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European Commission

Farming in Tsetse Controlled Area
FITCA

Environmental Monitoring and Management Component

EMMC
Project N° 7 ACP RPR 578

Assessment of disease risk and tsetse challenge

Ethiopia, Kenya, Uganda

February – March 2002

Short term consultancy

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Abstract :
Le projet FITCA a pour objectif la promotion et le développement de l'élevage dans des zones d'Afrique de l'Est où les glossines et la trypanosomose représentent des contraintes majeures. Le volet « Suivi de l'environnement »(EMMC) évalue l'impact direct sur le milieu des méthodes de lutte employées.
Les stratégies, les priorités et les méthodes sont très variées selon les pays concernés par le FITCA. Cette diversité correspond à des situations contrastées, au niveau sanitaire, au niveau socio-économique et au niveau agro-écologique. La compréhension du lien entre les dynamiques de paysages plus ou moins façonnés par l'homme, la contrainte trypanosomienne et les outils de contrôle est un préalable pour la conception d'une méthodologie de suivi environnemental. De cette compréhension découlera notamment le choix des échelles de travail, des indicateurs et des zones pilotes. Des propositions sont faites pour ordonner les informations, construire la base de données et identifier les paramètres de suivi.

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List of acronyms

Acronym	Label
AAT	Animal African Trypanosomosis
HAT	Human African Trypanosomosis
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CIRAD-EMVT	Département Elevage et Médecine Vétérinaire Tropicale du CIRAD
CIRAD-TERA	Département Terroirs et Acteurs du CIRAD
CIRDES	Centre international de recherches pour le développement de l'élevage en zone de savanes (Burkina Faso)
EMMC	Environmental Monitoring and Management of Change
FITCA	Farming in tsetse controlled area
ILRI	International Livestock Research Institute
KETRI	Kenyan Trypanosomosis Research Institute
LIRI	Livestock Research Institute
NARO	National Agricultural Research Organisation
OAU – IBAR	Organisation for African Unity, International Bureau of Agricultural Research
NTTICC	National tsetse and Trypanosomosis Investigation and Control Center
PLE	People, Livestock and Environment
RTTCP	Regional tsetse and trypanosomosis control programme (Malawi, Mozambique, Zambia and Zimbabwe)
SEMG	Scientific environmental monitoring group (EU)
SS	Sleeping sickness
STC	Short term consultancy
TA	Technical assistant

I. Introduction

This report was elaborated after a short-term consultancy (STC) in Kenya, Uganda and Ethiopia (8th Feb. - 14th March, 2002) carried out in the frame of FITCA-EMMC. The title of this STC was "Assessment of disease risk and tsetse challenge" and it was conducted together with other STCs:

- Agro-pastoral and agro-ecological baseline survey in the FITCA regional area;
- Landscape and land-use analysis using satellite imagery at the FITCA regional and national level;
- Community profile analysis in the FITCA regional area;
- Regional and national FITCA database harmonisation.

In the frame of a regional project with national components, disease-risk and tsetse-challenge assessment must rely on longitudinal data, to (i) estimate changes in these features and (ii) make a joint analysis with environmental changes (landscape and land use). Clearly, this leads to consider a two-level information system (national and regional components), gathering disease, tsetse, control and environmental data. Design issues of such an information system are complex, because:

(1) it should match community and decision-makers' needs, with different situations and constraints in the different countries,

(2) information should be treated according to these needs and still be useful at a regional level,

(3) national components should have a complete control of their own information system, while ensuring a sufficient output flow towards the regional information system.

Because the other STCs were focused on specific aspects of the monitoring, we tried to make proposals both for disease-risk and tsetse-challenge assessment and for a more general, conceptual and logical frame ensuring the relevance and consistency of the whole work.

The frame and the general steps of the process were elaborated at the beginning of the STC. It was presented and discussed with the ILRI staff involved in FITCA-EMMC. Subsequently, field visits were achieved in the three National FITCA components. Thus, proposals were designed and validated together with the local teams. The available data were listed (as well as the need for further data) and their possible use was evaluated. Because ILRI will be the key actor to implement this project and has a large field experience

in all of the FITCA countries, we deliberately adopted its general philosophy in environmental monitoring and management of change related to farming in tsetse-controlled area.

The FITCA project faces a wide range of agro-ecological and disease situations, together with different national control strategies. Our proposals are adaptable to the specific situations and strategies prevailing in each FITCA country, thus meeting local requirements for the quantity and quality of pre-processed information (tables, maps, standardised reports,...). However, a set of design and implementation rules for databases, data collection and data analyses should ensure that between-country results might still be compared. The general scheme is thus to collect, manage and analyse data describing the relationships between trypanosomosis risk, environment (landscape and its dynamics related to human activities) and control measures (tsetse control and trypanocidal treatments). The first step is to set up a conceptual and qualitative model of this complex system (risk, environment and control), based upon known mechanisms or widely-accepted assumptions.

II. Context and frame of the short-term consultancy

A. Environmental Monitoring and Management Component of FITCA

This paragraph was extracted from the terms of reference for the Environmental Monitoring and Management Component (EMMC) of the FITCA Project (Anonymous, 2000). The initial document was slightly edited for the purpose of this report.

"Most tsetse control / eradication projects of the past have failed in the long run because they proved not sustainable. After the initial control operations, funded or assisted by foreign donors, tsetse regularly reinvaded the cleared areas. Local communities were either not motivated to maintain control because they considered it a public good and not their concern, or, they were too poor to make any input into a continuation of tsetse control. Therefore the FITCA ***philosophy wants to engage the communities in tsetse control*** *in order to enable livestock keeping and* ***to increase the agricultural productivity to enable the communities to continue control after the end*** *of the project.*

As the agricultural policy (livestock and crops) in Kenya, Uganda, Ethiopia and Tanzania seeks to increase the productivity of agriculture in a sustainable manner, the FITCA project is perfectly in line with the national policies of these countries. One important constraint on livestock productivity in each country is trypanosomosis, transmitted by tsetse flies. Each FITCA country seeks to increase livestock productivity by controlling the disease, either directly or by controlling the vector. Tsetse control has the potential to remove a significant constraint to sustainable rural development and enhance agricultural production.

The sustainability of benefits *achieved under the program* ***is dependent*** *on assuring that* ***environmental attributes are not adversely affected****, either* ***directly*** *by the control activities undertaken,* ***or indirectly*** *as a result of changes in the production systems arising through removal of the disease constraint. It is in the same intention that in the financing agreement it was foreseen that FITCA would assist in strengthening local capacity to monitor environmental changes. Funded by the EU, the environmental monitoring and impact assessment component is part of the regional FITCA program [...]"*

"The environmental impacts of controlling tsetse-transmitted trypanosomosis can be separated into direct (e.g. effects of insecticides on wildlife) *and indirect components [...].* ***During the last years, ILRI has developed monitoring tools related to the indirect impacts*** *of livestock activities on environment. These research are currently conducted within the PLE programme (People, Livestock and Environment). The indirect impacts [...] are now of greatest concern. [They] are the effects of* ***controlling trypanosomosis through the expansion of livestock and human populations, and land-use****. Trypanosomosis is*

preventing the utilisation of livestock in vast (fertile and humid) *areas of Africa and is the cause of overuse of areas outside the fly belts.*

Control of trypanosomosis increases the efficiency of oxen so those farmers can plough more land in areas with low compared with high disease prevalence. In many cases, control of animal trypanosomosis acts as magnet for human migration. People move to new lands after they are freed of the tsetse fly.

If this disease is controlled, there are almost certainly environmental consequences resulting from the ***expansion of cultivation and livestock numbers****,* [such as] ***habitat loss and species extinction****, a net release of* CO_2 *to the atmosphere and* ***loss of vegetative cover that protects soil structure and fertility****. Farmers often burn vegetation in the process of clearing land, which further releases harmful greenhouse gases. Land cover changes can also affect regional-scale hydrology and climatology.*

These general environmental concerns apply to the specific project areas in the different countries as follows:

- ***In Kenya and Uganda****, much of the proposed project areas* ***are already densely populated****. The landscape is heavily used for agriculture and the potential for further agricultural expansion is limited [...]. However, there are other* ***small patches of vegetation*** *that people have avoided using, principally because of the threat of contracting diseases. These areas, which experience low use, include riparian corridors, swamps and wetlands. These are the very habitats that are richest in species and* ***can become overused when the constraint of trypanosomosis is lifted****. These areas will be one of the first focuses of the environmental monitoring (environmentally sensitive areas) of indirect impacts at the Kenyan and Ugandan sites.*
- ***In Ethiopia****, farming systems in tsetse infested areas are* ***poorly developed****, with 10-25% of the land area cultivated, but are* ***adjacent to highland areas with high population densities****. The principal indirect impact of tsetse control concerns the effects of the expansion of cultivation and grazing into areas that have a history of low use. Trypanosomosis forms a strong constraint on agriculture in south-western Ethiopia, thus* ***changes in agricultural systems after disease control will probably be rapid****. In this region, highland and gallery forests are* ***biologically rich****. There is great potential for impacts in these vegetation types if more intensified use follows tsetse control. There are several endemic species in the area and these should be given special attention in impact studies. Soil fertility impacts will be low initially because soil fertility is high "*

  [...]

  "Monitoring of project impacts needs to feed directly into ***strengthening the ability of***

monitoring has no impact on the rural poor. A series of techniques have been developed to involve communities in monitoring and to empower them to better manage their natural resources. The overall objective is to increase the sustainability of natural resources and agricultural systems, through environmental monitoring and management, in participating FITCA countries. The twin objectives of increasing productivity to improve human welfare and to sustain those gains over the long term are at the core of the objectives of the agricultural sector in each country.

Comments

The tsetse constraint for agricultural development, the impact of environmental changes on tsetse distribution and the impact of tsetse control on environmental changes were described in different part of Africa (Bourn *et al.*, 2001, Ford, 1971, Nagel, 1993, Reid *et al.*, 2000, Reid & Ellis, 1995, Reid *et al.*, 1997). Much of these works were conducted in countries involved in the FITCA project. If data on tsetse are often sparse at the beginning of the project, prediction on their distribution are also available at the regional and local level (Rogers & Wint, 1996, Wint, 2001). We will use those available results where appropriate. At this stage, our understanding is that one of the main purpose of the EMMC project is to increase the level of information and awareness of environmental change and increase the capacity to respond proactively to these changes among stakeholders in FITCA participating countries.

B. Objectives and expected results of the consultancy

The objectives of were given in the terms of this STC.

1. Objective of the Consultancy

"An interdisciplinary STC (epidemiologist + entomologist + land use specialist) ***will assess the associations between disease risks with tsetse challenge*** *related to* ***changes in land use and to the different habit of the different species of flies*** *in the FITCA area,* ***in order to provide a baseline data*** *at the first year of the project".*

2. Methodology

"This STC will take place after the remote sensing (RS) Imagery experts have provided their report. ***After a synthesis of available information*** *on epidemiological risk associated with tsetse burden, the experts will confirm their* ***working hypothesis*** *through a general survey at the field level. They will* ***integrate local community knowledge*** *in there observations. The Regional and national co-ordinators will provide some pilot areas where a* ***continuous survey on sentinel locations*** *would be established".*

Comments

The RS STC did not occur before ours for administrative reasons. As a consequence, it was more difficult to relate field reports on disease risk and high-tsetse challenge to environmental features and land-use change over the whole FITCA area.

After the field visits and preliminary discussions with the regional and national FITCA teams, we proposed some sites for disease, control and environment monitoring. It turned out that some of these sites had already been identified and were thus retained, while others were discarded for practical considerations.

3. Expected results

"*The experts will submit a synthesis of information available on epidemiological risk associated with tsetse challenge and recent changes in land use. They will* ***develop analysis of major associations with disease risk, tsetse challenge and land use changes****. At least, they will provide the project recommendations on assessment of disease risk and its association with tsetse challenge and land use changes. They will design the protocol of continuous survey on the sentinel locations".*

Comments

Field visits and discussions highlighted that very little quantitative information was readily available to analyse the interactions between disease risk, control measures and land-use changes. Thus, the first step would be to collect these sparse and scattered information before setting up new surveys and monitoring systems. This would take a long time (several weeks or months) and cannot be considered within a STC. At any case, we are currently unable to perform such an analysis.

The evaluation of disease risk depends on the local situations, e.g. the presence and abundance of different species of tsetse flies (ILRI, 2002). The description (and disentangling) of the association between land-use changes, disease risk / tsetse challenge and control measures is a difficult task:

- tsetse and tsetse control may have an impact on environmental change through human settlement and agriculture development;
- on the other hand, land-use and natural resources have their own dynamics in tsetse-challenged, highly-populated areas such as western Kenya and some parts of Uganda. This dynamics might alter the distribution of the flies (e.g. via damages to their habitat) without any specific control measure.

These interactions are complex and contrasted situations are encountered within the different national FITCA components. For a correct interpretation of the indicators provided

by the information system, all these known or assumed interactions should be summarised in a qualitative model. This should be done before the implementation of the specific national monitoring to ensure that the key information are recorded. To meet a local and regional consensus, this qualitative model should be simple, and require as few additional information as possible (i.e. most of the input data should be available without implementing time-consuming and expansive field surveys).

III. Diagnosis of the situation

Surfaces covered by FITCA areas are different in Kenya (5 districts, 7,300 km^2), Uganda (13 districts, 26,000 km^2) and Ethiopia (more than 60,000 km^2). Documentation is available to describe sociological and agricultural trends (crop and animal farming) in Kenya and Uganda, at the district or even lower levels. These references are useful for a basic understanding of the rural contexts. However, aggregation level is different according to the kind of data and the country ; it is difficult to know how the indicators were computed and from which basic data. Obviously, a large amount of work is needed to harmonise and homogenise the data within each country, and still more for a between-country comparison.

A. Variations in land use

1. Intensive land use in Kenya and Uganda

In Kenya and Uganda, FITCA is implemented in two adjacent areas intensively used for agriculture and livestock rearing. In both countries, FITCA territory corresponds to rural landscapes of smallholdings where fields and grasslands (including fallow) cover more than 90% of the land. Smallholdings on both Kenyan and Ugandan sides of the border occupy the integrity of the landscape and agro-pastoral activities have left virtually no natural vegetation cover in the respective FITCA areas. Live hedges of exotic woody species (Eucalyptus, Grevillea, Nem, Juniperus,) and secondary growth on old fallows (*Lantana camara, Tithonia diversifolia*) constitute the spontaneous vegetation in these areas.

In Kenya, this intensive land use is historically based on the clanic, customary allocation of land by Luhya farmers and the progressive settlement of Teso pastoralists. Both have evolved toward private, entitled tenures encouraged by the national policy of freeholds since the 70s. In Uganda, similar agro-pastoral transformation of land cover was achieved under customary tenure and absence of *de jure* private property of land.

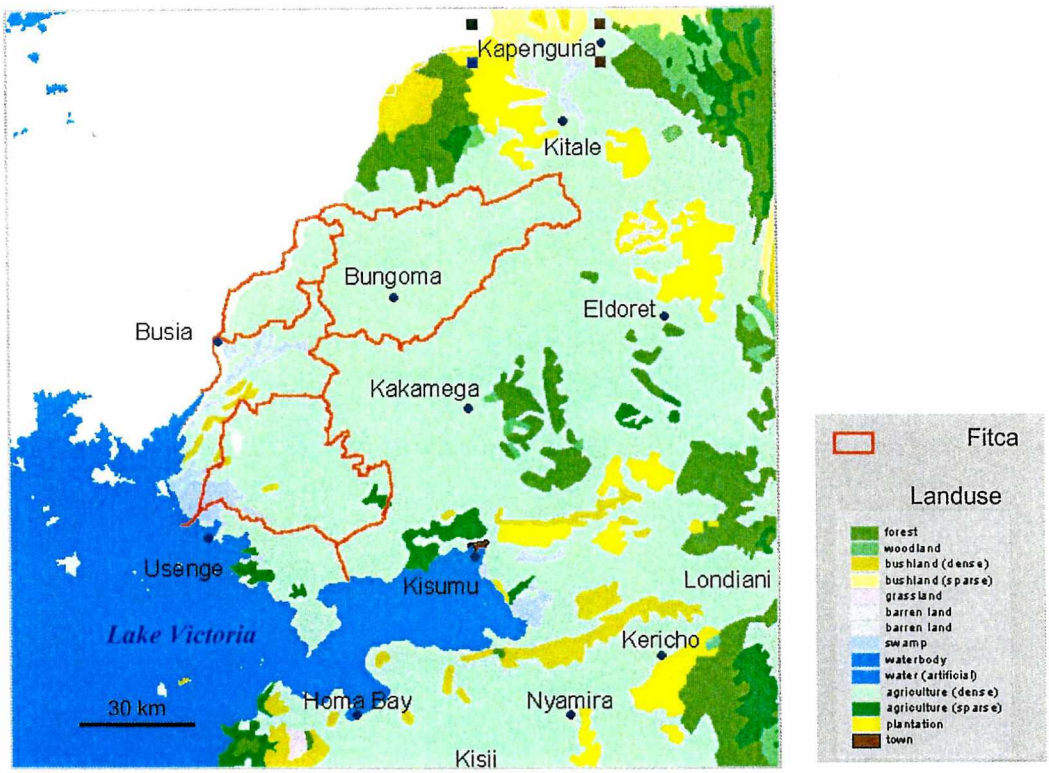


Fig. 1. Land use (unknown date) in FITCA-Kenya area (Source: ILRI, from unknown source)

Box 1. The Kenyan FITCA area.

The Kenyan FITCA area includes 5 districts on 7300 km². It is an old cotton zone, but its development was largely reduced during the last decade. The joint changes in landscapes and tsetse-control campaigns resulted in the increase of two species of flies, *G. pallidipes* and *G. f. fuscipes*. Their unequal distribution lead to contrasted epidemiological situations in the area:

- The north-western part (district of Teso) is characterised by a marked relief. The agricultural surface is estimated at 40% of the territory, cultivated plots being small and divided. Most of the fallow lands are 2 to 5 years old, with many bushy formations of *Lantana camara* and *Litonia* initially used as plants of hedges.

  Populations of *G. pallidipes* were very high at the beginning of the FITCA program (usual densities ranging from 300 to 800 flies $trap^{-1}$ day^{-1}, with maxima reaching 1400 flies). Animal trypanosomosis was a major problem for cattle: extension services reported that 87% of the cattle disappeared within the last 5 years. Before the FITCA project, trypanocide treatments were very frequent (up to two treatments per month), with important risks of chimioresistance.

  An emergency intervention was undertaken by FITCA with the deployment of deltamethrine-impregnated screens (2500 screens, 4 screens km^{-2}). Apparent fly density was reduced to 10 flies $trap^{-1}$ day^{-1} within a few months. Today, an increase of the number of cattle is already observed, which is an argument to plan another type of intervention based on insecticide treatments on animals (live bait technique).

- In the north-eastern part (district of Bungoma), cattle trypanosomosis is confined in the western

part, where the risk is moderate. *Glossina pallidipes* is dominant. No intervention is conducted yet.

- In the intermediate part (district of Busia), cattle trypanosomosis is related to *G. f. fuscipes* and primarily affects settlements located near the rivers. Cattle densities are high. Two tsetse-control measures are implemented:

  (1) local farmer organisations are created (so-called crush-pen committees) and trained for cattle spaying with insecticides (deltamethrine, also efficient against ticks). loans are provided to purchase a pump and an initial amount of insecticide.

  (2) the promotion of zero-grazing units (installation of impregnated nets around the cowshed), which allow an optimal family production and also act as an attractive system for the tsetse flies. About sixty units were implemented at the time of STC.

- In the southern part (districts of Bondo and Siaya), *G. f. fuscipes* is abundant near the Lake Victoria; its apparent density is higher than in Busia (10-15 tsetse $trap^{-1}$ day^{-1}). *G. pallidipes* is also present in the North-East of the Bondo district. The incidence of AAT is high. Epidemics of HAT were reported at the beginning of the century and in the 50's. Some epidemiological indicators, such as a high frequency of blind dogs, might be related to a low-noise transmission of *Trypanosoma brucei rhodesiense* in this area.

  Tsetse control is conducted with impregnated targets (approximately 400 screens, 4 screens km^{-2}) and 50 crush-pen committees should be implemented. Fly density had already strongly decreased at the time of our visit.

In both areas, rural livelihoods are based on subsistence crops (cassava, maize, matoke, millet, ground nuts, etc.), cash crops (cotton, tobacco, coffee), animal rearing (cattle, sheep and goats, pigs, poultry), and various and important activities (fishing, trade, shops, crafts, local or external employment). These activities support the highest densities of rural populations in each country, with 200-300 inhabitants km^{-2}. A first feeling after the field visits was that, along the Kenya-Uganda border, land use was less intensive in the Kenyan side, with more trees, hedges and old fallow lands than on the Ugandan side.

2. Agro-pastoral zones, wetlands and smallscale coffee production in Uganda

Beyond the intensively farmed area bordering Kenya (Tororo district), the Ugandan FITCA covers a variety of agro-climatic situation and land-uses. Pastoralism is the dominant activity in Soroti, and in the northern part of the intervention zone, in general. In these areas, negotiations between communal tenure for grazing and individual usufruct for tillage are a key component in land-use changes. South of Lake Kyoga, farming systems in Iganga district are facing a growing rice production. Such transformation of wetland ecosystems is

district, coffee plantations, dairy farming and intensive mixed-cropping systems are favoured by high-potential agro-ecological conditions. Levels of land pressures, tenure security and land-use intensiveness need to be further documented.

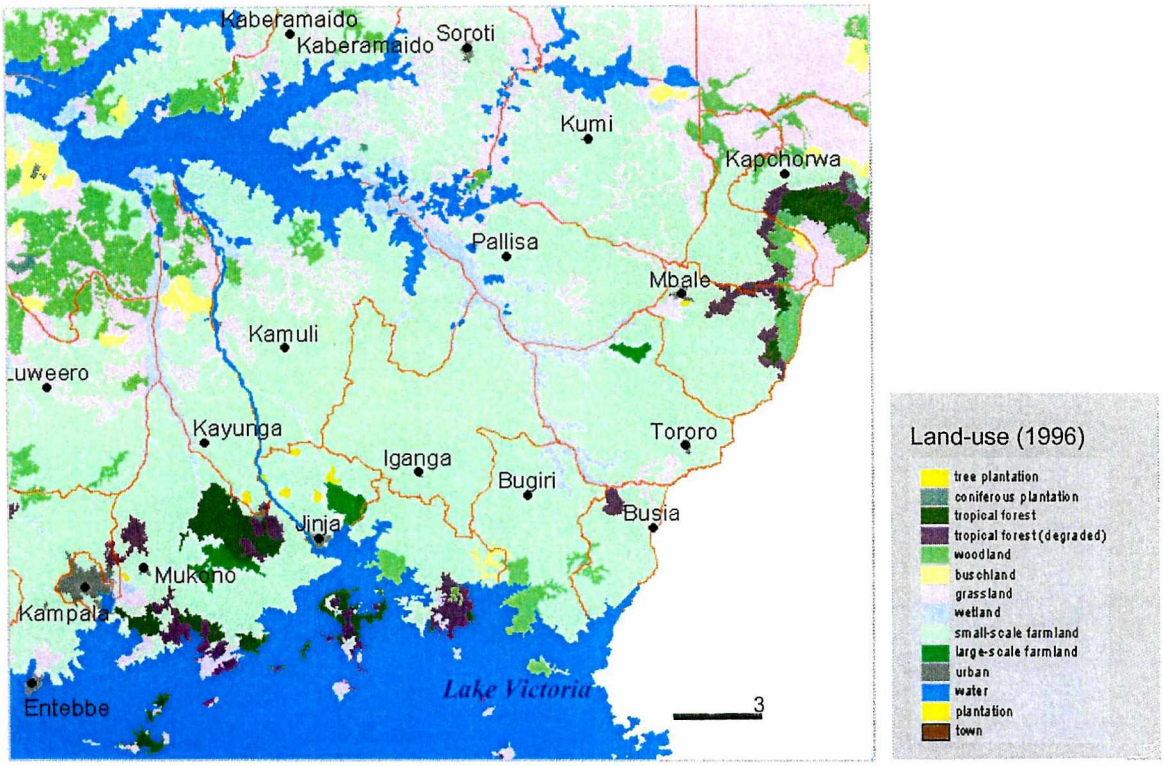


Fig. 2. Land use (1996) in FITCA-Uganda area. Source: National Biomass Study, Department of Resource (Uganda, 1996). Land use was determined with an analysis of SPOT satellite images supervised with field work.

3. Frontier farming in South West Ethiopia

The FITCA intervention area is located in upper Didessa and Wamma Valleys (Oromiya Region, Ethiopia), covering 5,500 km^2. This is a midland region (1,300 – 1,500 m) with steep escarpments raising to plateaux at 2,000 m on either side. Human density is low and with typical extension-retraction of smallholdings within little disturbed savannahs, wooded grasslands, and riparian forests (Ford *et al*, 1973 cited in (Bourn *et al.*, 2001). Historical changes in national land tenure policies, from a feudal system to communal management, have led to a contemporary situation in access to land that associates – in variable combinations – individual decisions, decentralised authority ("Village Association" and their elected chairperson) and administrative intervention (the Regional and / or Zonal authorities).

A national policy of tsetse control was implemented to allow highland farmers to settle in these areas (Muressa, person. comm.). This project was supported by the FAO from 1986 to 1990 (Slingenbergh, 1992). Nevertheless, the STC team has not accessed official

resettlement objectives, plans, and methods covering the FITCA area. Given the high stakes in environmental issues in the region, these policy elements should be crucial to the implementation of FITCA.

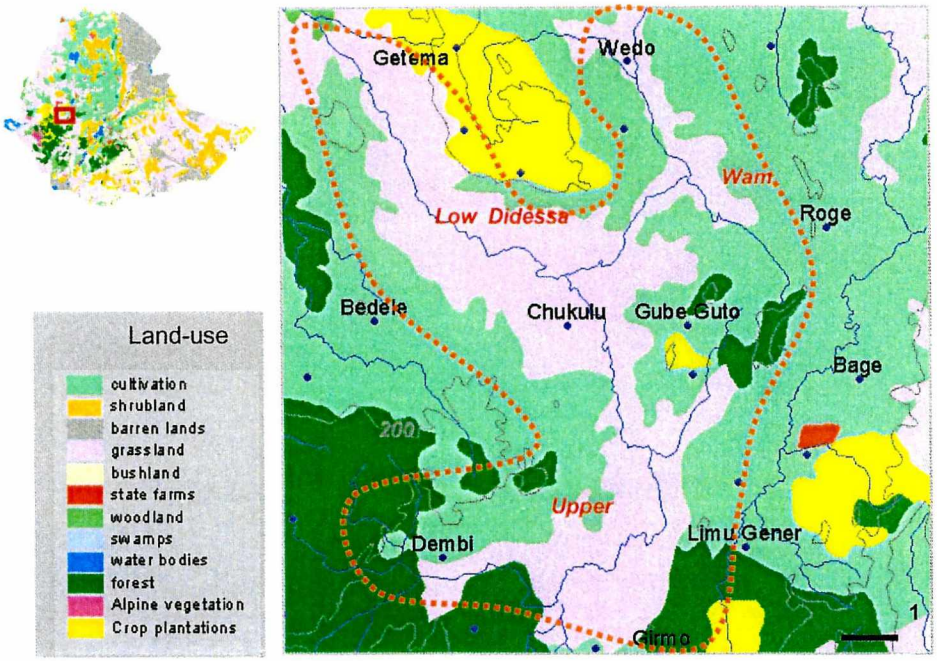


Fig. 3. Land use in FITCA-Ethiopia area. Source: ILRI

This overview of the situations in Kenya, Uganda and Ethiopia with regards to land tenures portrays important differences across the FITCA intervention areas. These contrasts are augmented when other aspects are accounted for, such as impact of trypanosomosis on livelihoods and landscapes, reaction of villagers to epidemic situations, and control measures.

B. Relationships between trypanosomosis, local livelihoods and land uses

In the three visited countries, the farming systems rely on cattle which are used for animal draught (ploughing and any agricultural hard work), soil fertilisation, landscape maintenance (prevention of heavy bush encroachment in fallow lands), human nutrition (milk and by-products, meat), saving and capitalisation, and are an essential component of the social cement (loans, dowry, compensation…). Any disease with a high impact on cattle health - like trypanosomosis - is likely to induce severe consequences in terms of system sustainability.

1. Dynamics of tsetse distribution and epidemiological situations

- In Busia District (Kenya), Bourn et al. (2001) indicate a reduction of the natural riparian *G. fuscipes* habitats during the last decades. In contrast, they argue that *G. pallidipes* might have found new niches in the bush-regrowth of long-lasting fallow lands present in this district's rural landscapes. Field observations in Angurai / Teso districts gave evidences of an animal-trypanosomosis epidemic with severe losses from 1998 to 2001 (87% animal losses). In this area, the importance of old fallow lands (only 30-40% of the fertile soils are cultivated) would favour the assumption that the epidemic situation was associated with *G. pallidipes* (Bauer & Oloo, 2001). However, different entomological and epidemiological situations were identified and will be described latter.

- Across the border, in Uganda's Tororo District, more farms and less bush and old fallow lands[1] are observed than on the Kenyan side. This might constrain the epidemiological situation to a riparian system associated with the *G. fuscipes.* This is consistent with the results of recent studies on *G. pallidipes* distribution in the area (Katabazi *et al.*, 2001). Trypanosomosis pressure prevents farmers from keeping cattle and sleeping sickness occurs among villagers which are settled in too close contact with the riparian landscape. Compared to Busia (Kenya), the intensively farmed interfluves of Tororo (Uganda) look safer. These empirical observations point to changes in *G. pallidipes* habitat linked to farming intensity (pattern of fallow lands and hedges, etc.) as an important factor in the occurrence and development of animal trypanosomosis epidemic.

On another hand, as its traditional habitat disappears, *G. fuscipes* is able to adapt to peri-domestic vegetation and scrub remainders in rural landscapes (D'Amico, 1993). Consequently, the geographical distribution of this tsetse species is probably wider than 10 or 20 years ago. This was confirmed by recent entomological studies in Uganda (Okedi, personal communication). The present distribution of *G. fuscipes* seems to extend to all main waterways and tributaries between Lake Kyoga and Lake Victoria. Field work and retrospective studies should assess these general impressions (precise map of *G. fuscipes* distribution and accurate description of epidemiological situations).

The timing and location of recent sleeping sickness epidemics - 1970s on the shores of Lake Victoria, 1982 in Kamuli, 1984 in Mukono, 1989 in Soroti, 1990 in Southern Apac (Odiit & Enyaru, 1999) - seem to be related to the collapse of public animal- and human-health services (70s), in a socio-political context marked with mass human and cattle movements.

---

[1] *These empirical findings should be confirmed with diachronic remote sensing (historical aerial photos*

The main tsetse species involved in this epidemics was *G. fuscipes*, probably as a consequence of the spread of bushy fallow lands (decrease in cotton production).

- After the 1986-90 tsetse-control measures, the habitat of *G. morsitans* was completely destroyed by the human settlement in the Upper Didessa and Wama valleys (Muressa, person. comm.). Such a situation was reported in neighbouring valleys (Nigatu *et al.*, 1992). The uncertain uptake of areas of riparian forests for cultivation (Reid & Swallow, 1998) and the more difficult control of vectors in such habitats, render the densities and localisation of *G. tachinoides* key to reduction of remaining trypanosomosis risk.

Box 2. Tsetse flies in the FITCA area.

In the FITCA area, two types of tsetse flies play a key role in the transmission of human and animal trypanosomosis. Savannah species of the Morsitans group, *Glossina pallidipes* and *G. morsitans submorsitans*, are more abundant in wooded and bushy areas. Riparian species of the Palpalis group, *G. fuscipes fuscipes* and *G. tachinoides* (Palpalis group) are distributed within the valley floors, in riparian vegetation and along the shores of Lake Victoria.

- Different types of vegetation offer favourable ecological conditions to several species of tsetse flies, making it difficult to define specific habitats according to this criterion.
- Some species are homogeneously distributed across landscapes (savannah flies) while others are limited to particular locations (riparian flies) implies major differences in their respective epidemiological systems:
  - for savannah flies, disease risk is related to fly density;
  - for riparian flies, disease risk is related to the frequentation of riparian habitats.

To broadly summarise the current (and still somewhat empirical) knowledge of flies distribution in FITCA areas:

- *G. pallidipes*
  - is found in Kenya at the North of the FITCA area and in a residual pocket in the Busia district,
  - is present in Uganda, near the lake Victoria and in some eastern areas located at the North of the lake.
- *G. fuscipes fuscipes*
  - is found in Kenya on the Victoria lake shores and along the main rivers of the Busia district,
  - is widespread in Eastern Uganda.
- *G. tachinoides*
  - is found in Ethiopia along the main rivers and tributaries in Wama and upper Idessa valleys
- *G. m. submorsitans*
  - is found in Ethiopia in the savannah of the low Idessa valley, but is currently absent from Wama and upper Idessa valleys.

	Savannah flies		Riparian flies	
	G. m. submorsitans	*G. pallidipes*	*G. f. fuscipes*	*G. tachinoides*
Kenya		X	X	
Uganda		X	X	
Ethiopia	X			X

2. Impact of trypanosomosis on rural livelihoods

2.1. Epidemiological patterns

- In Angurai (Kenya, Teso district), cattle owners mention the drastic drop in herd size and draught power in 1997/98 to explain the extension of secondary-growth bush land of *Tithonia diversifolia* and *Lantana camara,* a putative habitat for *G. pallidipes.* Farmers in this area reported extension of fallow periods, old fallow lands and hedges, as well as the adoption of cash rather than cattle payment for dowry and disappearance of large herds with more than 100 heads of cattle. Thus the reduction of cattle population and subsequent landscape changes might have been caused by tsetse flies and trypanomosis rather than by social or economic dynamics.

- In places where cattle mortality related to trypanosomosis was lower, such as Butula and Mundika (Busia district, Kenya), farmers were not aware of a possible relationship between cattle trypanosomosis and landscape changes. The high prevalence of human sleeping sickness might be related to land scarcity: disadvantaged households are rejected to the periphery of safe interfluves where they utilise wetlands for their farming activities. The shortcomings of tsetse control capacities in these remote areas might have been an aggravating factor.

- In Soroti (Uganda), pastoralists had to restock their herds after important raids and insecurity during the early 90s. Cattle importation from places with a high trypanosomosis prevalence (such as Tororo) has probably lead to the on-going AAT and AHT epidemic situation in this pastoral area (Fevre *et al.*, 2001).

- In the Didessa valley, historical accounts of extension and contraction of smallholdings highlight the importance of animal trypanosomosis as primary factor of settlement (Itty *et al.*, 1995, McCann, 1995). However, in Limo Say (Sokoro District, Upper Didessa valley), a pilot tsetse control site was implemented in the mid-90s. *Glossina morsitans* was successfully controlled and farmers do not consider AAT as a limiting factor anymore (accessibility, transport and profitable markets for cash crops are seen as the most important features to predict farming extension towards valley's lowlands).

2.2. Disease awareness

Different reactions were observed when human-community were confronted to AAT and AHT. In places where extension of *G. pallidipes* is recent, AAT is little known and reactions of angst and confusion were observed, such as in Angurai (Teso District Kenya).

In endemic situations, villagers adopted risk-reducing practices and copping

water; they favoured trypanotolerant animals and limited their livestock rearing activities (Ossiyeka, Bongo District, Kenya).

In situations where AAT prevalence was moderate and cattle mortality was low, villagers considered the disease as a constraint to animal productivity (animal draught, milk yield) and had a speculative behaviour, investing money in crush-pen committees (farmers' organisation around a cattle retention corridor, a spraying crush pen and remnant insecticides) or protected 0-grazing units.

In the Upper Didessa Valley (Ethiopia, Sokoro District), the initial boost in cattle ownership, cropped area, and farmers confidence allowed by successful control of *G. morsitans* (mid/late-90s) was thwarted during the last three years by very low prices of agricultural produces, with farmers selling domestic animals and adopting copping strategies such as qat production or withdrawal of cultivated areas.

C. National strategies for tsetse and trypanosomosis control in FITCA areas

- In Kenya, the first control measure in areas with high tsetse densities and AAT incidence was the implementation of a network of insecticide-impregnated targets, maintained by private, village-based and self financed "target attendants" (Bauer & Oloo, 2001). Once the fly density reached an acceptable level (as perceived by the farmers), it was replaced by the aspersion of cattle with a remnant insecticide managed by the village crush-pen committees: for each treated animal, fees (20 KS) were paid by the farmers to the committees. In peri-urban and market-oriented systems, protected 0-grazing units were experimented as a final control measure (tsetse apparent density < 1 fly $trap^{-1}$ day^{-1}).

- In Uganda, priority was given to the control of sleeping sickness, with mass detection of human cases and treatment of affected people. When this emergency measure is attained, more systemic preventive control measures will be implemented, with large-scale tsetse control (impregnated pyramidal traps) and animal-based measures such as crush-pen committees and protected 0-grazing units. The control of sleeping sickness is devoted to national human health services, but all the other activities (tsetse control, animal treatments) are decentralised in each of the districts (13 in the FITCA area), in the frame of a nation-wide regionalisation policy implemented by the Ugandan government.

- In Ethiopia, a progressive (South to North) tsetse eradication was envisaged within two valleys (Upper Didessa and Wama) protected by natural vector barriers (altitude >1900m), using state-managed (NTTICC) targets. This strategy relies on the setting of permanent barriers along openings of the valleys to prevent tsetse re-invasion (a 5 by 8

km sanitary cordon equipped with targets). In the rest of the FITCA intervention area (Amhara, Benishaangul / Gumuz, and Gambella regions), training and capacity building of public animal health assistants was proposed as first stages[2].

These preliminary observations suggest that complex interactions occur between epidemiological situations, landscapes, livelihoods, and tsetse / trypanosomes control measures:

- tsetse distribution is a dynamic and flexible feature;
- different impact of similar epidemiological situations might be observed on rural livelihoods and landscapes;
- farmers' reactions to both animal and human trypanosomosis were contrasted;
- the association of general and local (non-tsetse related) factors, policy contexts, disease history, tsetse control measures creates local, differentiated disease risk situations.

As a consequence, we think that an integrated logical framework should be developed to describe the panel of control, palliative, and copping measures which are currently undertaken within the FITCA countries.

D. Concept and working assumptions

The need to take into account the simultaneous changes in disease risk and control measures in an anthropised environment pushes this work in the field of system analysis. In this case, the system under study is the agro-ecosystem : tsetse proliferation, AAT and sleeping sickness are considered as the manifestation of a systemic imbalance. Control measures must solve the trypanosomosis problem as well as ensure the sustainability of the agro-ecosystem : beyond the insurance of an acceptable situation in terms of human health and animal productivity, it is thus a matter of agro-ecosystem (Faye *et al.*, 1999).

Information systems will be implemented to store and manage the information describing the changes in tsetse flies and trypanosomosis challenges, control measures and landscape / land use along with the project. Because local communities would be both an information source and the main users and recipients of this system, they should be deeply involved in its design, and information returns should match their needs. This latter point is crucial to ensure the sustainability of the information system after the end of FITCA programme.

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[2] *In Ethiopia, other tsetse and trypanosomosis control programmes are implemented in areas*

These data bases will be set up at the national and regional levels to supply national teams with decisions tools and the regional co-ordination with an integrated summary and perspective. Existing data are listed in this report as well as a call for the collection of missing data. Finally, aspects of local use by decision makers, local participation in data production and analysis, and links with environmental impact monitoring are discussed.

IV. Material and methods

A. Mission time table

- Friday, Feb 8th. Arrival in Nairobi at 6.00 AM (R. Lancelot, S. de La Rocque). Welcomed at the airport by D. Bourzat, co-ordinator of the EMMC project and East-African CIRAD representative ; hotel accommodation and meeting at the OAU/IBAR - FITCA regional office, with D. Bourzat and FITCA regional staff. Visit to Dr Solomon, head of FITCA Kenya / FITCA regional and H. Politzar, TA FITCA regional. Frame of the STC, administrative matters.
- Monday, Feb 11th. Meeting at the ILRI with D. Bourzat, J. Mc Dermott, T. Robinson and R. Reid : general presentation of the STC, provisional time schedule and framework, background information on on-going activities and relationships with partners. Informal meeting with CIRAD-EMVT team at ILRI.
- Tuesday, Feb. 12th. Meeting in OAU/IBAR office with H. Politzar : detailed presentation of FITCA activities and relationships with EMMC. Meeting in ILRI with D. Bourzat, J. McDermott, M. Nyabenge, R. Kuska and J. Maitima. Available data and tools for GIS issues.
- Wednesday, Feb 13th. Meeting in KETRI with G. Murilla, chief research officer & deputy director research, G. Muriuki, environment and land use : available information and KETRI involvement in FITCA. Meetings in ILRI : technical discussions with T. Robinson (remote sensing, available satellite imagery and software) and J. McDermott (epidemiological situation, conceptual and practical frames of tryps / tsetse surveys and monitoring in the different FITCA countries).
- Thursday, Feb 14th. Meeting at OAU/IBAR office with B. Bauer : presentation of FITCA Kenya, tsetse & tryps situation and control measures. Meeting with D. Bourzat : 1st week summary and preparation of the Friday meeting.
- Friday, Feb. 15th. Workshop meeting with EMMC team : conceptual frame, possible technical options and organisation of the forthcoming field trip.
- Sunday, 17th - Monday, 18th. Arrival of G. Dewispalaere, M. Djama, G. Fournié and G. Kleitz. Drive to Busia. Meeting with B. Bauer and time schedule for the coming week.
- Tuesday, Feb. 19th. Field trip to North Teso district (Angurai location), near the Ugandan border. Tsetse trapping and cattle tryps surveys. Meeting with farmers and field team.
- Wednesday, Feb. 21st. Field trip on the Bondo district, on the Lake Victoria shore. Tsetse trapping and cattle tryp surveys. Meeting with farmers and field team

- Thursday, Feb. 22nd. Field trip : 0-grazing units and crush-pen committees in Busia district. brainstorming with FITCA – Kenya team : examination of available data (maps, forms, electronic files, tables,...). Definition of the main epidemiological / flies / landscape patterns. General meeting with K.H. Politzar.
- Friday, Feb 22nd. General meeting with FITCA – Kenya team. Proposals for a general database scheme and GIS implementation. Choice of the observation scale and sites for the longitudinal survey.
- Saturday, Feb. 23rd. Final meeting with FITCA – Kenya team. Drive to Uganda.
- Monday, Feb 25th. Visit to the Livestock Research Institute (LIRI), institute of the National Agricultural Research Organisation (NARO). Meeting with C. Otim, LIRI General Director, M. Odiit, responsible for human trypanosomosis control and A. Gidugu, head of FITCA Uganda. Presentation of the mission by K.H. Politzar and D. Bourzat. Examination of available data provided by ILRI – EMMC. Trip to Kampala – Entebbé (D. Bourzat – M. Djama) : data collection and visit to the University (Monday 25th – Wednesday 27th).
- Tuesday, 26th. Field trip with M. Odiit in the Tororo district. Collective work on database and GIS schemes.
- Wednesday, 27th. Collective work on database and GIS schemes.
- Thursday, 28th. Collective work on database and GIS schemes. From 12 to 14 PM : meeting with S. Gould (Technical assistant FITCA – Uganda) and A. Gidugu. General presentation of tsetse and tryps control activities in FITCA Uganda : national- and district-level strategies, main features and differences with FITCA – Kenya. Presentation of the goals of the information system : general scheme, information needs (storing and returning). 16 – 18 PM : presentation of the details of the database and GIS. Discussion for the choice of the sites of the longitudinal survey.
- Friday, March 1st. Drive back to Nairobi.
- Saturday, March 2nd . Collective synthesis after Kenya and Uganda. Meeting with D. Bourzat to summarise mid-consultancy items. Preparation of the second half of the mission.
- Sunday, March 3rd. Departure to Addis (M. Djama, G. Kleitz, S. de La Rocque).
- Monday, March 4th. 9-16 H: Discussions with FITCA Ethiopia team (K. Miressa, S. Flint, Dr Debebe) and H.M Solomon: General presentation of tsetse and tryps control activities in FITCA Ethiopia, planning of the work. 4-5 PM : meeting with the Head of Animal & Fisheries Resources Development, Ministry of Agriculture (H. Gebru)

- Tuesday, march 5th . departure to Nekemte; visit of the Wama Valley and of the veterinary post, Arjo Goudeton
- Wednesday, March 6th . Field trip in low Idessa Valley ; departure to Bedele
- Thursday, March 7th. Discussions with FITCA & NTTICC, field visit in FITCA control sites, upper Idessa valley, discussion with local communities
- Friday, March 8th . departure to Addis. Visit of the ILRI station, the Ghibe Valley
- Saturday, March 9th. Flight Addis-Nairobi. Collective work.
- Sunday, march 10th. Collective work. Meeting with D. Bourzat. Arrival of P. Poilecot and B. Toutain
- Monday, March 11th. Collective work. Debriefing with ILRI team (R. Reid, J. Maitima, M. Nyabenge). Departure of M. Njama & G. Kleitz
- Tuesday, March 12th . briefing of P. Poilecot and B. Toutain. Work on the report
- Wednesday, March 13th. Work on the report, conference in ILRI.
- Thursday, March 14th . Work on the report, departure (S. de La Rocque)

B. Key-people met

Name	Institution	Position	Address
FITCA Regional			PO Box 30786 Nairobi
H. M. Solomon	OUA/IBAR	Project Officer	Solomonhailemariam@oua-ibar.org
K.H. Politzar	OUA/IBAR	FITCA Regional Co-ordinator	heintzpolitzar@oua-ibar.org
D. Bourzat	Cirad-emvt	SEMG/FITCA Co-ordinator	d.bourzat@cgiar.com
B. Rey	UE	Advisor	
J.M. Maitima	ILRI/FITCA Nairobi (Kenya)	Ecologist	j.maitima@cgiar.org
M. Nyabenge	ILRI/FITCA Nairobi (Kenya)	GIS and RS specialist	m.nyabenge@cgiar.org
L.M. Awori	FITCA Nairobi (Kenya)	GIS officer	maida38@hotmail.com
ILRI			PO Box 30709 Nairobi
R. Reid	ILRI/ PLE programm	Ecologist, co-ordinator of the PLE	r.reid@cgiar.org
B. Perry	ILRI/epidemiology	Head of epidemiology unit	
T. Robinson	ILRI/ PLE programm / Oxford Univ.	Remote sensing specialist	t.robinson@cgiar.org
R. Kruska,	ILRI/ PLE programm	GIS analyst, systems analysis	r.kruska@cgiar.org
J. McDermott	ILRI	Epidemiologist	j.mcdermott@cgnet.com
FITCA Kenya		Box 30786 Nairobi,	PO Box 261 Busia
B. Bauer	FITCA kenya	Technical Assistant	FITCAnn@iconnect.co.ke
F. Oloo	FITCA kenya	Liaison officer	oloo@net2000ke.com
S.M. Karanja	FITCA Kenya / KETRI	Veterinary, PhD student.	muturikaranja@yahoo.com
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KETRI			P.O. Box 362, Kikuyu
G.A. Murilla	Ketri / Nairobi	Chief research Officer & Deputy Director	
G. Muriuki	Ketri / Nairobi	Environment and land use	gymuriuki@yahoo.com
Kenya national services			
Chenza	Busia	District Officer n°1	
S.O. Orot	District of Bondo	District Veterinary Officer	
J.M. Merisya	District of Teso	District Veterinary Officer	
Murekefu	District of Busia	District Veterinary Officer	
FITCA Ouganda			
A. Gidudu	FITCA	National project co-ordinator	npc.FITCA@utlonline.co.ug
S. Gould	FITCA	Technical Assistant	simongould@infocom.co.ug
C. Laker	FITCA	Agricultural economist	Cdl@africaonline.com
LIRI			
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M. Odiit	LIRI Tororo (Uganda)	Doctor, LIRI/FITCA component	Jenyaru@africaonline.co.ug
L.M.A. Okedi	LIRI Tororo (Uganda)	entomologist, tsetse specialist	
J. Enyaru	LIRI Tororo (Uganda)	Diagnosis of human trypanosomosis	
J. Okello-Onen	LIRI Tororo (Uganda)	Tick-borne diseases	
FITCA Ethiopia			
K. Miressa	FITCA	National project co-ordinator	
S. Flint	FITCA	Technical Assistant	
Dr Debebe	NTTICC	Senior officer	
M. Begna	NTTICC	Technical team leader	
Ethiopia national services			
H. Gebru	Ministry of Agriculture	Head, animal & fisheries resources development	
Cirad			
S. de La Rocque	Cirad-emvt/Cirdes	Entomologist. Bobo Dioulasso	stephane.delarocque@cirad.fr
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G. De Wispalaere	Cirad-emvt	Montpellier	gerard.de_wispalaere@cirad.fr
R. Lancelot	Cirad-emvt/isra-l nery	Epidemiologist. Dakar	renaud.lancelot@cirad.fr

C. Available information

Because little time was available for data collection, the following list is far from extensive. We wish to thank the ILRI team, and specially J. Maitima for his collaboration. The main information supports are the following :

- Cartographic data from the IFAD project (see in appendix);
- Working papers: survey questionnaires, extracts of Landsat images;
- Preliminary results of the national projects:

Kenya :

- Entomological investigation carried out by Ketri before the beginning of FITCA interventions;
- Monthly entomological follow-up data in the Angurai district;
- Location of protected O-grazing Units;
- Exhaustive census of farmers and questionnaires (in process);

Uganda :

- Entomological investigation by Liri in Eastern Uganda (in progress, distribution map of *G pallidipes*);
- Area-wide entomological investigation by FITCA (in progress);
- Parasitological survey by FITCA (165 villages, 60 animals per village, in progress);
- Extensive records of HAT (individual cases and village locations);
- Census of cattle population, production systems and socio-economics: field work finished, information to be processed and analysed;

Ethiopia :

In Ethiopia, the information are mainly from local tsetse surveys.

- Regular entomological survey carried out by the NTTICC (annual reports);
- Report of the FAO control projects:

  - TCP / ETH / 4523, 1986: Assistance to tsetse and trypanosomiasis control;

  - TCP / ETH / 6755, 1987: Emergency assistance to tsetse and trypanosomiasis infestation;

  - UNDP / FAO / ETH / 88 / UO1, 1988: Tsetse control and related development in the Upper Idessa Valley;

- A recent national study of the Ministry of Agriculture and the WBISPP (Woody biomass inventory and strategic planning project, 1997-2001) has produced some useful information (see appendix).

This limited amount of information might be related to "*the lack of exposure to wider development concepts [which] has lead to weak emphasis on the need to select area by using carefully analysed data on land-use and economic planning, community development and potential environmental impact... in addition to technical information of the various rates of fly infestation and disease prevalence. Hence, area-specific data on land-use planning, land resources potential inventory, human and livestock populations, tsetse abundance and distribution and trypanosomosis epidemiology are not available*[3]".

Clearly, the first year of the FITCA program should be devoted to disease assessment and baseline surveys (tsetse, trypanosomosis, socio-economics, environmental and land use) in the Oromiya region, and to capacity building in technical staff which is still very few in number.

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[3] Farming in tsetse control areas of Eastern Africa. Ethiopia national component. Addendum to the

V. Concepts and analysis strategy

A. Relationships between landscape, disease risk and control measures

1. Conceptual scheme

The system of interest (Fig. 3) is defined within an agro-ecosystem (i.e. "changes" should be analysed conditionally on each agro-ecosystem), managed by human communities and made up of (i) the landscape (abiotic / biotic features), (ii) disease risk (tsetse challenge and ATT / AHT prevalence) and (iii) the control measures (FITCA or whatever). The goal of EMMC is to monitor this system to provide useful information to human communities, veterinary and environmental services, and FITCA staff.

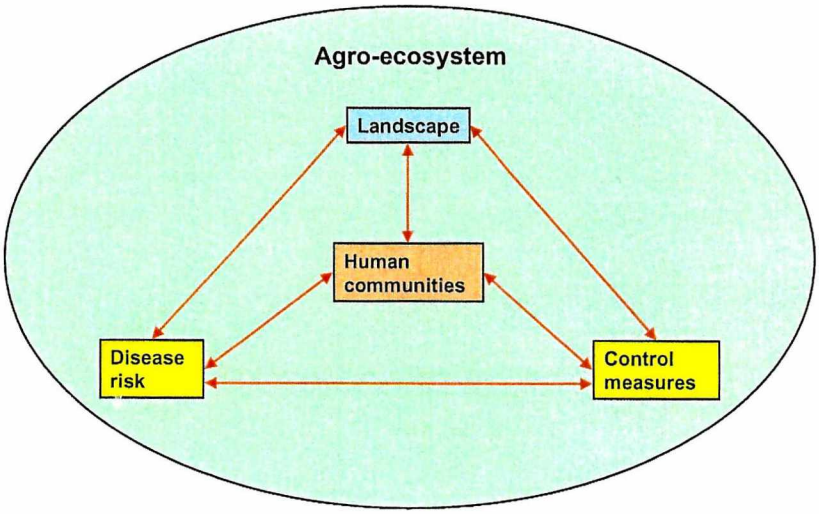


Fig. 3. Conceptual scheme of the system under study

Within this system, the main working hypotheses are symbolised on Fig. 4 and summarised in Table I.

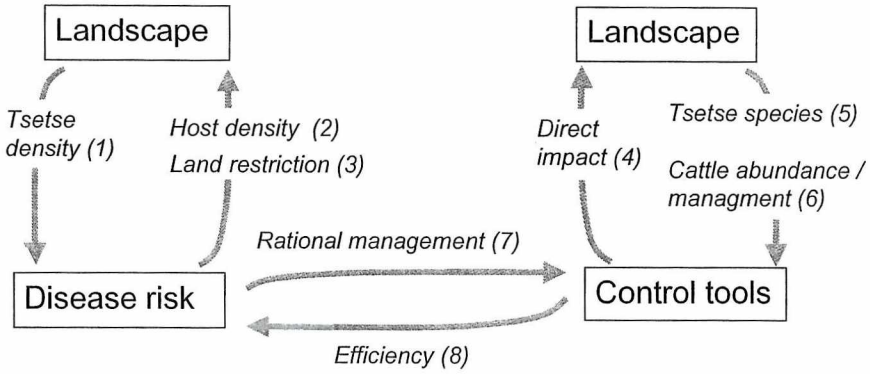


Fig. 4. Main working hypotheses for EMMC

Table I. Key features and working hypotheses

Key features	Hypothesis
1. Tsetse density	Tsetse abundance is linked with the vegetation, water and density of available hosts.
2. Host density	AAT is a main causes of death for cattle, has an impact on cattle density and thus on the land pressure / oxen power. AAT / HAT is a reason of departure for people.
3. Land restriction	AAT is a main constrain for land use, with some no-cattle land.
4. Direct impact	Toxicology
5. Tsetse species	Control measures and their intensity are different according to the tsetse species.
6. Cattle abundance and management	Live baits might be used if cattle density is high enough. O-grazing units might be used in intensive-production areas.
7. Rational management	Farmers and local in-charge people are able to adapt the tools, i.e. have an appropriate level of information.
8. Efficiency	Interventions are well made, i.e. farmers and local in-charge people are trained.

2. Description of the hypotheses

(1) Tsetse distribution and abundance are related to the structure of the landscape, in terms of favourable habitats (thicket / fallow land for *G. pallidipes*, woody savannah for *G. m. submorsitans*, riparian vegetation and / or peri-domestic habitats for *G. tachinoides* and *G. fuscipes*), the presence of more or less specific feeding hosts (wild ungulate for *G. m. submorsitans*, reptiles / cattle / human for the riparian species, cattle / human for *G pallidipes*).

(2) Disease risk has an important impact on the animal and human compound of the landscape. Foci result in high cattle mortality, with consequences on land-use and land-cover (oxen availability), on the management systems and the socio-economic panorama. To an extreme degree, and especially in case of human disease, the risk may lead to the abandonment of some areas. Such a situation seems to have recently occurred in the Angurai location (Busia district, Kenya). The consequence is the increase of fallow lands, caused by the lower human density and the lack of animal draught.

(3) Animal trypanosomosis is one of the main constrain for the extent of cultivation areas, in limiting the number of oxen and the development of fertile land.

(4) Control methods may have a direct impact on some compounds of the landscape, with polluting residues and effects on no-targeted organisms (biodiversity).

(5) The control methods (types of traps, screens) and their application (savannah, hydrographic network) may change according to the species of flies and the major sites of transmission.

(6) Cattle abundance and cattle management have an influence on the choice of the control methods: pour-on applications or aspersion if cattle regularly visit the flies habitats (waterpoint for example), impregnated nets in O-grazing units (used as a tsetse-attractive system) in areas where such a farming system is possible (socio-economic context and availability of forage).

(7) The farmers are trained and local in-charge people are able to assess the risk and adapt the strategies:

- a high risk of sleeping sickness leads to emergency control measures targeted at human health. An example is the mass detection and treatment of positive cases implemented in Uganda.
- A high risk of AAT, associated with high tsetse densities, leads to control measure aiming at reducing the number of flies : insecticide-impregnated targets or traps.
- A high risk of AAT, associated with low tsetse densities leads to cattle-based control measures : pour-on or spray insecticides.
- A low risk of AAT in more market-oriented systems (dairy production with exotic breeds or crossbred cattle) may lead to other control measures such as net-protected 0-grazing units.

(8) Control measures are efficient and correctly implemented. Tsetse flies and tryps are also sensitive to the drugs which are used.

Interactions of human communities with each of the three components (disease risk, control measures and landscape) are obvious and need not be detailed here. However, the occurrence of confounding factors might result in unexpected dynamics. For example, a high incidence of malaria or AIDS, or the collapse of an economical speculation (milk, sugar cane, cotton...) could lead to a negative balance of human demographics or rural exodus. Therefore, many cultivated fields might turn back to fallow lands and favour the return of tsetse flies. The present sleeping sickness epidemics in Uganda is thus thought to be related to the collapse of governmental health and livestock services after a period of social troubles (cattle raids, etc.) and mass population movements.

3. Comments

- A study limited to the relationships between control measures and landscape (hypotheses 2, 3 and 4) would be too restrictive. Many other factors might have major impacts on landscape evolution (climate change, regional trends in rural economics, social disorders). Thus, impact assessment of the factors of interest (including tsetse control) should consider such possible confounding factors and

- It would be impossible to define treated and control areas (both for ethical and practical reasons) to get a quasi-experimental design enabling to draw valid inference from a random sample of sites. Instead, we propose to select a panel of different sites included in the FITCA area (i.e. with the full set of control measures implemented in the frame of the FITCA), according to their representativeness of the epidemiological situations described above. Therefore, focus should be put on picking up relevant indicators of these contrasted situations and to monitor the changes.
- Different situations are encountered in the national FITCA components (size of the areas, disease and tsetse patterns, landscape and land use, control measures and policies):

- in Kenya, the project is oriented towards confining disease (AAT) at an economically acceptable level;
- in Uganda, priority is given to the eradication of HAT in the Iganga, Kamuli, Jinja, Mukono and Tororo districts (according to Odiit, 1999, 4,649 human cases were recorded, i.e. an annual cumulative incidence of 46 / 100,000 from 1988 to 1998, at the most);
- in Ethiopia, a tsetse-eradication strategy was retained to free new agricultural lands in (potentially) high-production areas.

The information system should therefore be flexible enough to face these different epidemiological situations, control strategies and intervention scales and still provide useful information at any level (village, district, national FITCA area, overall). It is doubtful, however, that the same precision might be reached in each country.

B. Conceptual framework

1. Overall scheme

After exposing the concept and working assumptions, we should define the different data domains to be described in the information system, with their specific indicators (see also the reports on data harmonisation (Gilles Fournié) for the organisation of the database and on agro-pastoral and agro-ecological baseline survey methodology (J. Maitima, P. Poilecot, B. Toutain) for the description of the indicators). These data domains and their relationships are shown in the graph below.

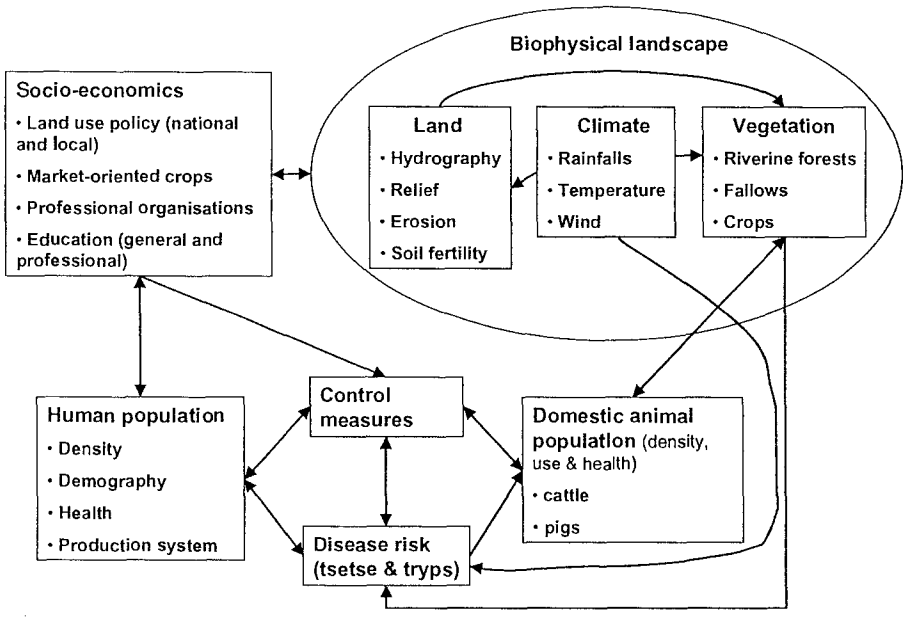


Fig. 5. Data domains and their relationships to monitor disease risk, control measures and environmental changes

2. Data domains and data requirements

2.1. Disease risk and control measures

Table II. Monitoring of disease risk

Domain	Type of information	Availability [a]	Source	Scale
Tsetse flies				
Population	Species, density, species ratio	+++	FITCA	CS [b]
Distribution	Habitat and dispersion	++	FITCA	CS
Behaviour	Feeding hosts	+	FITCA	CS
Infection	Tryp. infection, type of tryp.	++	FITCA	CS
Trypanosomes				
Animal tryps	Cattle prevalence, dogs	+++	FITCA	CS
Human tryps	Sleeping sickness	+++	FITCA	CS
Host and Transmission				
Animal	Cattle density, cattle land-use	+++	FITCA	CS
	Wildlife density, dogs	+		CS
Human	human settlement	+++	FITCA	CS
Transmission	Proximity of tsetse habitats	++	FITCA [c]	CS

[a] *+++ readily available ; ++ easy; + should be possible*

[b] *Control sites selected by the FITCA - EMMC team*

[c] *via GIS query*

The choice of control measures depends on local conditions and project strategy:

- Impregnated targets (screens) are necessary when cattle density is low or no agreement was obtained to use life baits. They are considered as public good: farmers communities must be involved to achieve a sustainable tsetse control and training is necessary to convict them on the interest of their active contribution/participation.

- Aspersion or *pour-on* techniques (live baits, crush-pen committees, etc.) require higher involvement of farmers organisations to achieve efficiency and sustainability (costs and maintenance, training) and are more on the side of private goods. On the other hand, they are efficient for ticks and tick-borne-diseases control. From a community viewpoint, efficiency changes with time should be regularly assessed. The impact of aspersion strategy on flies populations also depends on the relative location of cattle and tsetse habitats.
- Net-protected 0-grazing units are clearly private initiatives (depending on farmers awareness i.e. popularisation by extension services / programmes (Echessah *et al.*, 1997)). They rely on a specific production system (market-oriented, intensive system with high labour and food inputs) which cannot be imposed to farmers. Moreover, like for aspersion techniques, tsetse population must be monitored to assess the impact of this measure.

2.2. Landscape

Table III. Animal and human populations, socio-economical data

Data domain	Type of information	Availability	Source	Scale
Land-use policies crash crops	Crops surfaces (cotton, tobacco...)	+++		District
	Land tenure policy	+++		District, country
Farmers organisation	Farmers field school	+++		District
	Farmers training centre	+++		District
	Crush-pen committee	+++	FITCA	District
Local demography	Number, stakeholders, age distribution (census data)	++	Central Bureau of Demography	Village
Education, health	Level of education (school rate)	+++	FS [a], FITCA	Village
	Rearing and management practices	+++	FITCA	Village
	Level of information	++	FS, FITCA	Village
Health	HAT, AIDS, Malaria	+	MSF, WHO	?
Marketing	Marketing channels	+	FS	District
	Market location	+++	FITCA	Village
Farming systems	Farming systems, spatial organisation	++	FS, FAO africover, FITCA	Village

[a] *Field surveys*

Table IV. Biophysical landscape

Domain	Type of information	Availability	Source	Scale
Physical geography	Agro-climatic maps, rainfalls, ETP, temperature	+++	ILRI	Division
	Hydrography drainage, roads, villages...	+++	ILRI database	1/25 000
	Digital elevation model, type of valley, flat area, hills	++	FAO, Africover Topo. Elevation line	Village
	Soil, erosion indicators, soil fertility, overgrazing	++	Icraf Field survey	Village
Vegetation				
Land use	Crops, residual forest, forest gallery	+	Remote sensing / field survey	1/10 000
Land-cover	Fallow lands, bush... Structure of units	+	Remote sensing / field survey	
Phyto-sociology	Indicator of changes	+	field survey	

C. Observation scales

Impact assessment of tsetse- and tryps-control measures on environment will require different observation scales according to the local situations (cf. report on landscape and land use analysis, G. de Wispelaere).

✔ In Kenya and part of Uganda, FITCA areas are characterised by intensive land use (no natural tsetse habitat left, soil-erosion and soil-fertility issues, direct insecticide impacts, grazing pressure etc.). A high-resolution scale is needed to understand the relationships between landscape changes and epidemiological situations (proportion and age of fallow lands, importance of hedges, secondary vegetation growth, all habitats of *G. pallidipes*).

✔ In wetlands or pastoral areas (other FITCA areas in Uganda), wider scales should be sufficient. A first step might be to draw a middle-resolution map of landscapes and to refine spatial data, indicators and analysis in a second step.

✔ In Ethiopian frontier-farming systems, more details will be required on elevation (slopes), settlement dynamics, land-use and land-cover changes. High-resolution scale would be needed to describe and understand the local dynamics.

D. Selection of pilot areas

They were selected within a set of proposals arising from Kenyan and Ugandan FITCA components, according to contrasted landscape (agro-ecological systems, vegetal formations, land use, relief and hydrography) and disease-risk (relative abundance, including presence / absence, of the different tsetse species, cattle density, AAT prevalence, HAT incidence) situations.

1. Kenya

Pilot areas are all located in the warm, sub-humid, tropical zone (Fig 6 and Table V).

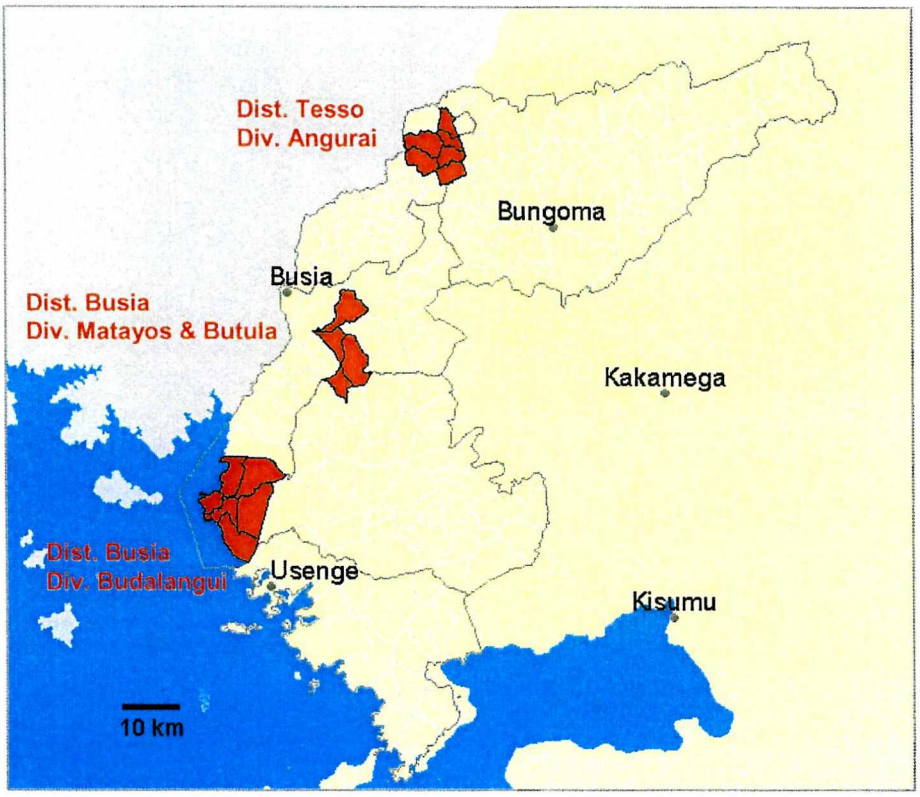


Fig. 6. Location of pilot areas in Kenya. Selected areas are drawn in red.

Table V. Main features of the selected pilot areas in Kenya

Thema	Angurai	Butula	Budalangui
Length of growing period (days)	240-270	210-240	150-180
Land use: A Agriculture, S swamps, W waterbodies	A	A / S	A / S / W
Population density (98)	220	> 50	< 20
Percentage of crop	30 %	> 50 %	< 20 %
Livestock density 1995 (head km^{-2})	140	50	60
Livestock density 1998 (head km^{-2})	40	60	85
Human trypanosomosis	+	+	?

2. Uganda

Pilot areas are also located in the warm, sub-humid, tropical zone (Fig. 7). Selection criteria were more stringent: location in places where HAT recently occurred and representativeness of large agro-ecological systems (so that inference on results observed in the sample might involve a significant proportion of the FITCA intervention zone). The selection was undertaken according to available map data and after meetings with the Ugandan FITCA staff (M. Odiit, C. Laker). Their main features are summarised in Table VI.

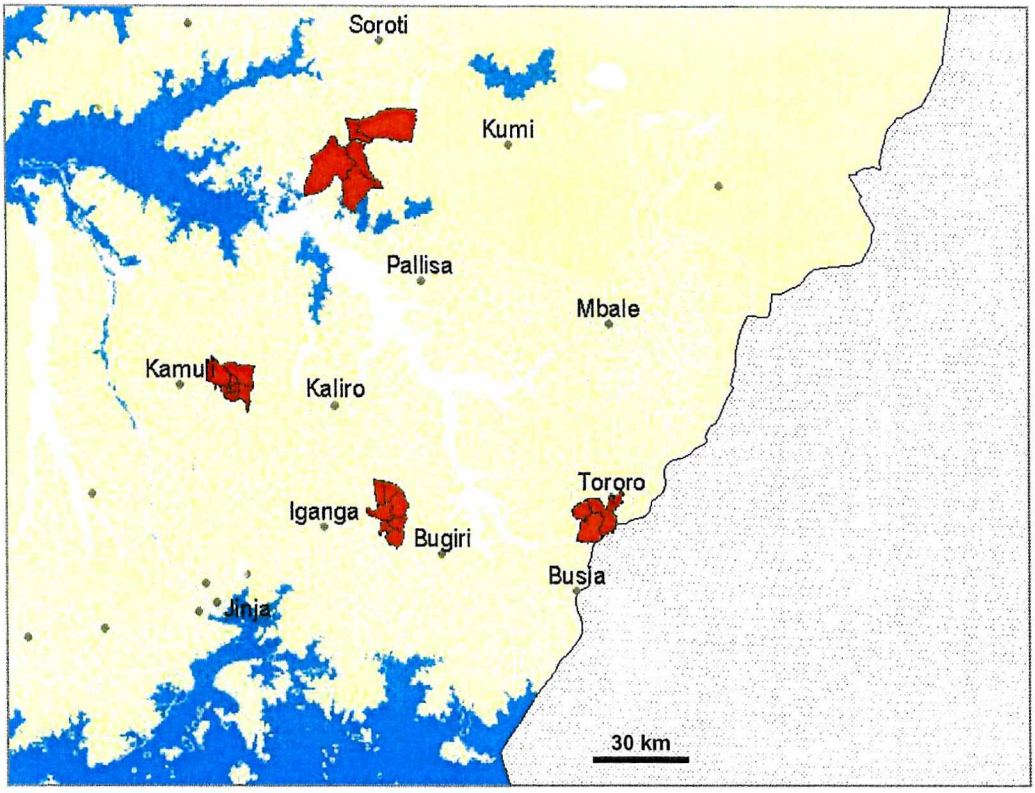


Fig. 7. Location of pilot areas in Uganda. Selected areas are drawn in red.

Table VI. Main features of the selected pilot areas in Uganda

Features	Selected areas			
	Kamuli	**Serere**	**Tororo**	**Iganga**
Length of growing period (days)	240-270	240-270	240-270	240-270
Land use: farmland (F) / grassland (G)	F	F / G	F / G	F
Population density (inhabitant km^{-2})	>200	50-200	>200	>200
% crop	> 85 %	50 %	> 85 %	> 85 %
% woodland / forest	< 2%	< 2%	< 2%	< 2%
% wetland	2 %	7 %	0 %	0 %
Livestock density 1995 (head km^{-2})	20-50	< 5	> 50	20-50
Livestock density 2000 (head km^{-2})	20-50	20-50	> 50	20-50
Trypanosomosis risk[a]	80-100	80-100	50-70	60-80

[a] *ILRI, 2002. Decision support for trypanosomiasis control in Uganda. IFAD /ILRI/ Ministery of Agricuture, Animal Industry and Fisherie, the Republic of Uganda, 23 p.*

Field visits allowed us to collect further information:

- Kamuli is a high-potential area for cultivation: coffee, maize, banana, etc. Many cross-bred cattle are found but AAT prevalence is high (20%) due to *G. fuscipes* (no *G. pallidipes*);
- Serere is a drier area with a lower agricultural potential (millet, sorghum, maize). It is made up of low grasslands, open flats and communal lands. Human population is low and the only tsetse species is *G. fuscipes* (no *G. pallidipes*);

- Tororo is a cultivated area (millet, sorghum, cassava) with grasslands and very few trees. The potential for agriculture is low. There is a middle-to-low density of local-breed cattle and a moderately high prevalence of AAT (10 - 15%). The dominant tsetse species is *G. fuscipes* with a low density of *G. pallidipes*.
- Iganga area is a wetland, with rice growing and swamps elsewhere. Its a place of recent human settlement with a middle cattle density and moderately high prevalence of AAT (15%). There are many *G. fuscipes* and no *G. pallidipes*.

3. Ethiopia

Basic data are not available and will not be collected to identify the different epidemiological situation at the FITCA area scale[4]. Discussions with the technical teams of NTTICC were useful but disease risk assessment (namely in the situation of the riparian fly *G. tachinoides*) and cattle distribution should need further investigations.

Moreover, the control strategy, i.e. the progressive eradication of the tsetse flies behind a geographical front, is different of the priority-zone strategy implemented in Kenya and Uganda (priority area). As a consequence, it is difficult to anticipate a schedule with control and comparative site in the different part of the area.

However, it might be possible to draw an agro-ecological zoning at the FITCA-area scale, using data from the Biomass project (Anonymous, 2001). This will take several months and might lead to rough risk indicators, relevance of which should be assessed by field work (tsetse and tryps surveys). The Ethiopian-FITCA STC contract has planned several technical supports, namely with experts in biology, natural resources, forestry and land-use. An aerial survey in Wama and Didessa valleys might be undertaken. We propose to delay the choice of pilot areas until more precise information are available on effective control measures and environment.

VI. Comments

A. Design and utilisation of the information system

The information system (IS) should meet local decision-makers and communities requirements, namely for the type of information which are collected, the observation scale and information return (maps, tables, ...). Data collection should be under the primary

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[4] "The lack of data limits awareness of the scale and scope of the problem". *Farming in tsetse control*

responsibility of national FITCA teams with a regional supervision. Therefore, the regional FITCA team should implement the IS in co-ordination with the local and national levels.

The key point is an accurate definition of epidemiological indicators and information needs for local decision makers. Moreover, the IS should be flexible enough to account for new situations such as local epidemics. The indicators we proposed should be able to do so; we checked, as far as possible, the effective availability of the required basic data.

B. Data collection

Existing methods for the assessment of tsetse-control environmental impact should be used (see the papers of Reid *et al.* and Bourn *et al.* in the list of references) and should form the main body of the regional IS. Most of the information collected with these methods (changes in land use, land cover, animal or plant species, production systems, economic, livelihood and technical indicators) fit the present proposal.

Many disease-risk, landscape-change and control-measure data might be provided by existing data-collection protocols and databases. Missing data might be collected though complementary and focused studies. This report aims defines general guidelines which have to be adapted and refined to the national contexts. The unique experience of the local teams will be useful for this purpose. Some data harmonization is indeed required.

VII. Conclusion

Along with other important policy trends, FITCA programme implements local management of control measures in tsetse infested areas. In this context, EMMC's role is to highlight and model (tables, maps, dynamics and hopefully predictions) the relationships between land-use changes, agricultural dynamics, tsetse populations and trypanosomosis prevalence.

Links between land use changes and Tsetse control have been studied in depth and they identify indirect influence of changes in land-use on tsetse habitat and biodiversity (ILRI, 1997, Reid *et al.*, 1998, Reid *et al.*, 1997, Wilson *et al.*, 1997). Additional sources suggest that land-use changes, subsequent tsetse habitat transformations and cattle management can play a major role in tsetse evolution and epidemiology of trypanosomosis, especially with riverine flies (de La Rocque *et al.*, 2001a,b, Hendrickx, 1999). The quantitative assessment and understanding of the underlying mechanisms are important for the sustainability of the present systemic approach, the validation of the hypothesis and the monitoring of the impact.

Finally, the ability to retrieve appropriate data from the EMMC information system is the cornerstone for giving rural communities and local extension services a central role in tsetse and trypanosomosis control, and thus ensure control sustainability.

ANNEX 1 : AVAILABLE CARTOGRAPHICAL DATA

Kenya

AT THE NATIONAL LEVEL

Theme	Scale	Units	Origine
topographic	national	Topographic unit, numeric format	Kenya survey
soil	national	Soil type, soil composition, land form, geology, drainage, depth	Kenya soil survey
Livestock 96-99	per division	Total livestock for each year	ILRI & Ministry of Agriculture and Livestock
Livestock 97	per agroecological zone	Dairy, Zebu, agro-ecological zones (7)	ILRI & Depart. of Ressources Surveys and Remote Sensing
landuse	national	Broad Landuse unit	unknow
Malaria	per district	Human population 89, 97, 99; endemic or low	Kenya medical Research Institute
1979 Population census data	per sub-location	Nb of male, femelle, Households	Central Bureau of Statistics
1989 Population census data	per sub-location	Nb of male, femelle, Households	Central Bureau of Statistics
1999 Population census data	per sub-location	Nb of male, femelle	Central Bureau of Statistics
length of growing period	national	Nb of days and classification	FOA 1983
1989 Administrative boundary	per district	surface	Kenya survey
1999 Administrative boundary and population	per sub-location	Surface, population data	fitted with 1989 population data
Crops	per sub-location/division	Cultivated surface area in hectares (food crops)	ILRI & Ministry of agriculture
Cattle from 96 to 99	per division	Nombre of cattle	ILRI & Ministry of agriculture

In the future : Africover, landuse map, FAO

AT THE DISTRICT LEVEL

Theme	Scale	Units	Source
Agro-ecological zone	District level	Identification names for agro-ecological zones in Kenya	GTZ project
1998 Cattle density	per location	Total cattle from 94 to 98	ILRI livestock database.
Culture in 1997	5 km grid & per location	Percentage of cultivated area	Departt of Resources surveys and Remote sensing
Cattle from 94 to 98	per division	Number and density	ILRI & Depart. of Resources Surveys and Remote Sensing
1989 Human population density	per sub-location level	Number of man/female and density	extracted from the national population census.
1997 & 99 Administrative boundary	per sub-location	2-3-4-5th Level administrative	

Uganda

AT THE NATIONAL LEVEL

Theme	Scale	Units	Origine
1997 Administrative boundary	national, per parish		
Topographic data	national	roads, drainage…	topographic maps
1991 human population data	national	Number of male/females and density	
1998 Wildlife and forest protected area	national	Identification code	National Biomass Study, Ministry of Natural Resources, and Uganda Wildlife Authority
1996 Land use\cover data	national, 1 km x 1 km resolution	12 units	derived from SPOT XS images of February 1992 to December 1992, Aerial photos of 1995, National Biomass Study, Department, Ministry of Natural Resources
Length of growing period	Africa/ national	Number of days, agro-climatic area	FAO 1983
1995 Crops production data	National, per district	Different crop production in percentage	International Centre for Tropical Agriculture (CIAT)
1987-94-95 Livestock data	national, per district/parish	Cattle, pigs, goats, sheep	Ministry of Animal Industry and Fisheries

AT THE DISTRICT LEVEL

theme	scale	units	origine
1994-97-99-2000 Cattle density	Sub-country	Number of cattle	
1995-2000 Crops production data	National, per district	crop production in percentage (2000 not complete)	
1991 population	Per parish	Number of males/females	
1997 Administrative boundary	districts	Parish, human population 1991	

Ethiopia

AT THE REGIONAL LEVEL

Theme	Scale	Units	Origin
Vegetation cover	1/250 000 - woreda	Landcover/vegetation/cultivation : 56 units	Woody biomass inventory and strategic planning project, notably from Landsat TM
crops	wereda	Crop percentage cover and hectares (94-2000)	Central Statistical Autority
natural grazing land	1/250 000 - woreda	Extracted from the vegetation cover : 27 units	Woody biomass inventory and strategic planning project
Forage products	1/250 000 - woreda	Natural products, crops products, ...	Woody biomass inventory and strategic planning project
Livestock data	1/250 000 - woreda	Livestock density, from 94 to 99 Main livestock production systems, grazing management patterns and hers movements : 3 types Natural grazing types : 10 types	Woody biomass inventory and strategic planning project
Landuse systems	1/250 000 - woreda	Cereal farming, enset farming, woody fallow cultivation, agro-poastoral and pastoral : 12 units	Woody biomass inventory and strategic planning project
landuse	1/250 000	Cover percentage, description, name	Ministry of Agriculture
Human population	weredas	Males, females, total and density	Ethiopian Mapping Autority / Central statistical autority
Length of growing period	Africa	Number of days, agro-climatic area	FAO 1983

ANNEX 2 : REFERENCES

Anonymous. Terms of reference for the enviromnental monitoring and managment component of the Fitca project, Nairobi, European Union, 12 p. 2000,

Anonymous. Report on natural grazing lands and livestock feed resources (per regional states). Woody biomass inventory and strategic planning project, Ministery of Agriculture of Ethiopia. 2001,

Bauer, B. & Oloo, F. progress report on farming in tsetse controled area (FITCA-Kenya project). 2001, 26th Meeting of the International Council for trypanosomiasis Research and Control, Ouagadougou, 1st - 5th october 2001,

Bourn, D., Reid, R., Rogers, D. J., Snow, W. F. & Wint, W. Environmental changes and the autonomous control of tsetse and trypanosomis in sub-saharan Africa. 2001. 248 p.

D'Amico, F. Rôle de *Glossina fuscipes fuscipes* Wewstead, 1910, dans la transmission des trypanosomoses bovines en Afrique centrale. Cas de la zone d'élevage d'Ouro-Djafoun (République centrafricaine). Thèse Doct. Sci., Univ. Montpellier II, 1993, 160 p.

de La Rocque, S., Augusseau, X., Guillobez, S., Michel, V., De Wispelaere, G., Bauer, B. & Cuisance, D. The changing distribution of two riverine tsetse flies over 15 years in an area increasingly occupied by agriculture in Burkina Faso. *Bulletin of Entomological Research*, 2001a, 91, 157-166.

de La Rocque, S., Michel, J. F., Cuisance, D., De Wispeleare, G., Augusseau, X., Guillobez, S. & Arnaud, M. Le risque trypanosomien, une approche globale pour une décision locale. 2001b. Edition du CIRAD, Montpellier, 152 p.

Echessah, P. N. S., Swallow, B. M., Kamara, S. W. & Curry, J. J. Willingness to contribute labour and money to tsetse control: application of contingent evaluation in Busia District, Kenya. *World Development*, 1997, 25, 239-253.

Faye, B., Waltner-Toews, D. & McDermott, J. From "ecopathology" to "agroecosystem health". *Preventive Veterinary Medicine*, 1999, 39, 111-128.

Fevre, E., Coleman, P. G., Odiit, M., Magona, J. W., Welburn, S. C. & Woolhouse, M. E. J. The origine of a new sleeping sickness (T.b.rhodesiense) outbreak in eastern Uganda. 2001, 26th Meeting of the International Council for trypanosomiasis Research and Control, Ouagadougou, 1st - 5th october 2001,

Ford, J. The role of the trypanosomiases in African ecology. 1971. Clarendon press, Oxford, UK.,

Hendrickx, G. A geo-referenced decision support methodology towards trypanosomosis managment in West Africa. Thesis, University of Gent, Gent, Belgium, 1999, 176 p.

ILRI, Final Technical Report for Project Number, R5874 entitled: Collaborative research on the environmental and socio-economic impact of tsetse and trypanosomosis control in southern Africa, 1 january 1994 to 31 march 1997, Nairobi, pp. 278.

ILRI, Decision support for trypanosomiasis Control in uganda. ILRI / IFAD / Ministery of Agricuture, Animal Industry and Fisherie, the Republic of Uganda, Nairobi, pp. 23.

Itty, P., Swallow, B. M., Rowlands, G. J., M., W. & D'Ieteren, G. D. M. The economics of village cattle production in a tsetse-infested area of southwest Ethiopia. *Prev. Vet. Med.*, 1995, 22, 183-196.

Katabazi, B. K., Okedi, L. M. A. & Abila P.P. Farming in tsetse controled area (FITCA) Uganda: tsetse apparent densities and species composition in south eastern Uganda. 2001, 26th Meeting of the International Council for trypanosomiasis Research and

McCann, J. C. People of the Plow: An agricultural history of Ethiopia, 1800-1990. 1995.

Nagel, P. 1993. The effect of tsetse control on natural resources, *In: A systematic approach to tsetse and trypanosomiasis control. Proceedings of the FAO Panels of Experts.*, Rome, Italy, FAO, Animal Production and Health Paper n° 121, 104-119.

Nigatu, W., Abebe, M., Hadis, M. & Lulu, M. The effect of resettlemement and agricultural activities on tsetse populations in Gambella, south-western Ethiopia. *Insect Science and its Application*, 1992, 13, 763-770.

Odiit, M. & Enyaru, J. Human African trypanosomiasis in south eastern Uganda, 1988 to 1998: a comparative epidemiological analysis. 1999, OAU/STRC International Scientific Council for Trypanosomiasis Research and Control, Mombassa, Kenya, 27 sept-1oct 1999, 114-119.

Reid, R., Kruska, R. L., Deitchmann, U., Thorthon, P. K. & Leak, S. G. A. Population human growth and the extinction of the tsetse fly. *Agriculture, Ecosystems and Environment*, 2000, 77, 227-236.

Reid, R. s. & Ellis, J. E. Impact of pastoralists on woodlands in south Turkana, Kenya : livestock-mediated tree recruitment. *Ecological Applications*, 1995, 5, 978-992.

Reid, R. S. & Swallow, B. M., Final Technical Report for IFAD TAG grant to ILRI: An Integrated Appproach to the Assessment of Trypanosomiasis Control Technologies and their Impacts on Agricutlural Production, Human Welfare and Natural Resources in Tsetse Affected Areas of Africa, phase 1,. pp. 95-106. ILRI, ICIPE, Nairobi.

Reid, R. S., Swallow, B. M. & Brent, M., Final Technical Report for IFAD TAG grant 284 - ILRI: An Integrated Appproach to the Assessment of Trypanosomiasis Control Technologies and their Impacts on Agricutlural Production, Human Welfare and Natural Resources in Tsetse Affected Areas of Africa, phase 1,. pp. 95-106. ILRI, ICIPE, Nairobi.

Reid, R. S., Wilson, C. J., Kruska, R. L. & Mulatu, W. Impact of tsetse control and land-use on vegetative structure and tree species composition in south-western Ethiopia. *Journal of Applied Ecology*, 1997, 34, 731-747.

Rogers, D. J. & Wint, W., Toward identifying priority areas for tsetse control in East Africa. FAO, Rome, Italie, 46 p.,

Slingenbergh, J. Tsetse control and agricultural development in Ethiopia. *World Animal Review*, 1992, 70/71, 30-36.

Wilson, C. J., Reid, R. S., Stanton, N. L. & Perry, B. D. Ecological Consequences of controlling the tsetse fly in southwestern Ethiopia: effects of land-use on bird species diversity. *Conservation Biology*, 1997, 11, 435-447.

Wint, W., kilometre resolution tsetse fly distribution maps for the lake Victoria basin an West Africa. FAO/IAEA joint Division, Vienna, Austria, pp. 11,