Mapping the benefits:
developing a new decision tool for tsetse and trypanosomiasis interventions

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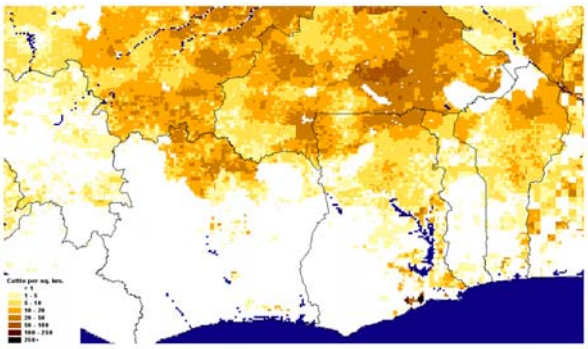
Introduction

The purpose of this study was to investigate the feasibility of linking quantitative economic variables to a geographical information system (GIS) spatial framework in order to provide new insights and reinforce the decision-making process for tsetse and trypanosomiasis (T&T) interventions. Hitherto, GIS studies have mapped a series of ecological, demographic and socio-economic indicators, but have stopped short of mapping the distribution of a derived measure quantified in monetary units. Furthermore, the economic aspects of T&T control have historically been dealt with separately from their other effects, with results usually expressed in terms of benefit–cost ratios or extra income per head of livestock. Even when they have been expressed in terms of dollars per square kilometre these results have not been mapped; instead they have been used as inputs for benefit–cost type analyses. In contrast, our approach combines – for the first time – economic herd models with mapping of both breed/production systems and the expansion of livestock populations under various scenarios.

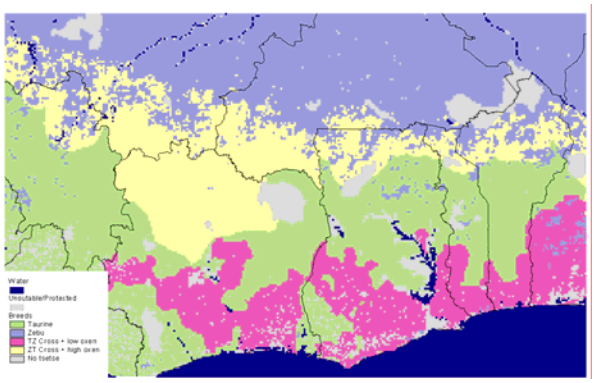


Cattle population density

The first phase of the work tackled Benin, Ghana and Togo. The second phase extended the work to cover parts of Burkina Faso and Mali. A range of standardised livestock, production and price data were collected at country, province and district level from each of these five countries, together with the most recent livestock population, cropping and disease data. These were amalgamated with the corresponding data layers derived and adapted from the Programme Against African Trypanosomiasis Information System (PAAT-IS). At the mapping stage, the data were extended to cover the areas around the five countries, notably including Côte d'Ivoire for which considerable data already existed in the authors' archives and databases.

Mapping breeds and production systems

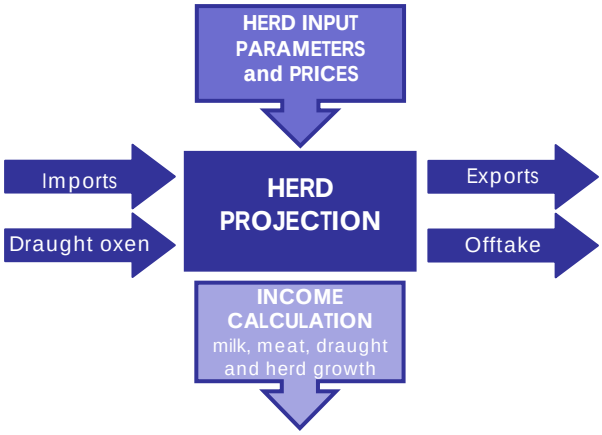
Four breed/production systems were defined and mapped: a predominantly taurine system with minimal use of animal traction; a crossbred taurine–zebu system with moderate use of animal traction; a crossbred zebu–taurine system with very high use of animal traction; and a zebu system with moderate animal traction use. By combining these definitions with the new data and the PAAT-IS data layers, a new distribution map was produced that linked trypanotolerant and susceptible cattle breeds to production systems.



A new map of production systems and dominant breeds in West Africa

Dealing with the economics

Existing information on the disease's impact on cattle production parameters was incorporated in a series of deterministic herd models, which projected the cattle populations and calculated the income derived from them over a period of 20 years. These modelled the situation both with and without the presence of trypanosomiasis in the 'core' population area, where cattle populations are currently located, and in the 'export' areas into which cattle populations are likely to expand over the period analysed. Thus 2 x 2 or four interrelated models were produced for each cattle breed/production system. For the purposes of the study, each herd model had two main outputs: an estimate of cattle population growth and an estimate of income. Income from cattle was calculated as the value of meat, milk, animal traction and herd growth less basic production costs. By comparing income in the absence and presence of trypanosomiasis, the potential benefits of T&T interventions could be estimated for the different cattle breed/production systems over the 20-year period. These were then discounted

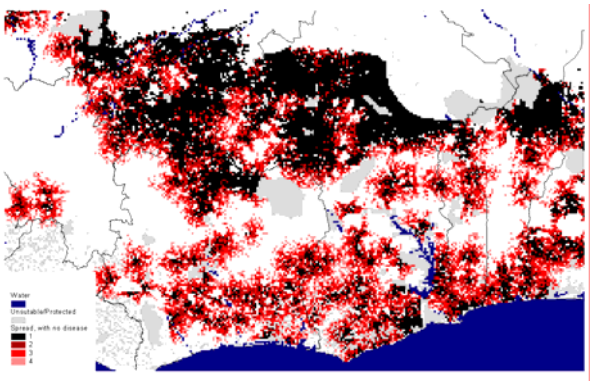


Structure of the basic herd model

to their present value and converted to a single dollar amount, expressed as benefits per head of cattle present at the end of the time period and split between those generated by cattle remaining in the core area and those arising from cattle populations that had expanded into export areas.

Mapping the spread of cattle populations

The final part of the study mapped livestock population distributions. By applying the estimates of the cattle-population growth rates provided by the herd models to maps of the current distribution of cattle, it was possible to map the estimated distribution of livestock in 20 years' time. This future population was compared to the land's estimated carrying capacity to identify those areas where cattle numbers exceeded resources available to sustain them. For these situations, an innovative step-wise spatial expansion model was applied to show how 'excess' cattle populations might spread into nearby areas where grazing was available. The cattle populations that remained in their original locations were those modelled as the core population; the cattle that spread to new areas were defined as the export herd. This spatial expansion model enabled us to quantify the potential benefits of the removal of trypanosomiasis from areas into which new cattle populations would migrate. The need to estimate the benefits from this type of expansion of livestock production has been a major unresolved issue in analysing the T&T problem.



Areas identified for sequential spread of cattle following removal of trypanosomiasis

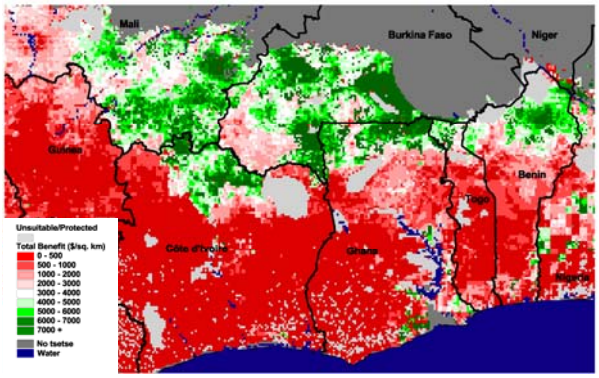
Producing the dollar maps

The results of the work are depicted in a series of maps throughout the text, culminating in the map below showing the total benefits achievable over twenty years. This map illustrates the geographical distribution of the potential dollar benefits from the removal of trypanosomiasis throughout the zone studied. As with all such modelling and mapping exercises, care must be taken not to interpret the figures as absolute values providing exact answers, but to keep in mind that combining a number of estimates in this way will always generate results that include a greater or lesser margin of error. That said, the resulting maps very clearly illustrate that combining economic and bio-physical variables adds a dimension beyond that which has previously been mapped. The summary map highlights the enormous potential benefits to be gained over the 20-year timeframe from those areas where there is already a high reliance on draught power: in the northern fringes of the tsetse distribution. It also shows that, within this time period, significant benefits from the removal of tsetse are unlikely to be gained in land to the south of this area for two reasons. Firstly, the cattle numbers are too low, even after expansion of cattle populations into new areas has been accounted for, and, secondly, this area makes limited use of animal traction, even taking into account the potential for a significant increase in its use if the constraint of trypanosomiasis were removed.

Discussion

The complexity of the analysis imposed a number of limitations that point to areas where either the modelling approach or the quality of the data could be improved. In particular, it was impractical to model more than the four production systems considered; these in themselves required 16 herd models, with the resulting dollar values mapped for eight categories of cattle. The data on the effects of the disease on cattle production parameters are mostly based on in-depth studies conducted in relatively small localities. This inevitably adds more uncertainties about their extrapolation to large areas and slightly different production systems. Another tricky aspect to the study was in determining the level of tsetse challenge and the prevalence of trypanosomiasis in the cattle populations. In particular, the levels of challenge in the areas that are on the limits of the tsetse distribution need more study. These aspects were factored into the calculations indirectly, as general effects of the disease within each production system. Finally, the economic models are also highly sensitive to the use made and the value of animal traction, and more fieldwork on these aspects would make the calculations more precise. Nevertheless, the results are in line with those found in other studies and modelling exercises.

From the point of view of decision making within the field of T&T interventions, having mapped the benefits the obvious next step is to consider mapping the costs. This would, however, first require undertaking a similar exercise to the current one to combine economic cost models with spatial data. The regions that show net benefits at calculated cost levels for different interventions could then be mapped, as could the benefit–cost ratios for the various control options.



Total benefits after 20 years from the removal of trypanosomiasis

Thus, this report provides 'proof of concept' that mapping economic benefits in this way does add an extra dimension and new insights to the existing range of mapped variables. It goes beyond simply mapping cattle and tsetse distributions and allows us to calibrate the effects of the disease in relation to the key components of livestock incomes and to place a value on income generated in new areas into which livestock populations could expand. By combining a demographic variable with projections of economic benefits for a range of production system layers, and taking account of expansion into new areas, this approach could have wide applicability in the analysis of other production constraints affecting agricultural expansion and productivity.

Acknowledgements

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This study will shortly be available as a book, jointly published by the DFID Animal Health Programme and PAAT. It will be sent out by FAO to everyone on the PAAT circulation list. If you would like to be sure of receiving a copy, please e-mail your name and postal address to raffaele.mattioli@fao.org