysis covered:

- sedentary herds, with mostly taurine or crossbred zebu–

FIGURE 11B

Higher challenge situation: tsetse eradication versus trypanocide use



Note: Eradication is assumed to remove all effects of the disease from all cattle within five years, high cost is US$2 500 per km², low cost is only US$1 300. Trypanocide use targets cows and draught males and removes one-half of the disease effects from these animal categories. Trypanocide use = three doses a year for all cows and draught males, equivalent to 1.5 doses a year per head of the herd.
Time frame was 20 years.

taurine animals, loosely based on herds in northern Côte d'Ivoire;

- areas of low to medium trypanosomiasis challenge, very loosely defined;
- current prices for livestock outputs and trypanocides;
- costs of tsetse eradication and barriers as postulated by Budd (1999);
- two control strategies: the use of drugs versus tsetse eradication, with a high- and a low-cost strategy for each;
- three starting cattle population densities: 5, 10 and 15 per

km^2, with a low carrying capacity threshold of 25 per km^2.

The results of the analyses are shown in Figure 11. This analysis focused on a key issue debated by decision-makers, that of implementing tsetse eradication in areas where farmers are currently controlling the disease using trypanocides. In this context it looked at three control scenarios:

- eradication, yielding the full benefit of completely controlling all effects of the disease in a defined area;
- the likely current scenario, taking forward the discussion above in the section "How herd models can be used to simulate benefits over time", page 43, by building on the knowledge of current drug use obtained from recent studies (Blanc, Le Gall and Cuisance, 1995; CIRDES, ILRI and ITC, 2000; Doran, 2000; Kamuanga et al., 2001a; Pokou, Swallow and Kamuanga, 1998), the assumption made is that farmers treat their valuable animals (cows and draught males) methodically, thus dealing with a significant proportion of the losses;
- a partial analysis looking at the benefits of switching from targeted use of trypanocides by farmers to tsetse eradication.

A selection of the outputs produced is shown in Figure 11. This shows outcomes for different levels of challenge and different levels of trypanocide use. Obviously, the assumptions underpinning the analysis can be criticized and improved upon.

However, the results, as shown in Figures 11A and 11B clearly illustrate some important trends.

- Under all assumptions, the highest benefit–cost ratio by far was achieved by the strategy currently employed by farmers, very much endorsing the comments in Doran (2000) and CIRDES, ILRI and ITC (2000). The results were obviously very sensitive to the number of doses given, and would change if drug resistance was found to be a major problem.
- As would be expected, tsetse eradication became more profitable at higher cattle population densities, since the

number of "benefit units" was higher; and the results were very sensitive to the cost per km^2 for eradication, but the higher returns are much in line with the results obtained in other studies (Chapter 2). The cost of eradication would tend to be higher in the higher challenge area and, as discussed above at lower cattle population densities (see section on "Tsetse control", page 27).

- The results for partial analysis for undertaking eradication in an area where farmers are already treating their animals (the situation that would be encountered in much of West Africa with costs and benefits as outlined in Table 2) were very variable. For the lower challenge situation, the switch did not yield a benefit–cost ratio greater than 1.0, except for one instance (low-cost eradication replacing trypanocide use with a cattle density of 15 per km^2) where it roughly broke even (Figure 11A). For the higher challenge situation, at the two higher cattle population densities (10 and 15 per km^2) the switch was profitable, yielding benefit–cost ratios of 2.3 and 3.1 respectively for low-cost eradication and 1.3 and 1.8 for high-cost eradication (Figure 11B).

Eradication was favoured by the use of the low discount rate of 5 percent. Looking at a longer time frame of 30 or 40 years would also make eradication relatively more profitable (preliminary sensitivity analyses showed this trend clearly) but it would never reach the benefit–cost ratios achieved by trypanocide use under current conditions. The analysis assumed that barriers were required for the full 20-year period, removal of these after 10 years increased the benefit–cost ratios somewhat, by 0.25 to 0.5. There would also be additional spin-offs from controlling the vector which are not fully captured here; such as benefits for livestock species other than cattle, the potential for using upgraded livestock in some areas, and the effect of inputs to agriculture not fully captured by valuing draught power in this model. In addition, linking the analyses to epidemiological models provides further insights. This was done by McDermott and Coleman (2001). From this they derived “relative rankings of the effect control strategies on reducing disease prevalence” which “were: vector control, vaccination, and drug use, in that order”.

Nevertheless, the analysis above demonstrates yet again that farmers know what they are doing and are behaving rationally under prevailing circumstances and given the tools at their disposal. There are many other situations which could be analysed using this methodology. Two are particularly relevant in the current decision-making context.

First, the benefits and costs of cheaper tsetse control, as against eradication methods, need to be analysed in more detail in the West African context, to see which performs better. The high returns from trypanocide use reflect the fact that these drugs are the first-line intervention used to control this disease. They tend to be used in a fairly targeted way, although farmers cannot always be sure that the animals they are treating suffer from the disease. The high returns are also of a level to motivate farmers who, as private individuals in a risky environment, tend to require a higher return than would be expected from a government project. Inexpensive tsetse control technologies provide farmers with an opportunity of reinforcing their efforts to control the disease and, perhaps, of saving some money by reducing their use of trypanocides and also reducing the risk of drug resistance. Most importantly, while eradication is an option controlled by projects and governments, such tsetse control technologies are more accessible to farmers. The costs cited in Table 3 (US$26 per km^2 for suppression using traps in Côte d’Ivoire, or US$60 for using pour-ons in Ethiopia) were low, and even if expended annually would compare well with once-off eradication costs (see Chapter 3, “Time value of money”, page 11). Furthermore, to the extent that they can be applied on a small scale, or can involve the farmer, they avoid the problem of overheads discussed above in the section “Tsetse control”, page 27. As well as offering high returns, empowering farmers and supplementing their current use of trypanocides, such schemes can also be seen as a way of working in higher challenge areas or as a transition strategy to be applied in areas where the fly is vulnerable because of the erosion of its habitat. The results from Ethiopia showed a high return to farmer investment, with a benefit–cost ratio of 8.1:1, and an overall project return of 4.3:1. In the Central African Republic, the benefit–cost ratio to farmers with large herds was 5.9:1 and 3.1:1 to those with small herds (Blanc, Le Gall and Cuisance, 1995). There is a real need for more analyses of this nature, especially for West Africa.

Second, the benefits and costs of tsetse control programmes tend to be studied before programmes are undertaken and then in the decade after they started. This is largely because of the exigencies of project monitoring and evaluation, where funding exists for an initial appraisal and for an evaluation after a certain period has elapsed. While these studies have often included amongst their sensitivity analyses the implications of re-invasion or breakdown of barriers after some time, the actual economic effect of this type of breakdown in tsetse control measures has not been studied in any detail for a real situation. However, there have been many such events across the continent. Breakdowns in tsetse control schemes and re-invasion of eradicated areas are probably characterized initially by farmers suddenly finding themselves confronted with a disease problem which they were unfamiliar with or had forgotten to consider on a daily basis. There would be an interval of heavy losses, while farmers once again took up the reins of control for this disease. Examples of the effects of a sudden increase in the incidence of the disease have been studied, and could be modelled – there is also knowledge of how and when eradicated areas were re-invaded. From this an analysis of the economics of this type of scenario could be constructed and used to inform the current planning exercises. In addition, a revisiting of old tsetse control and eradication schemes and an analysis of the factors influencing their success and failure would thus be very timely.

Chapter 5

Application of a standardized methodology for appraising and evaluating projects

Much of this paper has looked at the methodology of assessing the economics of individual tsetse and trypanosomiasis control projects. Many of the studies listed here adopt a similar approach based on comparing discounted benefits and costs for "with" and "without" project scenarios, and assessing benefits using herd models. The broad similarity of the approaches used does point to there being a general consensus as to how the problem should be tackled. However, small differences in the way the problem is handled do mean that the results from different studies are difficult to compare and difficult for non-economists to assess. For this reason, it is strongly recommended that a standardized methodology be adopted for analysing the economics of tsetse and trypanosomiasis projects, which could be set out in a small booklet.

This should incorporate the following features:

- basic benefit–cost analysis methodology, including the use of an agreed discount rate;
- presenting various "with" and "without" project scenarios, using the partial analysis layout to identify benefits and costs;
- as part of this, an analysis of the strategies currently in use, usually by farmers and livestock keepers, to control the disease;
- presentation of the full costs of disease-control techniques, incorporating a standardized list from the elements listed in Figure 3, probably omitting only research and unrelated overheads;

- a dynamic cattle herd model which, as well as charting herd growth and meat and milk production, either incorporates some of the main outputs from cattle into crop farming, i.e. draught and manure, or uses another method to link growth in livestock numbers to increased output from agriculture;
- a benefit–cost analysis model, which could be linked to a herd model and which also incorporates the "costs saved" category from the partial analysis, for example the fall in trypanocide use if tsetse challenge is reduced through control measures or habitat change;
- the ability to simulate a wide range of situations and outcomes and thus deal with aspects of risk and uncertainty.

While individuals will always tend to analyse a problem using their own preferred tools, there would be great advantage in their also using a generally adopted methodology that produced comparable results. Although it would inevitably handle some situations better than others, and incorporate some biases, as long as these were acknowledged and discussed before interpreting the results, this would not invalidate its usefulness.

In order to permit some historical comparisons, since even over a few years some prices change significantly, it would be useful if the convention of noting unit prices for key components of costs and benefits was maintained. These would be for such items as trypanocides, insecticides, aircraft hire, local staff salaries, price per kg liveweight for livestock, price per litre of locally produced milk, etc.

Linked to this, but outside the scope of this paper, is the nature of the data to be collected and the methods to be used to do this (see also Chapter 4, "Techniques and approaches used in quantifying benefits", page 37). Again, there would be great advantage here in standardizing. For example, the socio-economic questionnaires appended to Doran 2000 or the approaches used in Kamuanga et al. (2001a) could be adapted for more general use. Hendrickx (1999) has outlined cost-effective ways of collecting data on the disease in cattle. A short list of essential quantitative and qualitative data items needed to “feed” the simulation model and undertake sensitivity analyses could be drawn up. The ways in which the different types of data could be collected (PRA techniques, questionnaires, trypanosomiasis surveys) and suggestions for sampling methods could also be set out. It should be clearly linked to the filtering process for priority setting that has been developed using GIS techniques.

Chapter 6

Conclusions

> There are notable exceptions to practically any general statement about tsetse flies.
>
> MacLennan, 1980

> An assessment of the nature and rate of development expected in each ecological area, regardless of the presence of tsetse and trypanosomiasis.
>
> Ford, 1971, on the requirements of sound policy

This paper has tried to cover the main methodological issues involved in the economic assessment of area-wide tsetse and trypanosomiasis control programmes. To return to the original theme, the setting up of guidelines for prioritizing projects on the basis of their economic performance, and the analyses and figures above try to illustrate what might be the general trends governing the relative profitability of different approaches towards controlling tsetse and trypanosomiasis. However, as MacLennan (1980, quoted above) and many others have found, generalizing about this disease and its vector can be dangerous, as there is inevitably a good case study to refute any statement. With this caveat in mind, for West Africa, the key questions to be asked are summarized in Box 3. A similar typology was used by Bauer and Snow (PAAT, 1999) to suggest what types of intervention were most appropriate under different tsetse challenge levels.

Given the likely existence in many areas of the two turning points for area-wide long-term control or elimination illustrated in Figure 9, the decision-making process could be something like that shown in Figure 12. This figure must be interpreted in the light of individual situations. In particular, the population densities that

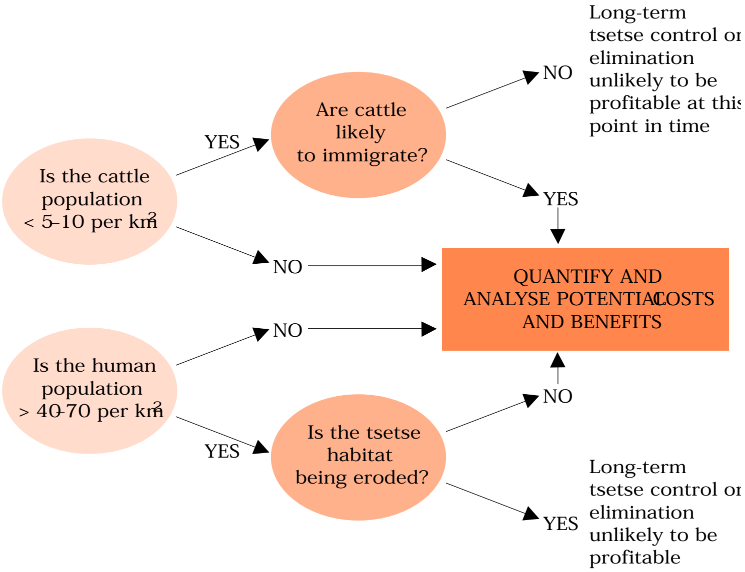
BOX 3

Key questions in assessing the likely profitability of tsetse and trypanosomiasis control strategies

- What are the current human and cattle population densities, and the population growth rates?
- Are the livestock breeds in the area trypanotolerant, or partially trypanotolerant?
- Is there likely to be immigration of people, or has there recently been such immigration?
- Is there likely to be immigration of cattle, or has there recently been such immigration?
- What are farmers currently doing to control the disease (use of trypanocides, breed choices, transhumance, other husbandry practices, use of pour-ons)?
- How much can other forms of tsetse and trypanosomiasis control add over and above this?
- Is (when is) the tsetse problem likely to diminish because of human population pressure?

define the two unprofitable “tails” of the benefit distribution (those to the left of turning point ▯ and to the right of turning point ▯) will vary from area to area, and may fall outside the range of figures given. The GIS priority-setting framework also implicitly filters out these two “tails”, and it is suggested that the logical point for a more detailed economic analysis to intervene is once the GIS-filtering process has highlighted potential priority areas, as shown in Hendrickx (2001). This still leaves a substantial number of options where such an economic analysis is required, which is why the use of a standardized methodology involving a cost-effective data collection exercise is so important (see Chapter 5). Updating estimates of tsetse control costs, including overheads is obviously one component of this. Once again, what the farmers themselves

FIGURE 12
Potential decision tree for the economic analysis of area-wide long-term tsetse control or elimination schemes



are currently doing is crucial to the assessment:

- in order to assess benefits correctly (what proportion of potential disease losses are already being prevented by farmers' actions);
- in order to gauge how acceptable the proposed control methods are and whether they would be sufficiently attractive for farmers to invest time and money in contributing to them, in particular to low-cost tsetse control options to be used by them alongside trypanocides;
- in order to investigate the implications for poor farmers and livestock keepers of any proposed interventions so as to find out if the interventions are more or less accessible to these groups and will benefit their livestock.

BOX 4
Situations where introducing tsetse control is likely to be profitable

- In newly settled areas with in-migrating farmers and cattle herders, particularly herders with trypano-susceptible breeds.
- Where tsetse have spread to a new area.
- Where mixed farming already exists and is expanding.
- Where a few isolated populations of riverine flies can be dealt with using bait technology or their numbers substantially reduced by the use of pour-ons.
- Around protected areas where tsetse persist and feed off people or animals

BOX 5
Situations where introducing area-wide long-term tsetse control or elimination is likely to be unprofitable

- Where the savannah tsetse have virtually disappeared; and/or
- people are managing the disease successfully using drugs targeting breeding females and draught animals; and/or
- there is a high proportion of trypanotolerant blood in their cattle population; and/or
- pour-ons are already being effectively used to control tsetse, in addition to controlling ticks; and/or
- where cattle and human populations are very low so that controlling the disease via the vector is premature.

These points are also important, since, as has been much debated, the tsetse control techniques available range from the high-tech, top-down techniques that require virtually no input from local farmers, to those that rely on the farmers' support and involvement. This in turn affects the existence or absence of large overheads, introduces considerable public and private good issues and has implications for long-term sustainability. These issues are outside the scope of this paper, but it is vital that they be considered at the priority-setting and strategic planning levels.

Finally, from the discussions above, it is possible to characterize the type of situations in West Africa where tsetse control in particular is likely to be economically profitable and those where long-term area-wide projects are not likely to show good returns. These are outlined in Boxes 4 and 5 respectively.

The types of situation described, and their implications for tsetse and trypanosomiasis control have long been known, as has been the need to look at development trends irrespective of the tsetse and trypanosomiasis situation before intervening (Ford, 1971). Hopefully, outlining what might be the priority areas will help to promote sound planning in the context of the area-wide proposals and higher profile currently being given to tsetse control. It is essential, however, that each situation be judged on its own merits, using sound economic methods to investigate how different interventions can improve on what the farmers are already doing, how they can involve farmers and how they fit into the broad sweep of development in that area.

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