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Farming in Tsetse Controlled Areas

FITCA

FARMING IN TSETSE CONTROLLED AREAS
FITCA

Environmental Monitoring and Management Component

E M M C

Project Number : 7.ACP.RP.R. 578

Multidisciplinary study of landscape in tsetse area, Angurai, Teso District (Western Kenya)

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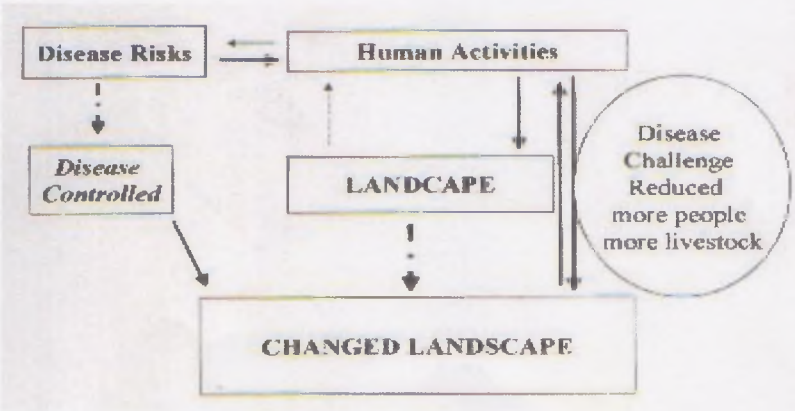
Translation by Jean NDIKUMANA, ILRI

October 2003



Natural Resources Institute

FITCA EMMC Report Number M1E

CIRAD

FITCA-EMMC

Multidisciplinary study of landscape in tsetse area, Angurai, Teso District (Western Kenya)

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Table of Contents

Table of Figures

Table of Tables

OVERVIEW: FITCA Project

The regional project FITCA (Farming in Tsetse Controlled Areas) has a general objective to integrate tsetse control activities into the farming practices of rural communities such that the problem of trypanosomosis can be contained to the levels that are not harmful to both human and the livestock and environmentally gentle and integrated into the dynamics of rural development and are progressively handled by the farmers themselves. The Inter-African Bureau hosts the project for Animal Resources of the African Union (AU-IBAR) and covers areas with small scale farming in Uganda, Kenya, Tanzania and Ethiopia.

EMMC (Environmental Monitoring and Management Component) is the environmental component of FITCA. It is implemented by ILRI in collaboration with CIRAD (as member of SEMG, Scientific Environmental Monitoring Group). This regional component has been charged with the responsibility of identifying of monitoring indicators and methodologies, as well as the development of an environmental awareness among the stakeholders. It contributes to propositions of good practices and activities mitigating the impacts and rehabilitating the threatened resources likely to result directly or indirectly of tsetse control and rural development.

The FITCA EMMC project was written by Dr. Robin Reid of the International Livestock Research Institute (ILRI) a future Harvest Centre supported by CGIAR (Consultative Group for International Agricultural Research).

The present report has been prepared under the responsibility of the leading group of EMMC:

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SUMMARY AND KEY WORDS

Due to the rampant trypanosomosis epidemics in Africa, international organisations developed a Programme Against African Trypanosomosis (PAAT). The Farming in Tsetse Controlled Areas (FITCA) project in Kenya, which was launched in July 2001, is a component of PAAT. Its major objective is to control the tsetse fly populations in selected zones. The tsetse fly is the vector of the pathogen causing trypanosomosis.

The selected zones have shown an important rate of trypanosomosis and a high level of tsetse population, which have significant adverse effect on animal production and therefore on agricultural production.

Located in Western Kenya, Angurai is one of the selected zones for the project implementation. A tsetse control mechanism expected to increase livestock and therefore agricultural production has been established in the area. The benefits from such mechanisms can however in the long terms lead to serious adverse effects on the environment. If the utilization of natural resources after such tsetse control mechanism is not properly monitored, ecological imbalance between the human population and the environment might occur.

The Environmental Monitoring and Management Component (EMMC) of the FITCA programme was developed to monitor these potential changes and anticipate potential negative effects. In order to achieve the above objective, there was a need to establish a database. The selected method to establish the database was a thorough study of the landscape. This was done through a multidisciplinary approach involving all the factors, which could have an impact on environmental changes. The factors monitored included; changes in crop and livestock production, vegetation cover, biodiversity (plant and animal), soil erosion and fertility as well as the control of potential trypanosomosis infections and tsetse fly populations.

The establishment of a database was not only necessary to facilitate the monitoring of environmental changes but also to carry out an agro pastoral-ecosystems' comparative study between the various zones of the FITCA project. The first zones compared included the Angurai in Kenya and the Tororo district in Uganda. Although the Malaba river only separates the two zones, they have numerous differences such as in Angurai there is a relatively low level of trypanosomosis occurrence, lower land area under cultivation and a higher number of habitats favourable to tsetse fly proliferation. The tsetse fly habitats in Angurai are mainly *Lantana camara* and *Tithonia diversifolia* shrubby savannah, which proliferate from abandoned fallows or on riverbanks. *Glossina pallidipes* and *Glossina fuscipes* are the two major tsetse fly species for which the ecological conditions are favourable to their proliferation. The presence of tsetse flies in an area inhabited by human population is conducive to the spread of trypanosomosis.

Key words: Trypanosomosis; crop and livestock production; environmental changes; tsetse fly control; utilisation of natural resources.

INTRODUCTION

Trypanosomosis (*nagana* in the Kenya local language) and its vector the tsetse fly are rampant in one third of the African continent. The *nagana* affects most of the domestic ruminants including sheep, goat, cattle and horses. The disease is a major constraint to the agricultural and rural development as it prevents full exploitation of all fertile land by farmers. In the absence of draught animals, farm cultivation is done manually, a slow and exhausting labour resulting into limited planted area and therefore low crop yields, particularly food crops. Besides its adverse effects on animal health, trypanosomosis determines farmers' choice for settlement as well as crop and livestock production, and therefore has serious consequences on land use (FAO, 1998). Western Kenya is a densely populated area where agriculture is the main economic activity. At Angurai located in the north of the Teso district, cassava, cereals and beans are the dominant food crops mainly produced for subsistence purposes as well as for the local market. Cotton and tobacco are the major cash crops.

Reports from the field at Angurai indicate that trypanosomosis epidemics are rampant in the area causing high livestock mortality rate. This is the reason for which the area was selected for the FITCA project (D. Bourzat *et al.*, 2002). The objective of the FITCA programme is to overcome the constraints of the tsetse fly, the sleeping sickness and trypanosomosis and contribute to improved human welfare of rural populations in the fertile and densely populated zones of East Africa i.e. in Western Kenya and Southwest Uganda along the North-East shore of Lake Victoria as well as in Southwest Ethiopia. The programme, which is coordinated by AU/IBAR, includes the coordination of activities at national level, the supervision of activities aimed at environmental impact analysis, which is carried out in collaboration with ILRI, the coordination of the research component of FITCA and the organisation of training workshops (Reid *et al.*, 1998).

The FITCA programme analyses the equilibrium between the population needs in terms of food security, the sustainability of the resources available for their sustenance, the conservation of natural resources and the prevention of environmental degradation.The study focuses not only on crop (increased area under cultivation due to increased number of draught animals) and livestock (increase of the livestock population) production but also on the environmental changes (vegetation, soil erosion and plant biodiversity dynamics) (Reid et al, 1997; Wilson et al., 1997). The introduction of a tsetse control and trypanosomosis eradication component in the framework of the agricultural and overall development is conducive to the improvement of beneficiary populations' welfare while minimizing adverse effects on the environment. In order to take into account the importance and complexity of the negative effects of the tsetse fly and trypanososmosis in the context of the national and regional poverty eradication programs, an interdisciplinary rather than a technology-based approach was promoted (FAO, 1998; J. Maitima *et al.*, 1998). Although tsetse fly and trypanosome biology is well known, the long-term consequences of the interactions between the vectors, the trypanosomosis disease, the human populations and the land use changes are yet to be well understood. The use of tsetse fly traps in the project implementation has significantly reduced the tsetse fly populations. Now that the tsetse fly control system is in place, it is important to investigate the subsequent changes in natural resources as well as the changes in crop and livestock production (D. Bourzat *et al.*, 2002).

PART I: CONTEXT OF THE STUDY

CHAPTER 1: OVERALL OVERVIEW

The selected study site is Angurai in the Teso district of Western Kenya. The study is designed to monitor changes in the landscape so far characterised by a high density of tsetse fly i.e. *Glossina pallidipes* and *Glossina fuscipes*. The two tsetse fly species are vectors of the *nagana* disease, which is particularly rampant in the area, with a particularly high incidence in the Angurai area (*Figure 1: (a) Kenya map, (b) Teso district, (c) Angurai).*

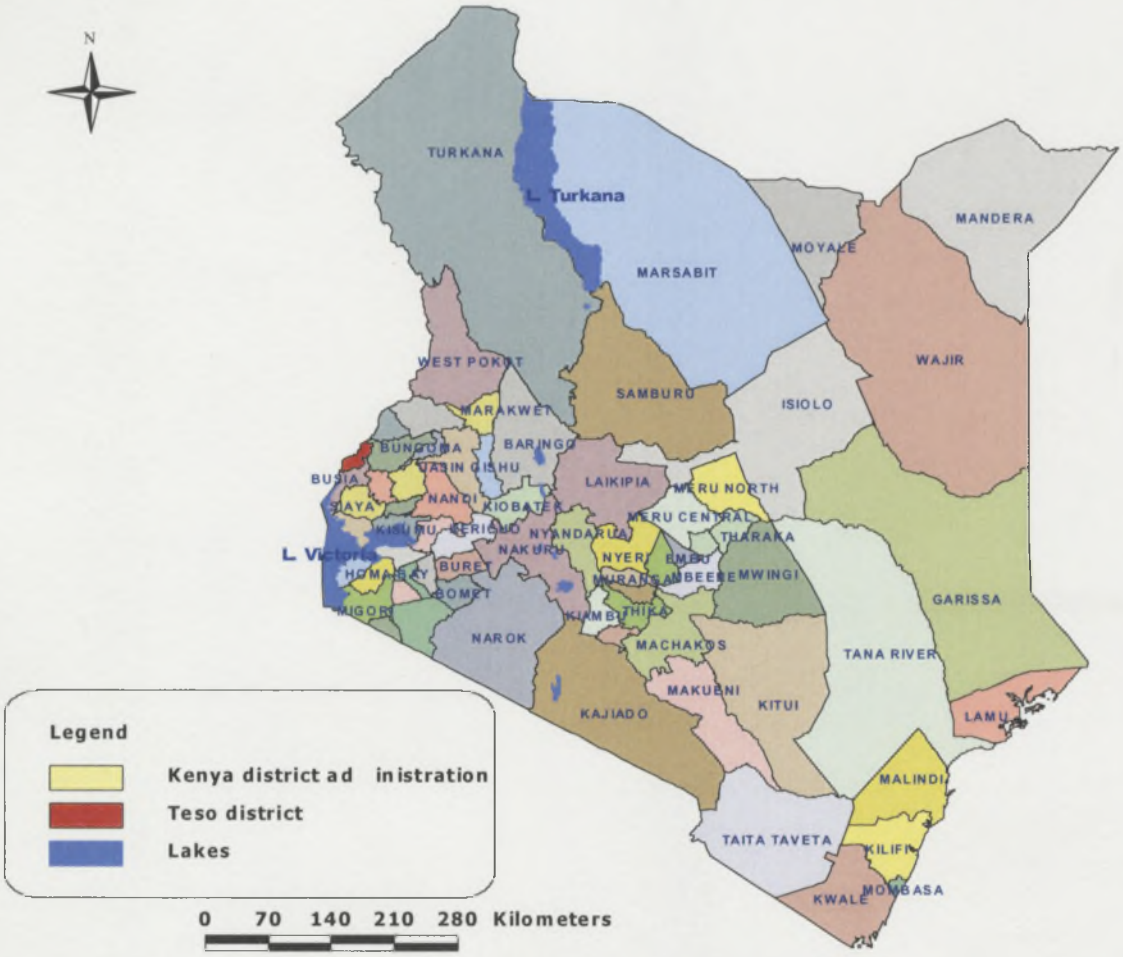


Fig. 1(a) Map of Kenya

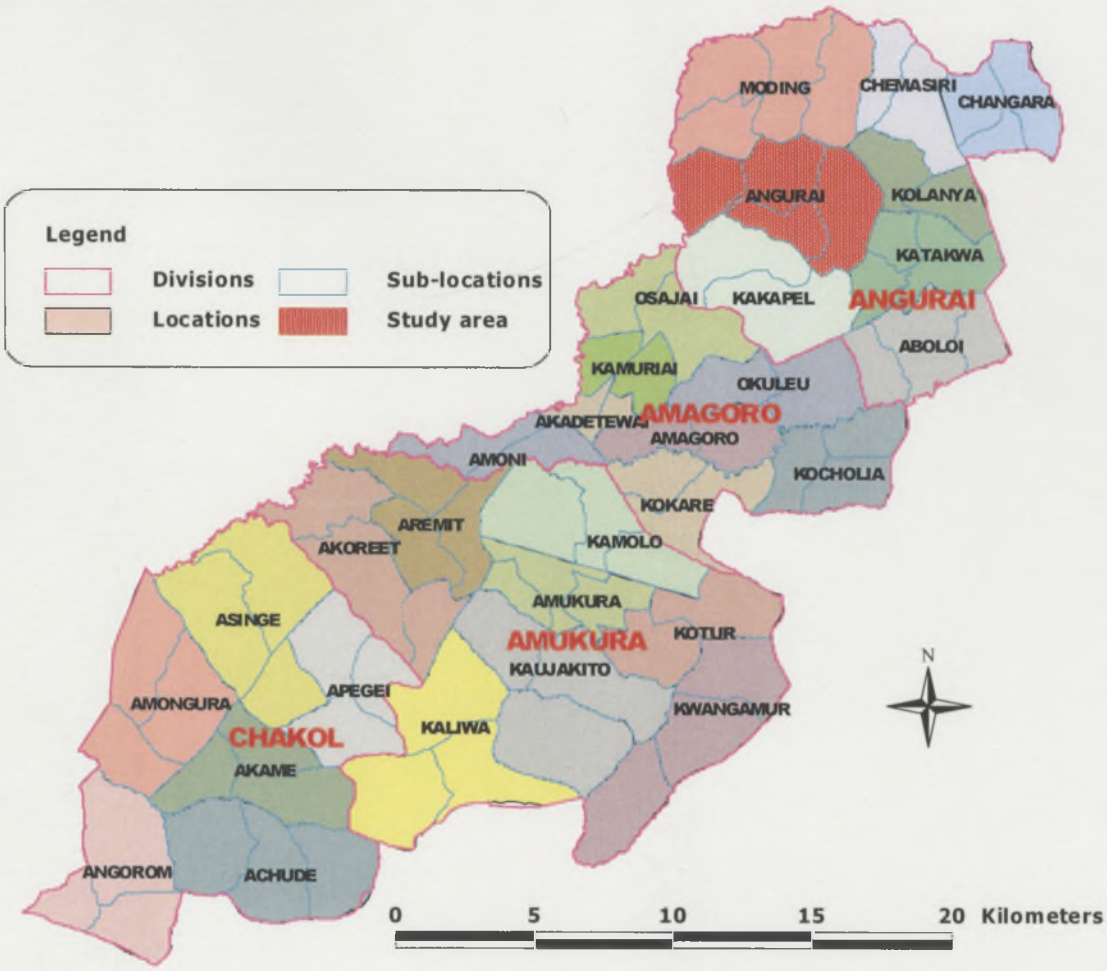


Fig. 1(b) Map of Teso District

Fig. 1(c) Map of Angurai

The EMMC-FITCA Project, Kenya

FAO Conference (1997) endorsed the Program Against African Trypanosomosis (PAAT). The objective was to achieve concerted efforts among the different agencies in the fight against tsetse and trypanosomosis. The programme seeked to combine FAO, WHO, IAEA and AU/IBAR forces in order to:

- Ensure harmonious, sustainable approach towards improved human health and sustainable socio-economic development and agricultural development in tsetse-infested areas;
- Promote and coordinate international alliances and efforts assisting in harmonised interventions against tsetse and trypanosomosis; and
- Achieve integrated trypanosomosis control in Africa.

Through its activities, PAAT seeked to depict the policy framework, strategies and guiding pest management principles encompassing:

- Socio-economic factors of trypanosomosis control
- Impact of trypanosomosis on African agriculture

- Community participation
- Drug management
- Integration control techniques
- Environmental concerns

The "Farming in Tsetse Controlled Areas" (FITCA), is a regional programme for Kenya, Uganda, Ethiopia and Tanzania, implemented under the auspices of the AU/IBAR. It's funded by the European Union as a project for East African countries. It consists of a Regional coordination unit based in Nairobi and national projects in countries where PAAT is implemented (FAO, 1998).

FITCA project in Kenya is based in Busia in western Kenya, which is a densely populated area. Agriculture is the main activity in the region. This region is still seriously affected by animal trypanosomiasis and now rarely sleeping sickness. FITCA project started in July 2001. It aims at controlling tsetse fly populations (*Glossina pallidipes* and *Glossina fuscipes*), which are high in the region in order to promote livestock production. It promotes farmers participation in tsetse control activities through adoption and self use of two major techniques:

- Use of impregnated permanent nets around the barns where the dairy cows remain. Two hundred farmers have been identified and receive convenient material, insecticides and extension service.
- Impregnating cattle with insecticide by spraying in a crush pen. These animals are like living target, able to poison the flies.

The project has also installed in strategic places different types of traps to reduce the tsetse fly density including:

- Traps, which catch the flies: Installed and removed after 24 hours, they have been designed to attract the flies and enable the assessment of tsetse fly density in the particular zone.
- Traps, which kill the flies: Designed to attract the flies and kill them through poisoning.

Using the various techniques, the tsetse fly population has been significantly controlled and reduced. Through the tsetse fly population monitoring, the project expects that crop and livestock production will improve significantly. Other components of the project include monitoring environmental changes such as the changes related to soil erosion as well as changes in vegetation types and cover which might have a negative or positive impact on agricultural production.

The Environmental Monitoring and Management of Change (EMMC) component of the FITCA project focuses on the environmental aspects of the fight against tsetse flies. The objectives of EMMC are:

- To increase the sustainability of natural resources and agricultural systems, through environmental monitoring and management in participating FITCA countries.

- Increase the level of information awareness on environmental change and increase the capacity to respond proactively to these changes among stakeholders in FITCA participating countries (D. Bourzat *et al.*, 2002; Weisheit Anke, Mbandi Antony, 2002).

Population

The population of Teso district as given in 1989 population census is 126,584. With a population growth rate of 3.5% per year, the population is projected to rise to 167,487 in 1997 and to 192,656 in 2001.The population of Teso district is evenly distributed with large concentration in the main centers like Malaba, Amukura and major market centers (Government of Kenya, 1997-2001).

Among the four divisions of the district (i.e. Amagoro, Amukura, Angurai and Chakol), Amagoro had the highest population density (413 persons/km2) in 1997, projected to increase to 475 persons/km2 in 2001. The divisions with low population density are Amukura followed by Angurai.

Ecological Characteristics

Most parts of Teso receive between 1270mm and 1790mm mean annual rainfall. About 50% of the annual rainfall falls between late March and late May, while 25% falls during the short rains in August to October. Maximum rainfall falls in April and May although there are no definite seasonal patterns. The annual mean maximum temperatures ranges between 26° C and 30° C while the mean minimum temperatures range between 14° C and 22° C.

Teso district's altitude ranges from 1300m above sea level in the south to an average of 1500m in the central and northern parts (Angurai division is in the northern part of the district). There are several hills rising above the general level. The topography is undulating with hilly terrain in some parts. Numerous bushes of *Lantana camara* that grow as fallow in abandoned farmlands, roadsides and bushes along streams and river Malaba characterize Angurai area of the district. These are known tsetse habitats and are expected to reduce due to increased cultivation and grazing (Government of Kenya, 1997-2001).

Livestock Production

In most parts of the district, livestock production is integrated with agriculture, both of which are practiced on small-scale farms for cash and on-farm consumption. The main types of animals kept are crossbred zebu cattle (which are more resistant to trypanosomosis than the exotic breeds and are stronger than the pure zebu as draught animals), sheep, goats, pigs and poultry. Existing estimates indicate that trypanosomosis has caused a 70% reduction in livestock population in humid zones where abundant vegetation is an important tsetse fly habitat. The trend in livestock production for the last 10 years shows a downward trend. This can be attributed to the high incidence of

livestock diseases, particularly trypanosomosis, which killed many animals. Between 1998 and 2001, 87% of the livestock population of the Teso district died due to diseases-particularly trypanosomosis (according to the Government extension services statistics). When affected by trypanosomosis, animals which escape death remain emaciated and anemic, a condition that affects their reproductive capacity, milking capacity as well as their draught power.

The Tsetse fly Population

Trypanosomosis is a vector transmitted parasitic disease. The trypanosome parasite is a protozoa transmitted to livestock through tsetse fly bites. The insect habitat is almost exclusively limited to the African continent and a few adjacent islands. The tsetse fly distribution across the African continent is related to the various types of habitat. The general habitat of the tsetse is woodland or forest along rivers or streams, thick forests or woodland savannah. Nevertheless, vegetative cover alterations or insecticides application have resulted in great reductions in the numbers of tsetse over wide stretches (Lancaster, J.L and Meisch, M.V., 1986).

In Eastern Africa, the common tsetse species include the *Glossina brevipalpis, G. pallidipes* and *G. fuscipes.* G. *pallidipes,* which is an important vector, is found in Central and East Africa bounded by and including South-West Ethiopia, Uganda, East Congo, Zambia, Zimbabwe and the coast of Somalia. This species inhabits the light rain forest to dry thickets in arid savanna (Smith K.G.V., 1973).

CHAPTER II: HYPOTHESES AND OBJECTIVES

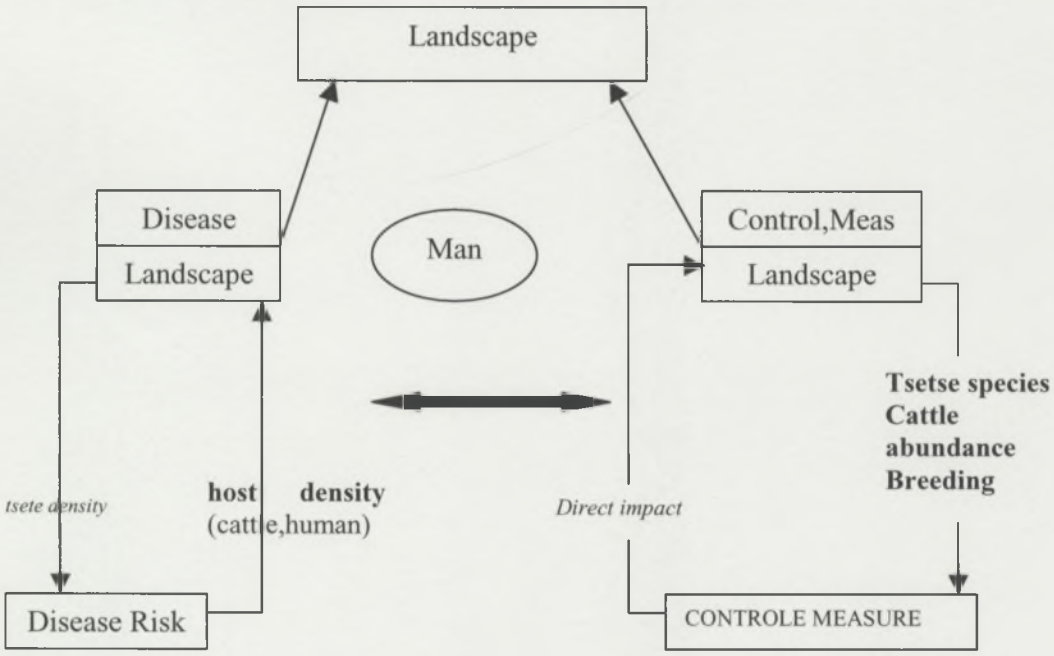
Nature of the Problem

Tsetse population has been brought to low levels following the on going control program by FITCA Kenya. It's expected that the livestock population might rise and hence traction power for cultivation. This might bring changes on the environment and therefore need for monitoring. Baseline data is therefore required for future follow up.

Hypotheses

Following the 1997 cotton market depression, a decrease in livestock population and an increase in tsetse fly density have been observed in western Kenya. The question here is to find out what was the determining factor for those changes. A land use change has occurred in the more than ten years (G. De Wispelaere, 2002), which has caused an environmental imbalance, which favored tsetse thriving (*Figure 2a*).

The woodland and the croplands have decreased so the bush and fallow has increased, causing more habitats for tsetse flies. The decrease in agricultural production can also be associated to decreased labor due high mortality rate within the population, caused by HIV/AIDS among others (Government of Kenya, 1997-2001).



i. Hypothesis

Tsetse density	Tsetse abundance is linked with the vegetation / water / density of available hosts	Direct impact	Toxicology
Host density	Tryp is a main causes of death for cattle Tryp is a cause of departure for people	Tsetse species	The intensity of control and the methods will be different according to the species
		cattle abundance	Bailed technic could be used if the density of cattle is high
		Breeding capacity	O-grazing units could be used in productives area

Fig. 2(a) Relationship between landscape, disease risk and control

Objectives

This study was designed to provide the baseline data and a landscape map showing major changes, which might occur in the landscape of the region with the objective of trying to understand which are the current or future factors that will determine future evolution. It was decided that survey be carried out within the population asking them about changes which occurred in their environment during the last 10 years and what they considered as cause of those changes. Preliminary observations in the study area indicated more intensive land use with less fallows and shrub land in the Tororo district in Uganda as compared to the Teso district in Kenya indicating differences in environmental and disease epidemics conditions as the two districts are only separated by the Malaba river.

When affected by the adverse effects of sleeping sickness and trypanosomosis on their land and livelihood, the populations from the two districts seemed to behave differently. The objective of the study was to generate a baseline data aimed at:

- Monitoring environmental changes resulting from the tsetse control activities carried out through the implementation of the FITCA project
- Understand the factors underpinning the differences between the Kenyan and the Ugandan sides of the project through a comparative study.

In order to develop the database, the FITCA-EMMC project monitored changes in the landscape following a multidisciplinary approach. The approach was most appropriate as it took into consideration all the factors (such as disease risks, crop and livestock production) determining environmental changes in the complex situation of the study zone (*Figure 2 (b) advantages from monitoring changes in the landscape following a multidisciplinary approach; 2 (c) importance of data base establishment for future activities).*

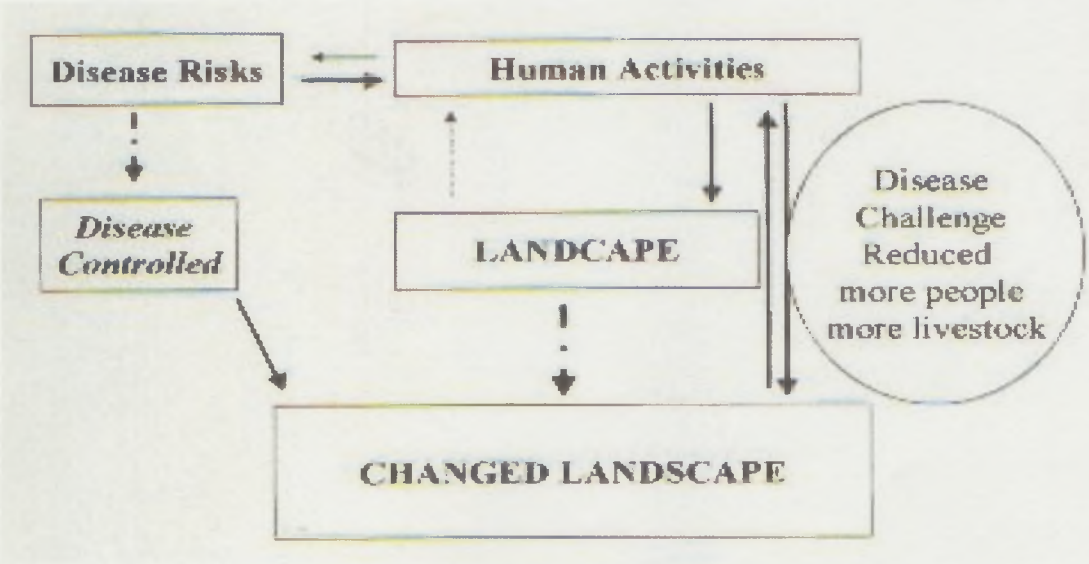


Fig. 2(b) Multidisciplinary approach to landscape study

PART II: MATERIAL AND METHODS

CHAPTER 1: DESCRIPTION OF THE STUDY AREA

The area of study was (2,5×2) km stretching along river Malaba. Before the launching of the FITCA project, the area was recording high flies density. Rough terrain, rocks and shallow soils characterize the area. Short trees, shrubs, bushes and tall grass represent most of the natural vegetation. This area is divided into three classes depending on the slope (high, moderate and low). Most of the cultivation is done on moderate and low areas, which include the hilltops and the lower parts next to the river and streams. The high slope areas are mostly covered by natural vegetation and little cultivation of crops, principally sorghum and maize (*annex 1, map transect (d)*).

The objective was to carry out a thorough study of the area to obtain a precise baseline data on the landscape following a multidisciplinary approach. The approach called for various types of interventions on a complex system where the tsetse habitats had proliferated. The various disciplines involved in the study include:

- Geography to support mapping
- Socio-economics: household survey questionnaire to investigate farmers' current and past agricultural practices under tsetse challenge
- Ecology: monitoring changes in the environment in relation to soil and vegetation

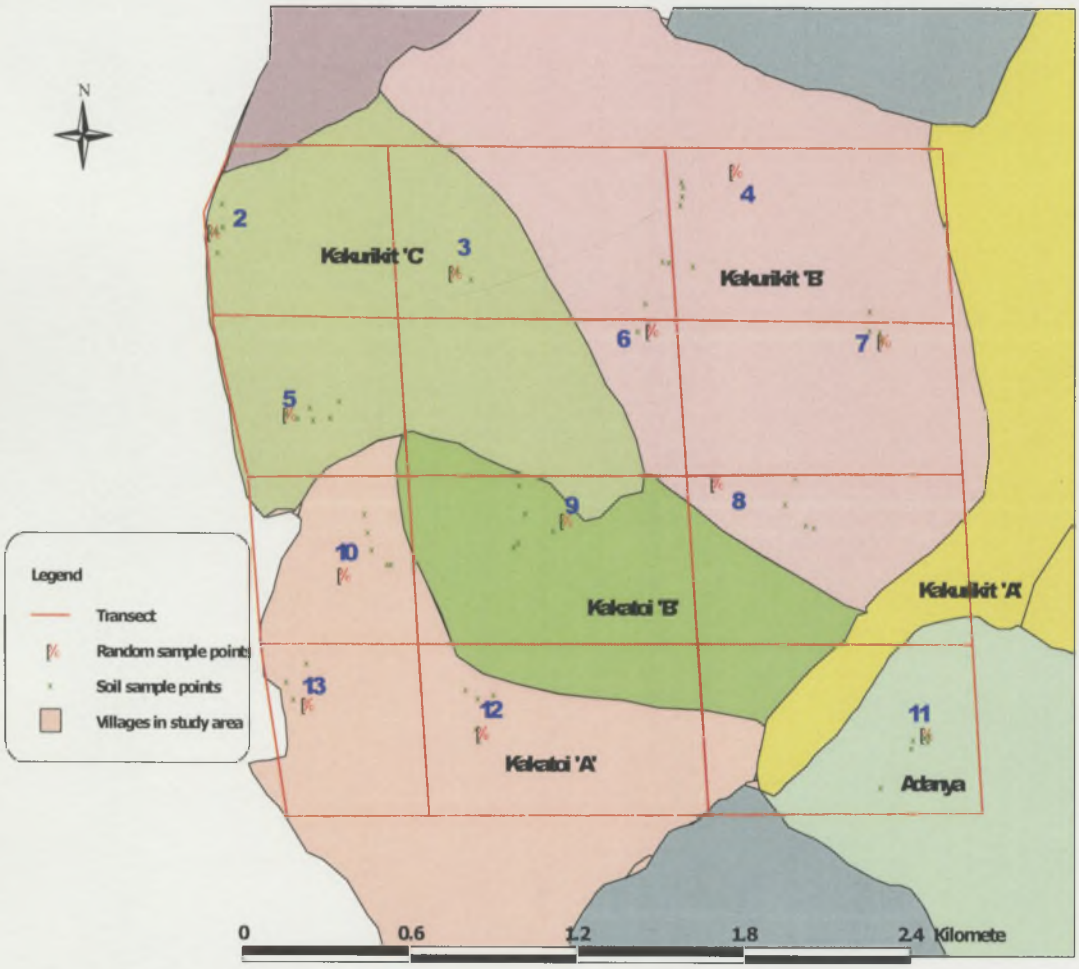


Fig. 2(c) Map of the site of study

CHAPTER 2: LAND USE MAPPING

Material

Data collection in the field was done using district topographic maps and GPS (Global Positioning System). The data was processed and maps finalized using various computer packages.

Methods

Using GPS, tracks were taken around each and every land use (crops, settlement and fallow). The different land use and land cover were marked as waypoints with their names saved. A coding system was developed in accordance with the limitation of 6 characters by the GPS for the waypoints names (*annex 3 (a) GPS dictionary*). The data was downloaded from the GPS to the computer for processing and mapping using various programs (Map source, Explorer, Excel, Access, Arc view and Arc info). The untracked areas therefore represented the non-cultivated zones on the vegetation maps, where the vegetation would be characterized and determined later.

CHAPTER 3. HOUSEHOLD SURVEY

Material

A questionnaire was developed on the following subjects (*Annex 4: Questionnaire*): -

- Watering points (type, users, distance from house hold, type of landscape and between point and household and water quality)
- Tsetse fly habitat (control; protection)
- Cropping pattern and trend over 10 years ago (crop type, size, changes during the last 10 years)
- Fallow period and trend (changes during the last 10 years)
- Livestock information (number, grazing, type of livestock and traction)
- Utilization of natural resources (fuel sources, building material and unconventional resources)
- Labor (number of people in the household)

Methods

Interviewed the head of the household on behalf of his family and those of the sons. In the region, most men were polygamous and women were not entitled to land ownership. All the households were not visited. The approach was to interview the heads of the households as representatives of the extended families. A sociologist and an assistant, helped to carry out the interviews as well as local people who helped to translate the questionnaire into Ateso, which is the local language of the people.

CHAPTER 4: SOIL AND VEGETATION

Vegetation

Material and Method

Using secateurs, main species samples were taken from selected points on the map spaces representing the natural vegetation. Those samples were identified and mounted for recording and future diagnosis. GPS reading was done for marking the points where the samples had been collected. Each type of cover was estimated and a description of the vegetation class given using vegetation survey forms (*annex 5: vegetation analysis, (a) vegetation survey form).*

Soil

Material

- A machete marked each 20 cm for excavating the soil
- Buckets for mixing the soil
- Plastic bags and labels for sample conservation until their analysis in the laboratory
- Erosion indicators survey forms
- Topographic map of the survey zone and randomly selected points (annex 1 (d) transect map)

Method

The survey area was divided into grids and one random point generated in each grid, using the computer. Samples were collected randomly in all of the survey area and GPS readings taken. The sample points were distributed in such a way that they represented all the types of land use. From each random point, 2 to 3 soil samples were colleted from 20 deep excavations. A 2 kg sample was collected into a plastic bag and properly labeled indicating the sample number and the vegetation type of the area where it had been collected. A first hand visual description of the sample was done using an appropriate description form, which could even be filled by people without any expertise in soil characterization.

Erosion indicators i.e. rill, ripples, deposition of soil on vegetation and on gentle slope, gully, nutrient deficiency, bare and barren spots, pedestals were recorded at each sample collection site. Qualified personnel then analyzed the soil composition and structure for each sample in soil laboratories. It was important to collect enough soil for each sample as the soil would be dehydrated and cleaned during the laboratory analysis.

PART III: RESULTS AND DISCUSSION

CHAPTER 1: LAND USE MAPPING

Results

After tracking each and every land use, collected GPS data was downloaded, processed using various computer packages and various maps were produced. The result was for the various maps of the study area including vegetation, water resources, settlements, roads and traps set up by the FITCA project maps. Maps and tables of results derived from the study are indicated below.

Tables of Results

Table 1: Land use and vegetation in percentage

Type of vegetation	Percentage of the study area
Crop	41%
Shrub land	25%
Fallow	18%
Bush land	10%
Settlement	3%
Planted forest	1%
Natural forest	1%
Swamps	1%

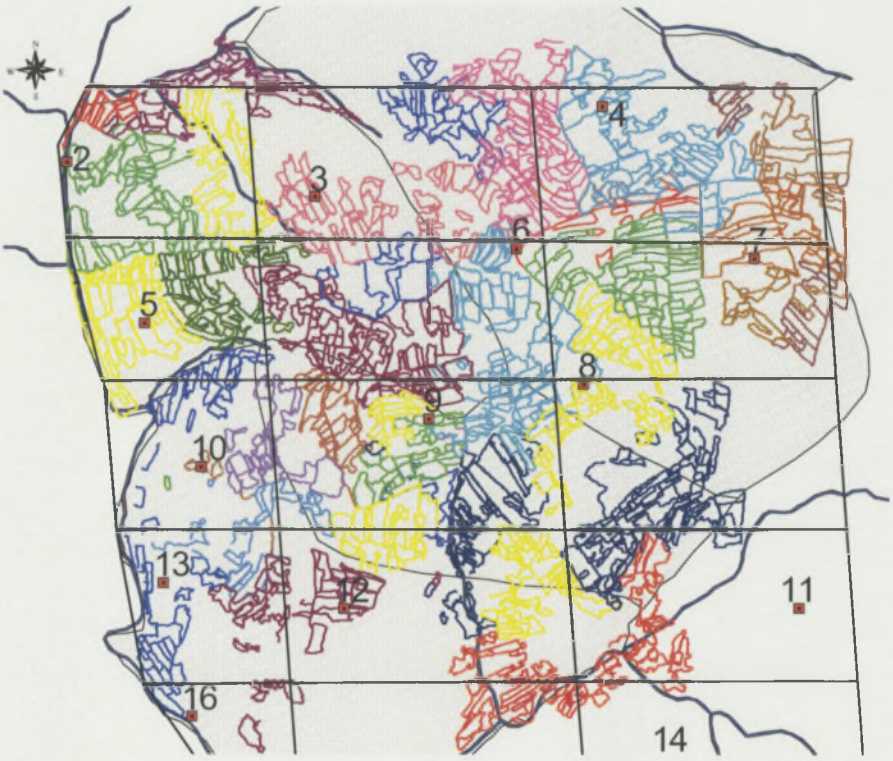
Table 2: Acreage under various crops in the study area as a percentage of the total cultivated area

CROP TYPE	PERCENTAGE
Other crops	33.5%
Cassava	23.4%
Maize	17.5%
Tobacco	8.4%
Sorghum + Millet	7.9%
Millet	3.8%
Groundnuts	3.3%
Banana	1.8%
Beans	0.3%

Tracks Maps

Track maps were generated from a preliminary processing of raw data using appropriate computer packages through the following process, which is quite complex. GPS collected data was downloaded into a computer where it was entered using the map source package. The data was then transferred onto Explorer and processed. The tracks (land use contours) and the waypoints (GPS readings on the study area) were separated, transformed into a format text (.txt) and loaded into different files. The files were thereafter transformed into Excel and Access files before further transformation into different formats. Using Arc View, the data was transformed from digital to map form on a map background of the study zone. Maps derived from the fieldwork were further refined using the GIS based Arc View and Arc Info packages. The Arc View and Arc Info processing enabled identify non-tracked areas, which represented non-cultivated areas.

Fig. 4. Land use maps derived from GPS tracking in Angurai, Teso district, Kenya

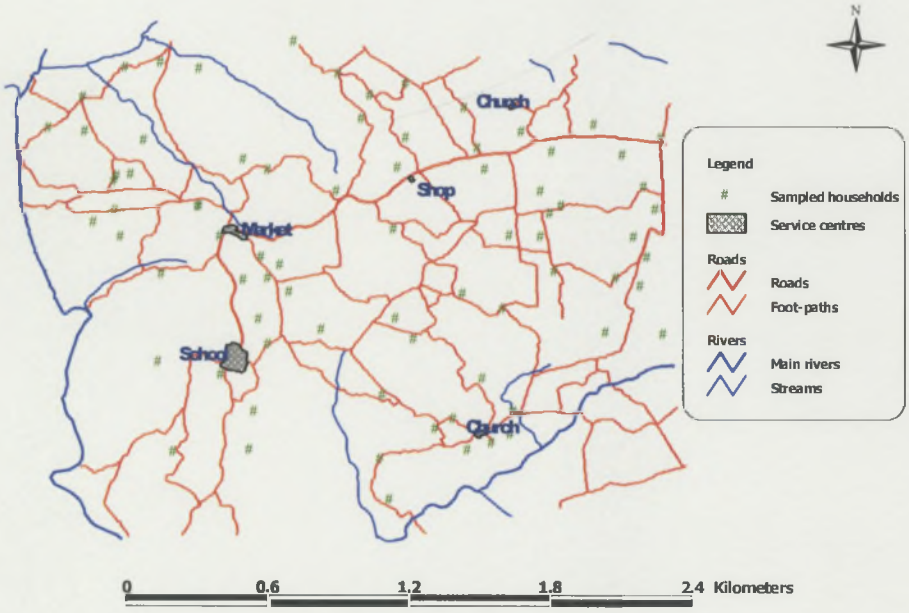


General Information Map

A map designed to provide general information about the study area was generated to facilitate the monitoring of the zone. There was only one road through which the zone could be accessed by motor vehicle. The map (*fig.5*) indicates the network of numerous footpaths enabling the local population to travel within the zone and get access to the

road as well as to the water sources. The map indicates also the location of households, which were interviewed during the study. The combination of households and footpaths on the map facilitate future monitoring of the project in the zone (*annex 1 (e) general information map).*

Fig. 5: General information map



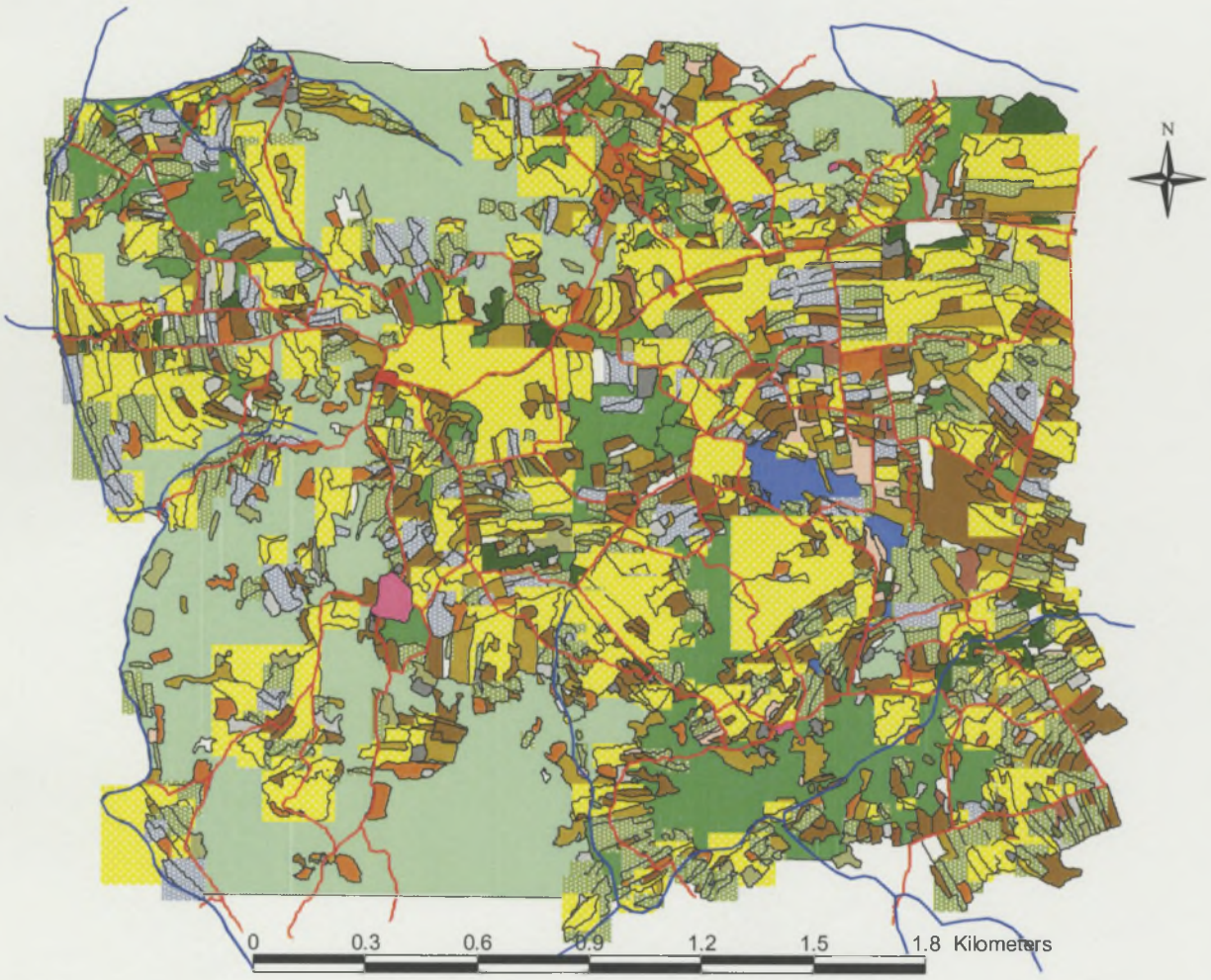
Detailed Vegetation Map

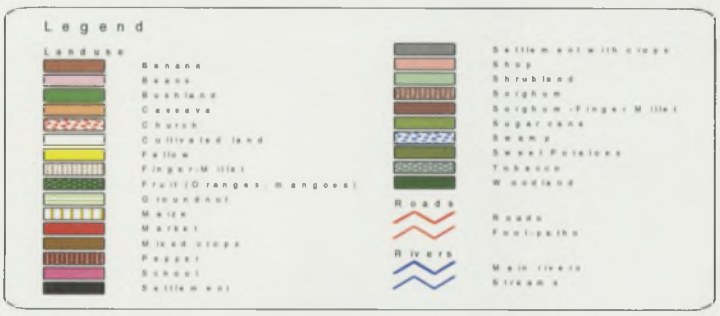
The detailed vegetation map (*fig 6*) shows details of cultivated zones and crop types as well as non-cultivated zones. Non-cultivated zones include natural vegetation, fallows, settlements and public buildings. The map gives precise information about the importance of each of the elements characterizing the landscape as well as its complexity during the study. It is useful as a reference map for future monitoring and investigations ((*annexe 1(f), (f bis).*

General Vegetation Map

The map shows cultivated and non-cultivated areas, locations of tsetse traps set up by the FITCA project and the density of tsetse fly collected through the traps. This vegetation and tsetse fly population map is very useful in monitoring of tsetse fly habitats (*annex 1(g) vegetation map).*

Fig. 6: Detailed vegetation map





Discussion

The general vegetation map as well as the data indicated in table indicates that more than 50% of the zone was not cultivated. The non-cultivated zone was occupied by bush and shrub lands, which were natural habitats for the tsetse fly, particularly the shrub land.

General Information Map

The map shows that the population was evenly distributed and only the shrub and bush land was not settled. The only road practicable for motor vehicles was rocky, had no tarmac and was poorly maintained. It was not practicable during the rainy season. The pathways were permanently practicable by foot. There were very few public buildings in the zone as there was only one primary school, one market place, two churches and one small and isolated shop, indicating that the welfare of the population was very low, at the minimum survival level. There were many streams in the area but they were not shown on the map, as the material used for mapping was sufficiently inaccurate. Water was quite abundant in the zone due to the Malaba River as well as a number of other important permanent streams.

Detailed Vegetation Map

Crops were generally cultivated on gentle or on moderate slopes, along river streams or on plateaus on hilltops. Some crops such as maize or cereal would however be grown on steep slopes with shallow soils, which could be ploughed easily. From the Malaba River to the right end of the transect, tobacco plots were increasingly rare as by the time we reached that particular end of the transect during our field visit, most of the tobacco plots were already harvested before plantings of the next season (*annex 6a: photographs of plots still under tobacco crop and plots after tobacco was harvested).*

The major part of the cultivated area was under intercrops, the most common being millet and barley, maize and beans or maize and groundnuts intercrops. Cassava and maize were the single most important food crops in the area. Cassava was particularly favored because it was a high yielding crop under low labor requirements as compared to the other crops, which were generally annual and therefore had to be planted each season. Some sugarcane plots were also observed along river as well as in floods prone areas (*annex 3b: inventory of cultivated plots*).

Settlements, which were generally located along pathways, were surrounded by small plots of food crops for subsistence such as sweet potato plots, fruit trees, bananas or *sukumawiki* (type of local cabbage).

General Vegetation Map

In the study zone, there were still large areas under natural vegetation. Many areas under fallow were abandoned to become bush lands. Bush lands were quite common in the area particularly on stiff rocky slopes not easily accessible. Natural forests, which were

generally a continuation of bush lands, were quite non-existent in the area, as were planted forests.

From March 2001 to January 2002, traps installed through the FITCA project indicated a relatively high density of tsetse flies in the study zone. Most of those traps were placed along pathways close to bushes, which were favorable habitats for tsetse flies.

CHAPTER 2: QUESTIONNAIRE

Results

Water Points

The main watering points cited by the respondents were springs/streams (88%) and rivers (20%) and only 1% used open well. The population depending on the severity of the dry season alternatively used springs and streams; some streams dried up (13%). Generally, there was no water shortage in the area due to the availability of the Malaba river. They claimed that the estimated average distance from the household to the permanent water points was 553 meters. Those who used seasonal sources walked an average of 1087 and 305 meters during the dry and rainy seasons respectively. The footpaths leading to the watering points are mainly bare soil (50%) and stones (35%), others have grass (14%) and gravels (1%). Human alone used mainly the cited watering points (77%) while both human and livestock used 23%. The water quality was reported to be drinkable by 83% of the people interviewed while the rest (17%) felt that it was slightly polluted. There was no programme to monitor water pollution in the region. The vegetation of the areas between the homesteads and the water points was relatively diverse. The table below summarizes the vegetation types surrounding the watering points according to the population.

Type of landscape	Percentage
Riverline vegetation	27%
Bushes	25%
Grassland	16%
Woodland	16%
Food crop	12%
Rocks	4%
	100%

Knowledge of the Tsetse habitats

The responses were grouped according to their level of knowledge of tsetse habitat as shown in the table below.

Knowledge level	Percentage of responses
No	36%
Fair	12%
Good	52%

Out of those who had knowledge, the following table summarizes responses according to time and seasons.

Tsetse time	Percentage of people with knowledge
Daytime	35%
Night	8%
Rain season	29%
Dry season	28%

The tsetse habitats that were mentioned are show in the table below: -

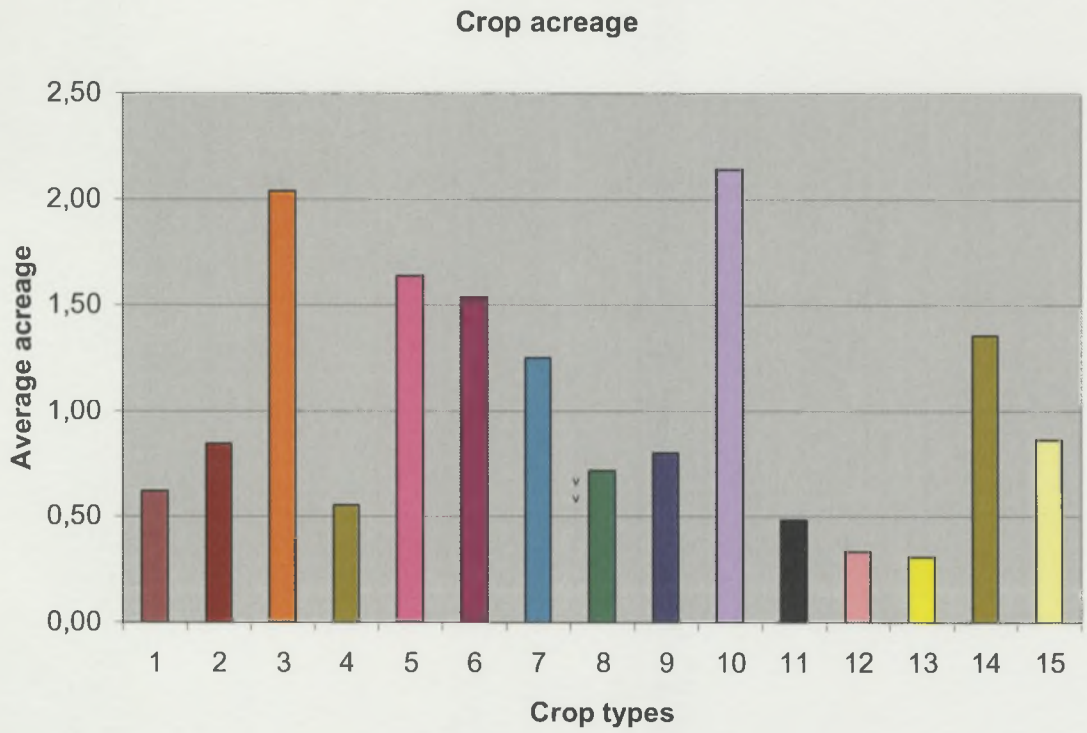
Tsetse habitat	Percentage of people with knowledge
Open grassland	1%
Bush land	53%
Woodland	1%
River-line vegetation	41%
Swamp	3%

Tsetse control and protection	Action
No protection	96%
Smoke	0%
Net	4%
No money	13%
No information	85%
No harm on man	3%
Participate in FITCA	25%
Cutting bush	25%
Burning bush	4%
No control	46%

Most of the people interviewed had no form of protection against tsetse bites. The reasons given were that they had no information and they did not monitor the vector.

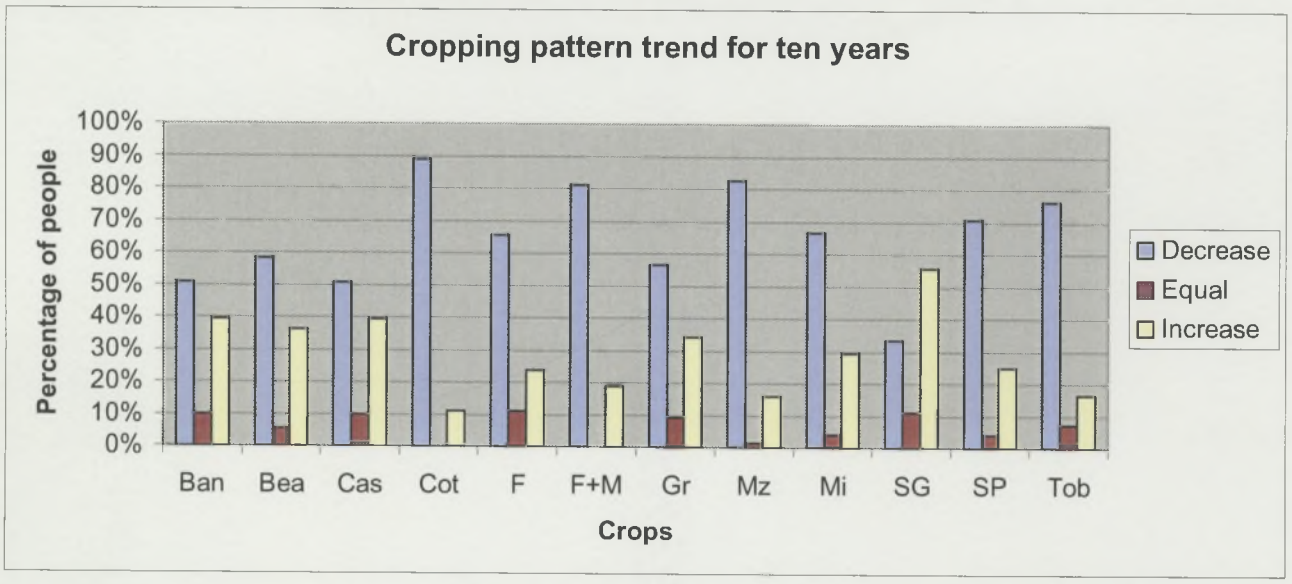
Cropping Pattern and Trends

The main crops produced in the area-included maize with an average acreage of (2.14), cassava (2.04), finger millet (1.64), finger millet mixed millet (1.54) and tobacco (1.35). The average acreage of crops grown for both commercial and subsistence purposes are presented in the chart below.



1=Banana 2=Beans, maize 3=Cassava 4=Cotton 5=Finger millet 6=Finger Millet and Sorghum 7=Finger millet, sorghum, sim sim 8=Gr nut 9=Gr nut , maize 10=Maize 11=Millet 12=Sugar cane 13=Sweet potatoes 14=Tobacco 15=other subsistance crops

Farmers reported major decline in cropping over the last ten years. Crops with the highest decrease were cotton (89%), maize (83%), finger millet mixed with millet (81%), tobacco (76%) and sweet potatoes (71%). Only sugarcane was reported to have increased by 56%. The following chart shows the trend of the cropping pattern.

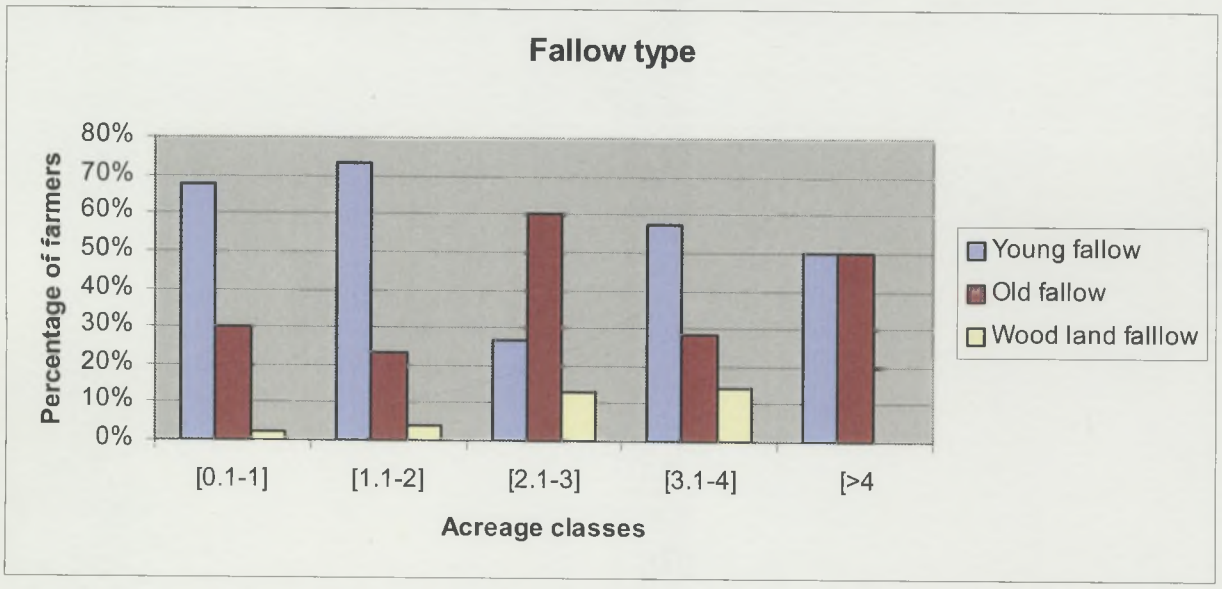


Fewer crops varieties were reported in the farms than ten years ago. The following table shows the percentage of people who had stopped growing the different type of crops.

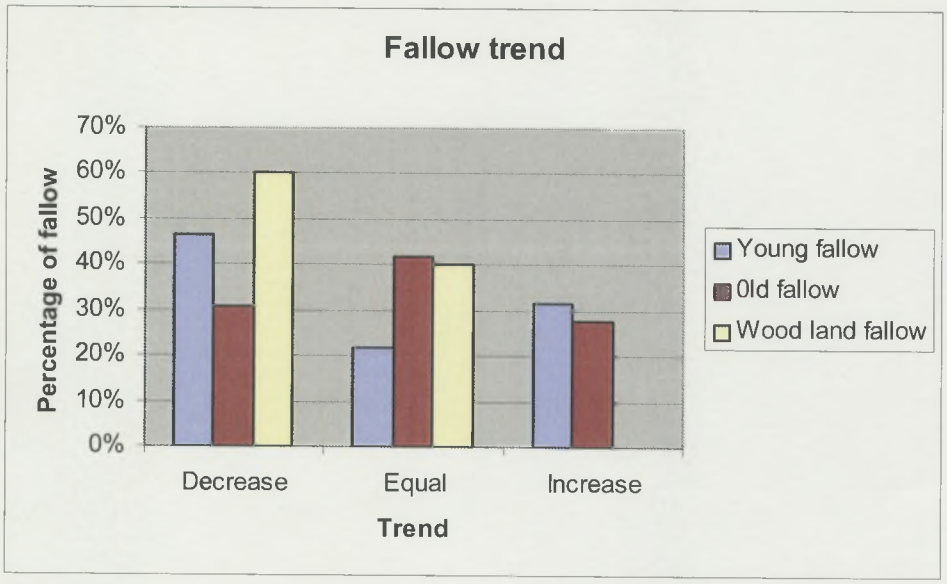
Crops more planted	**Percentage of people**
Cotton	21%
Green grams	20%
Sim sim	19%
Sun flowers	16%
Tobacco	11%
Nugu mawe	8%
Pepper	4%

Fallows

Most of the respondents had fallow land in their farms and only 4% claimed they didn't have it. The fallow types represented young fallow (79%), old fallow (47%) and woodland fallow (5%). The following chart classifies the types of fallow into acreage classes.

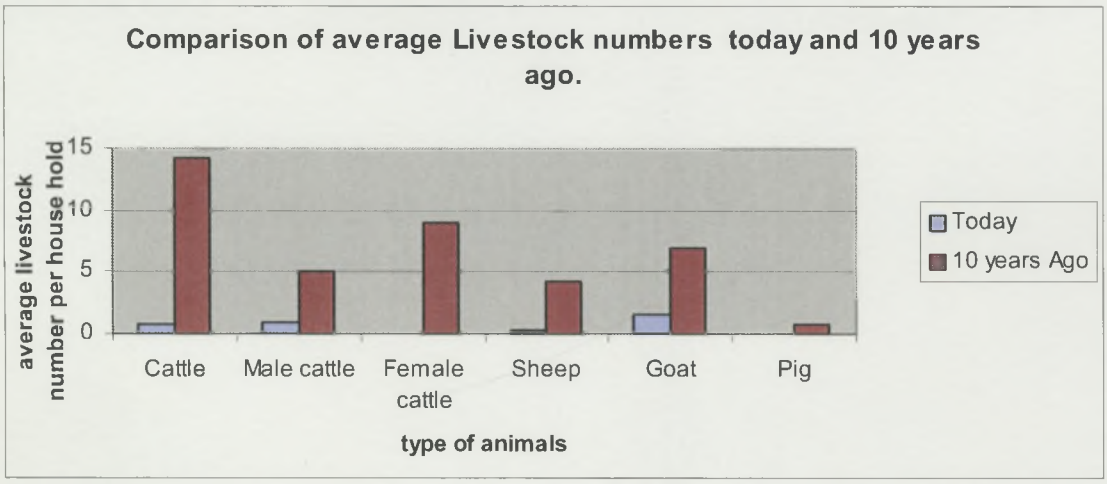


The trend of the fallow types is shown in the chart below.



Livestock Production

A big difference was reported between the current livestock numbers and 10 years ago, the chart below summarizes their average discrepancies.



The survey revealed only 49% of the farmers own at least one head of livestock, when they were 97% ten years ago.

The most preferred grazing areas were fallow (53%), crops residues (39%) and bush (11%), the result are presented in the table below.

	Rank in order of preference		
Type of grazing area	**1**	**2**	**3**
Communal	3%	5%	5%
Fallows	53%	16%	3%
Crops residues	0%	39%	11%
Swamp	0%	0%	5%
Bush	13%	13%	11%
Grassland	18%	3%	3%

Number of livestock owners 38

Fuel Sources

The majority of the respondents ranked dry wood as their most important source of fuel, others sources of fuel included timber wood, paraffin and charcoal. The consumption of all the fuel types had increased apart from charcoal, which had remained the same over the last ten years. It was evident that all the fuel sources were readily available since the respondents took as short time as ten minutes to access them (*see table below*).

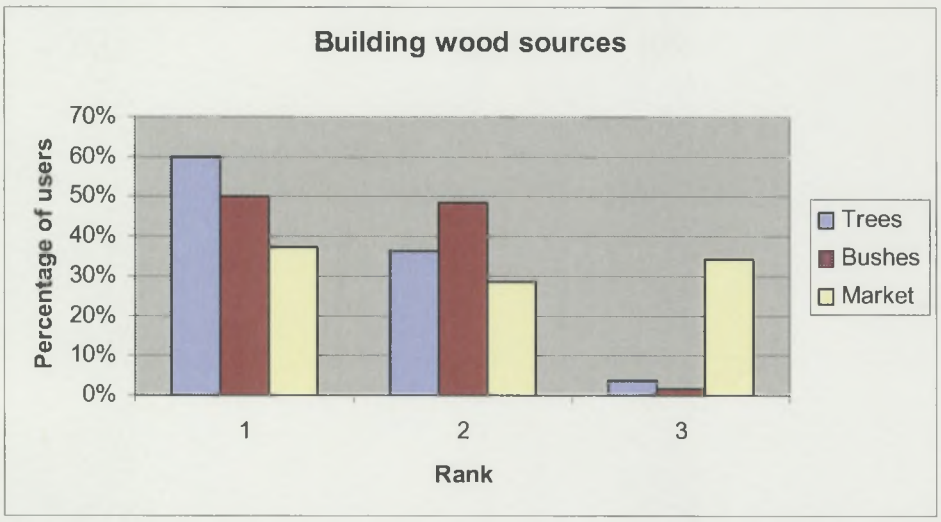
Main fuel sources: rank, trend and accessibility.

Fuel type	Order of importance	Consumption trend	Accessibility (Time in minutes)
Dry wood	1	Increase	10
Timber wood	2	Increase	10
Paraffin	3	Increase	*
Charcoal	4	Equal	10

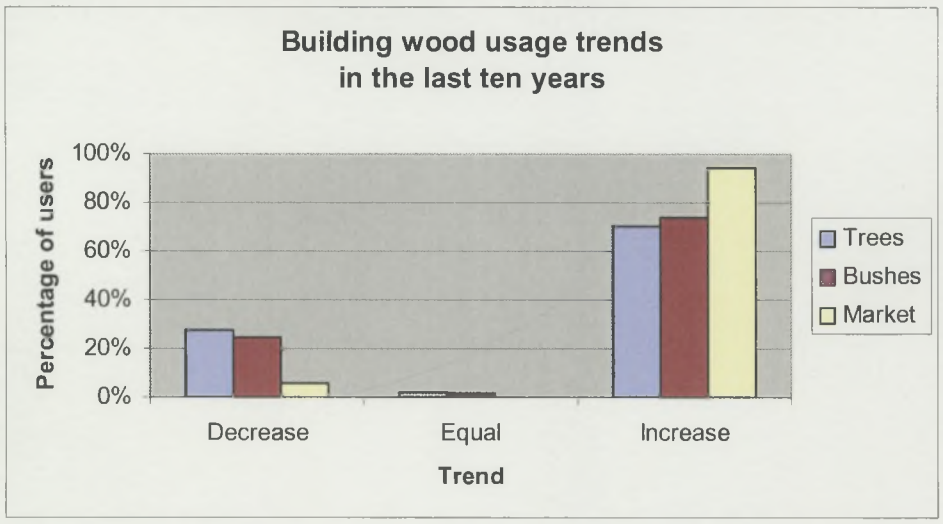
* Depend on the nearest market place.

Building Wood

The chart below ranks main sources of building wood in the order of importance according to the users.



The usage of building wood from various sources was in the increase as illustrate in the following chart



Unconventional Resources

The greater proportion of the respondents (91%) obtained various types of resources from the bush. The table below lists these resources, the percentages of users and compares their availability today and ten years ago.

Unconventional resources	Percentage users	Easier ten years ago	Difficult ten years ago
Medicinal plants	82%	46%	54%
Craft materials	79%	37%	59%
Wild animals	68%	50%	76%
Wild fruits	62%	29%	71%
Honey	49%	24%	79%
Ceremonial/burial rituals	13%	20%	80%
Others (grass)	10%	57%	43%
Toilet	6%	50%	50%

Discussion and Results from the Questionnaire

Knowledge of the Tsetse fly habitats

Most of the people who pretend having a certain level of knowledge on tsetse flies are also aware that the major habitats of the flies are bush lands along river streams. Despite that knowledge, the population had hardly ever taken any preventive or control measure. The population seemed even not to be aware that most of the bushes along their pathways to the water points were potential habitats for tsetse flies. Either the population was not fully aware of the importance of the problem or the population's priorities were much more focused at feeding their families rather than tsetse flies eradication. In deed, the survey indicated that the tsetse eradication was not a priority for the population partly

because of lack of money and partly because of lack of awareness. This finding seemed however contradicted by the fact that the interviewed farmers were participant in the FITCA project as one of FITCA's strategy was in training participating farmers in tsetse fly control. One of the objectives of this particular training was not only aimed at training participating farmers but also to encourage them pass on the information to their neighbours. Following the training, a number of farmers did indicate that they were then slashing or burning tsetse habitats as a way of controlling the flies. One can however wonder weather the slash or burn technique was really aimed at tsetse control or was done by the farmer for other more personal purposes. Whatever was the case, it is worth noting that although the population was aware about the adverse effects of the tsetse flies, the information was not shared between the various actors in the zone and the population continued farming in tsetse prone areas without appropriate measures to control the flies (annexes 6b, 6c, examples of habitats prone to tsetse infestation).

Agricultural Production

Subsistence food crops such as cassava, maize or millet are the dominant. Some cotton and tobacco are cultivated as cash crops. Mixed subsistence crops are the most important component of the cropping system in the area. Indeed, it is easier to plough one plot and harvest diverse products. This requires less labor while ensuring food variety. Moreover, agricultural production seems to have significantly declined and some farmers are no longer growing some crop species. This decline in agricultural production might be related to the observed overall decrease of manpower and of the number of draught animals during the past ten years. This is evident for cotton production and even more importantly for tobacco which requires for each year more and thorough work including animal traction. Results indicate a particularly important decrease of cotton production, which might be attributed to the 1987 cotton price depression at the international market. There are however positive signs of improvement on the international market, which might reverse the negative trend in cotton production in the near future.

Various hypotheses can be formulated to explain the negative trend in tobacco production; the major one being the decrease in available draught animals and inadequate firewood resources. Tobacco production requires not only sufficient manpower but also availability of firewood for drying tobacco leaves. The availability of firewood has been decreasing over years and it is becoming more and more difficult for farmers to get for tobacco curing (*annex 6(d), tobacco production practices*).

Sugar cane production seems however not to have been significantly affected by the overall decrease in agricultural production in the area as sugar cane [plots are generally very small and are located in very wet zones along river streams.

Fallow Land

A large number of farmers own young fallows of various sizes and some old fallows or some woodland fallows. The results related to the changes affecting these non-cultivated areas are not conclusive for various reasons including the lack of clear criteria for their

classification or/and the lack of a common definition of the various fallow types on behalf of the population. Whatever is the case, the overall conclusion is that fallows have not significantly increased over the last ten years. One of the hypotheses to explain that particular finding is linked to the use of firewood for tobacco curing. Due to fire wood harvesting, woodland and shrub land have evolved into formation similar to woodland fallows. Cultivated fallows are therefore compensated by woodlands from deforestation of wood and shrub lands, explaining therefore why fallow land seems not to have significantly reduced over the last ten years.

Livestock production

Intensive livestock production is very limited. Livestock population, particularly cattle, is very low in the study zone. The comparative study of the livestock population in the past compared to the current situation indicates that the number of livestock has significantly decreased, as well as the number of livestock keepers did. As the population said, that is due to trypanosomosis. Although the population seems to be aware of the disease, there are not fully aware that it is transmitted by tsetse. Another conclusion of the analysis is that, in the past, cattle population was female in majority, but now the farmers prefer the males. This reflects changes in the priorities of farmers: crossbreeds from zebu have been identified as disease resistant and males are more appropriate for animal traction as compared to their female counterparts (annex 6(f): different modes of crop production).

Unconventional Resources Utilization

Wood is largely harvested from forests and other woody formations easily accessed by the population for domestic use as well as for tobacco curing. Other products such as tall grass for huts roofing and other domestic use are collected. Wild fruits are harvested as well as medicinal plants or honey. The availability of all those natural resources is decreasing, except for tall grasses, which are still easily available. Significant changes have occurred in the landscape with a significant decrease of the woody/shrub types of vegetation, which evolved into more grassland.

Other Observations

Information about the family size has been collected. Men are generally polygamous and there are in general more adults and children in a family than adolescents. The uneven distribution of age classes in the families is due to two factors:

- Wife inheritance: traditionally in the area, a brother of the deceased, who marries her, generally inherits a woman, whose husband dies. If the husband died of an infectious disease such as HIV/AIDS (of which the infection rate is 25% in the area), the infected widow will also infect her new companion. The high rate of transmission of HIV/AIDS in the region has led to a high mortality rate within the population.
- Young girls are generally married while there are still very young, some of them as young as 14 years. Once married, there are considered and recorded as adults

even if there still very young. The issue is therefore whether the number of adolescents is really low or if it is low because some of them are considered and recorded as adults.

Whatever is the case, it is evident that the manpower available in the area is not adequate attributed by the population either to the high mortality rate or to the fact that young men prefer to abandon their parents' farmland to migrate to cities seeking for jobs.

In summary, the major issues raised by the population during the survey include inadequate manpower, livestock and money. The observed decline of the agricultural production could be linked to the decline of animal production due to high livestock mortality caused by trypanosomosis and therefore by tsetse. Tsetse population is high in woodland along rivers or steams as well as within the many bush land formations, which characterize the area.

CHAPTER 3: VEGETATION AND SOIL STUDY

Vegetation Study

In the area of study several types of natural vegetations are observed at stages of different vegetable successions. These vegetable successions are stopped in their growth by local practices like the slash and burn technique, the cut and the harvest of wood, branches and grasses.This happens particularly in dry season where the vegetation is frequently burned. The plantation of the tobacco implies a strong wood consumption of combustion for dryings of the sheets for marketing. This fact of great quantities of wood are cut and collected each year for this purpose. In order to study the various types of vegetations, a herbarium and a typology of the various types were constructed (*appendix 5 (b), Typology of the vegetable formations, (c) localization by GPS, (d) card used in herbarium of the FITCA-EMMC project).*

Types of not cultivated vegetation observed:

- Forests
- Shrubby Formations
- Meadows

The Forests

Far from many in the area of study, the forests are of two kinds. Natural for the majority and planted for the others. The found arborescent species are same as the ones found in certain bushes, but more mature (more than 5 m height). The wood harvest for the tobacco seems to be a significant factor of deforestation in the area.

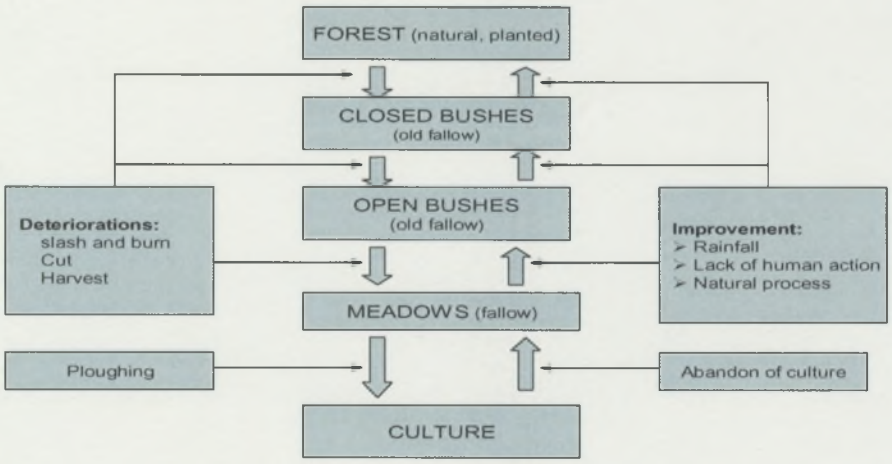
The Shrubby Formations

Like the forests, the scrubby vegetations seem to be of two kinds. Bushes with more arborescent species than scrubby species, whose branches do not leave the base of the trunk but with a few centimeters above ground level. The bushes with *latana camara* and/or *Tithonia diversifolia*, where the arborescent species are fewer and whose branches leave the principal base of the trunk. In both cases the arborescent species observed are at youthful stages of their growth and seldom exceed 5 m height. Among these two types of bushes, two sub species graft themselves according to their vegetable covers. The closed and opened bushes are differentiated according to the proportion from the vegetable cover occupied by the herbaceous species. Open bushes being those whose cover herbaceous are most significant. Certain species will be found in all or almost the vegetable successions.

The Meadows

The majority of the meadows were before cultivated grounds, now they are put in fallow. This vegetable succession is mainly made up of scrubby species. These species will be often found in the other successions with different proportions according to their type. A diagram of the evolution of the vegetable successions was carried out in order to include/understand how the standard passage from one vegetation to the other is possible.

Fig. 7: Diagram of possible evolution of vegetables successions



The Soil

Result

The assessment of erosion was based on a visual estimate erosion indicators, slope and type of culture in which the sample taking away were carried out. The majority of the cultures are planted on the grounds with weak slope. It should be noted however that certain farmers grow on the hillsides (strong slope) of corn, millet and sorghum, where harvest and the ploughing seem easier for cereals. All the plots observed had an obvious appearance of weak streaming on the ground. Some cultures like millet, maize and mixed fields of maize/groundnuts appeared to have a strong streaming. Drains on the level of the ground were observed in the fields of tobacco, millet, corn and groundnut.

No pile up of ground around the vegetation on the level of the mixed fields of corn and groundnuts, tobacco and groundnut, the others presented some slightly. All the plots observed presented deposit of ground at the level of the weak slopes (*annex 7: (a) table and (b) summary graphic of visible indicators of erosion of the soil).*

Discussion

Erosion coming upstream from the hills, plus the slope will be strong more of the signs of erosion will be visible. This observation depends on the capacity of the plants to retain the deposits, which come from the streaming upstream. The cassava for example will retain more easily the particles coming from streaming than a field of millet. It appears obvious that the more the slope will be strong the more significant the streaming will be and that the more the slope will be weak the more the deposits of ground will build up. A characteristic comes from the cultivation methods of the fields of tobacco, which are mainly cultivated on weak slopes. Indeed, tobacco planted in furrow present traces of streaming on the furrows and of deposits of residues of ground and the drains between the furrows.

The fields of groundnut are often cultivated near the dwellings on weak slopes and are often affected by streaming and deposits of ground. The farming of cereals, more particularly the millet and the sorghum, seem to be carried out on the strong slopes and the not very deep grounds (when they have some), because work with the hoe and the harvest of the grains is easier there. A difficulty of erosion of the ground is likely to arise in the long run, because the roots of cereals are not deep enough to retain the components of the ground firmly. The majority of the fallows show few visual erosion indicators due to a strong vegetable cover of the ground compared to the cultivated fields. The majority of the non-cultivated plots as the herbaceous vegetations are on the strong slopes to moderate.

In general the area does not appear much eroded; this is perhaps due to cultivation methods of separation of the grounds from one owner to another. Indeed hedges of *Lantana camara* and of *Tithonia diversifolia* grow between the plots and delimit the properties (*appendix 6 (b) habitat favorable to the development of the tsetse*).

The past use of animals of traction supported the structures non-rectilinear of the fields and allowed a work favorable for the renewal of the elements of the in-depth ground; the whole was modeling the shape and the richness of the grounds. With the manual ploughings, this resistant formation is in the long run likely to disappear and modify the agricultural landscape, if no evolution in husbandries intervenes.

CHAPTER 4: GENERAL DISCUSSION

The ecological study of the landscape is a new discipline, which aims at understanding how the various factors constituting the landscape interact between each other. Working on all the factors that can influence the evolution of the landscape of the zone enables a holistic approach, which leads to a better understanding of the major issues within the zones. The methodology adopted for this study led to the establishment of a data base which will be used as a powerful tool for a better analysis of the complex nature of the zone in order to gain a better insight about the major issues and be in position to make relevant comparisons with results from future investigations.

Results obtained through the different components of the methodology can be compared to a large extent. For instance both the vegetation map and the survey indicate that the major part of the land in the area is not cultivated although the population intensively utilizes it. Taking into consideration the numerous bushes of *Lantana* and *Tithonia* and the importance of woodland and other types of vegetation along the streams and rivers, it appears clearly that the zone is prone to the development of tsetse habitats.

The observed overall decrease of the areas under crop production can be explained by the high growth rate of the population. Traditionally, the population get married very young and for each newly married couple has to build its house. Polygamy is another factor leading to the increase of the number of houses, as each wife needs her own house. The combination of early marriage and polygamy leads to an increase of the acreage under housing and therefore too less acreage under cultivation as well as under natural vegetation under conditions where the population is increasing.

The lack of animals for traction had forced the population to adapt their production practices to that particular situation. Cultivated plots are becoming smaller as compared to the past and intercropping through which many food crops are grown on the same plot is the dominant aspect of crop production. Another consequence of this strategy is the development natural vegetation on the non-cultivated areas in place of grassland. Lack of livestock and excessive utilization of plants in woodland and shrub land are among the major problems in the area. Water points such as streams and rivers, which are exploited by the population, are generally near tsetse habitats.

The analysis of collected data indicates that the population utilizes available natural resources for most of their day-to-day activities. Their need to collect water, wood, fruits and other plants do not encourage them to protect shrub land and wood land, where they harvest most of those resources.

Two types of young fallow have been observed in the zone:

- Planned fallow, purposely by the farmer
- Unplanned fallow: a farmer might plough his plot early in the season but the rainy season might set in and get advanced before he had got the opportunity for planting loosing the work already done while the plot is invaded by weeds.

Most of the time, when a farmer decides to keep a plot under fallow, he will abandon it under fallow completely. The farmer generally cultivates the same plots each year under rotation, i.e. the plot is cultivated each year or nearly each year with the same crop. The system does however not apply for cassava, which is kept for more than one year on the same plot and does not need specific maintenance requirements. Cassava is sometime left in the field for too long where the crop end up becoming so dense that it looks like bush land.

Sometime, abandoned fallow are invaded by shrub species such as *Lantana*. In the long run, they turn to be potential tsetse habitats.

Strengths and weaknesses of the methodology

Strengths

Through the adopted methodology, accurate vegetation maps (natural and cultivated) were obtained, as well as the exact location of each household, accessibility (pathways or roads) and water sources. The maps clearly indicate how the various components of the landscape are organized. Based on data from the maps, a detailed database, which could be used in future to monitor environmental changes, can be established. Similarly, the maps will be used as the basis for the development of a GIS (Geographic Information System) from which results will be combined:

- With results from tsetse control program carried out through the FITCA-EMMC project;
- With the results from the interpretation of satellite images
- With the observed changes in livestock production.

A survey questionnaire is generally developed in order to respond to specific questions related to clearly identify specific objectives. The questionnaire developed for this project aimed at giving a clear insight on the agricultural production practices of the farmers as well as a thorough knowledge about the major focus of this project, the tsetse fly.

The method used for the vegetation study is simple, rapid and efficient in the identification of the various types of vegetation and their interdependency. GPS positioning of soil samples to be analyzed is not only a powerful tool to ensure that future samples are precisely collected at the precise location but is also an opportunity to identify gaps, which could strengthen the data base on environmental issues pertaining to the zone.

Weaknesses

The GPS used were designed for carrying out studies at lower resolution with a 4 m standard deviation, which has to be taken into account during mapping. There was therefore a need for cautionary measures. For instance during the field survey, large field crops could be combined with smaller plots of a different crop not larger than 4 meters to take into consideration on the GPS based standard error. The two crops will be considered intercropped on the map as are plots purposely intercropped by the farmer (*Annex 6 (e): example of mixed crops*).

Taking into consideration the husbandry practices in the area particularly crop rotation over crop seasons, it was imperative that the study zone be of limited size to ensure that the study could be carried out in a limited time frame so that the derived maps reflect the reality on the ground. For example, tobacco plots harvested between April and June could be planted with cotton or sunflower the next cropping season.

Due to the lower resolution of the GPS units, the vegetation along streams and river is not always mapped, as it is generally less than 4 meters wide and was not always accessible. The species composition of some thick vegetation types could not be satisfactorily established as samples could only be taken on the borders. Sometimes, the limits between some vegetation types could not be clearly defined.

The study would have benefited from a more accurate study of the vegetation before developing the survey questionnaire. This would have enabled more precise definitions of the various types of the vegetation in the questionnaire and would therefore ensured a better understanding of those definitions by the local population.

The objective of increasing crop and livestock production is apparently contradictory with the need for maintenance of an increased number of woodland formations, which are potential habitats of tsetse. Woodland formations have a positive effect on agricultural production. All these components of the landscape are related and interactive.

CHAPTER 5: RECOMMENDATIONS

Considering the results from the study zone, the following recommendations were formulated for future monitoring of the zone as well as for the improvement of the method used.

- During the training of farmers on tsetse eradication, women were generally left aside and it is the men, who were most involved. It important that women be more involved in such training as they are the ones who are most involved in the utilization of natural resources. Women are the most involved in activities such as water collection and utilization for cleaning, washing or cooking; they are most involved in collecting firewood for domestic use, harvesting wild fruits, honey or medicinal plants. Animal health problems are most handled by men but where women are most involved, they are the ones to be empowered.
- The materials used for tsetse traps making is sometimes diverted by farmers and used as poles or in making school uniforms. The population should therefore be more sensitized about how important are the traps to their welfare and schools should be informed to ensure that such material is not stolen for uniforms.
- Farmers should be encouraged to grow quickset hedges bordering their respective plots using indigenous species that are not potential tsetse habitats. Such hedges would also contribute to decrease soil erosion.
- Farmers should be encouraged to progressively restock cattle in ensuring a balanced sex ratio and control of major disease vectors such as tsetse. Increased females in the cattle herd would also harness livestock development in general and increased milk production, which would result into improved child nutrition.
- Tsetse traps should be positioned strategically to ensure that tsetse population in areas, which are not easily accessible such as woodland thickets, are dealt with.
- A more thorough study should be carried out to get a better insight on husbandry practices for cassava and most importantly for tobacco production. Keeping cassava plots unattended for long period results into the development of woodlands, which are favorable for tsetse infestations. Intensive wood harvesting for tobacco curing has a direct impact on the vegetation. Wood harvesting has an impact on natural vegetation with significant consequences on the natural plant and animal biodiversity.

CONCLUSION

In most countries, trypanosomosis is associated with poverty. Africa trypanosomosis are evolutionary diseases in space and time. Today, the rapidly growing human population is the major factor determining diseases dynamics. In some areas, the population growth has positive impact curbing trypanososmosis risk, for instance when tsetse habitats are destroyed due to increasing population pressure. In some other areas, trypanosomosis risk is increased due to the continuous increasing population and livestock exposure to the disease often maintained by protected areas, which might be, at the same time, favorable tsetse habitats. In sub-humid zones such as in Angurai, a proliferation of tsetse flies can be observed in areas characterized by high human population density. If the population continues to increase, it is however worth wondering how the human population needs will be balanced with the need to protect the environment. There is a need to develop a strategy for an integrated management of available resources to strike a balance between the human population needs for food as well as for the sustenance of their livelihood and the need for sustainable utilization of natural resources.

According to information collected through the survey, the population indicated that the population in the Uganda side of the area has started tobacco production since the last three to four years. A comparative study between both sides of the border would give a clear idea whether the agricultural husbandry practices observed in the Kenya side are different from the ones on the Uganda side or if the Kenya side practices can be used to predict what is going to happen in future on the Uganda side. Currently, the woodland vegetation, which evolved from abandoned fallow in Angurai, has become favorable habitats of tsetse. If those vegetation types are in Uganda exploited as intensively as it is currently in Kenya, significant changes are expected to occur in the landscape.

As cropping tobacco needs large quantities of firewood for curing, man should investigate the long-term effects of tobacco production on the vegetation cover, particularly on deforestation.

Since the beginning of activities to control tsetse population and trypanosomosis through the implementation of FITCA project, significant changes are expected to occur in the landscape and the following questions could be raised about those changes:

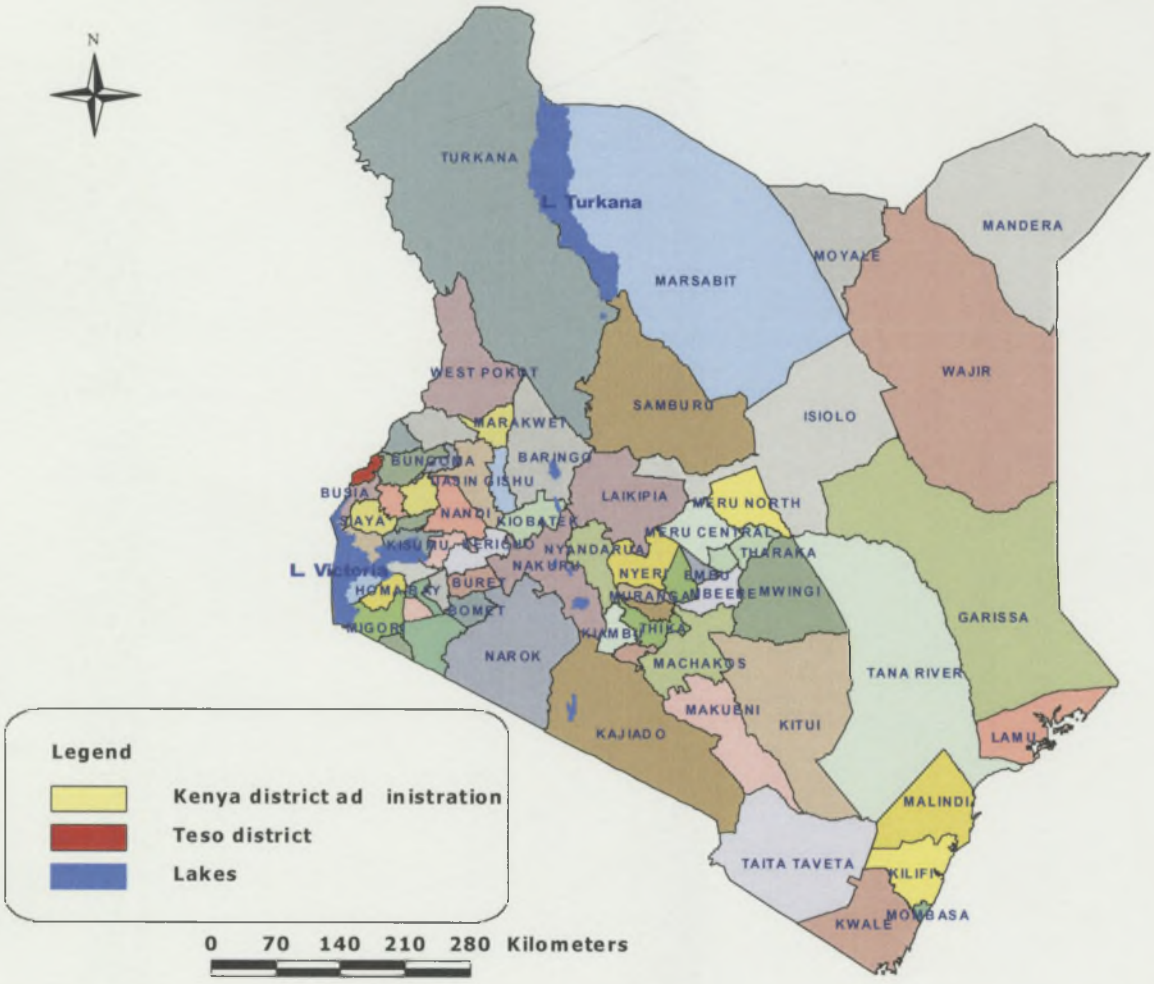
- Increased livestock production in the area will result in a significant expansion of crop areas and number of fields due to animal traction facilities. It is however worth wondering whether the population will combine tobacco and cotton production, particularly considering that cotton production is being encouraged by a newly launched enterprise in the area.
- If tobacco and cotton production continue to grow in the region as well as animal production, it is expected that natural vegetation formations will shrink significantly. How is the necessary balance between the increased crop production and the increased exploitation of natural resources be ensured?

- If the rehabilitation of livestock production is not properly monitored, increased livestock population will result into the need for more grazing areas. What will be the consequences on crop production having in mind that some farmers might find it easier to keep livestock rather than being involved in crop production? Increased livestock population might also result into overgrazing which will result in the long term into significant loss of biodiversity. Another potential consequence of overgrazing might be the restoration of shrub lands, which are potential tsetse habitats. The tsetse flies will therefore have got favorable hosts for their reproduction and proliferation, with subsequent increase of trypanosomosis epidemics in the area.

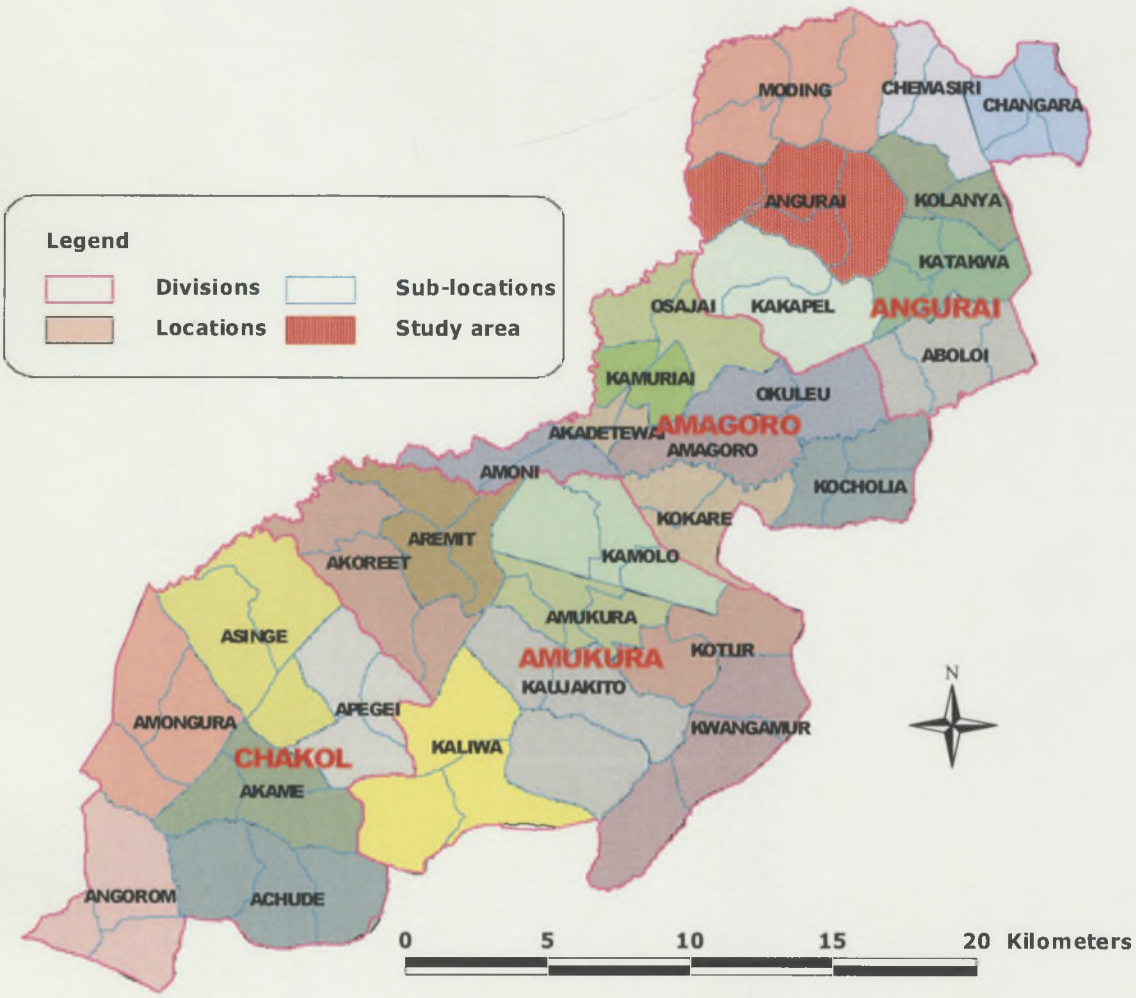
ANNEXE 1: CARTES

Annex 1: Maps

a) Map of Kenya

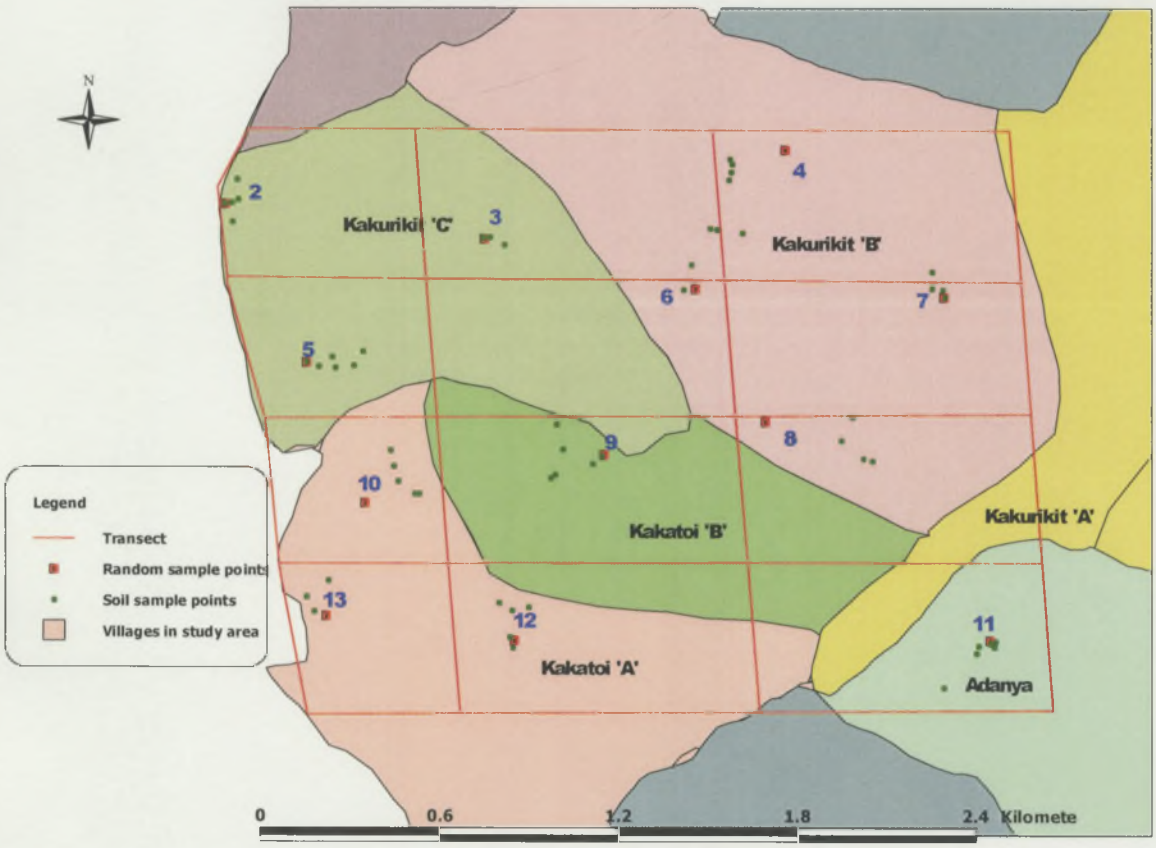


b) Map of Teso District

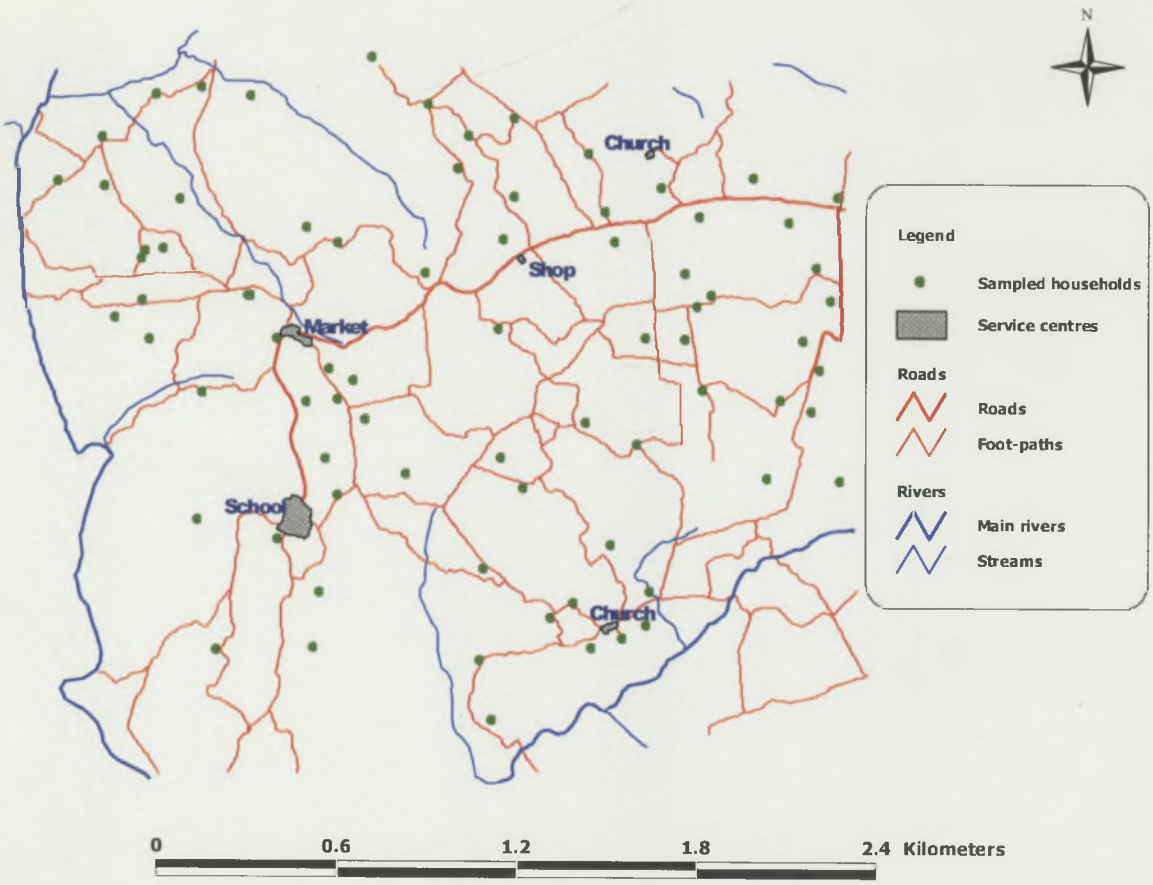


c) Map of Angurai

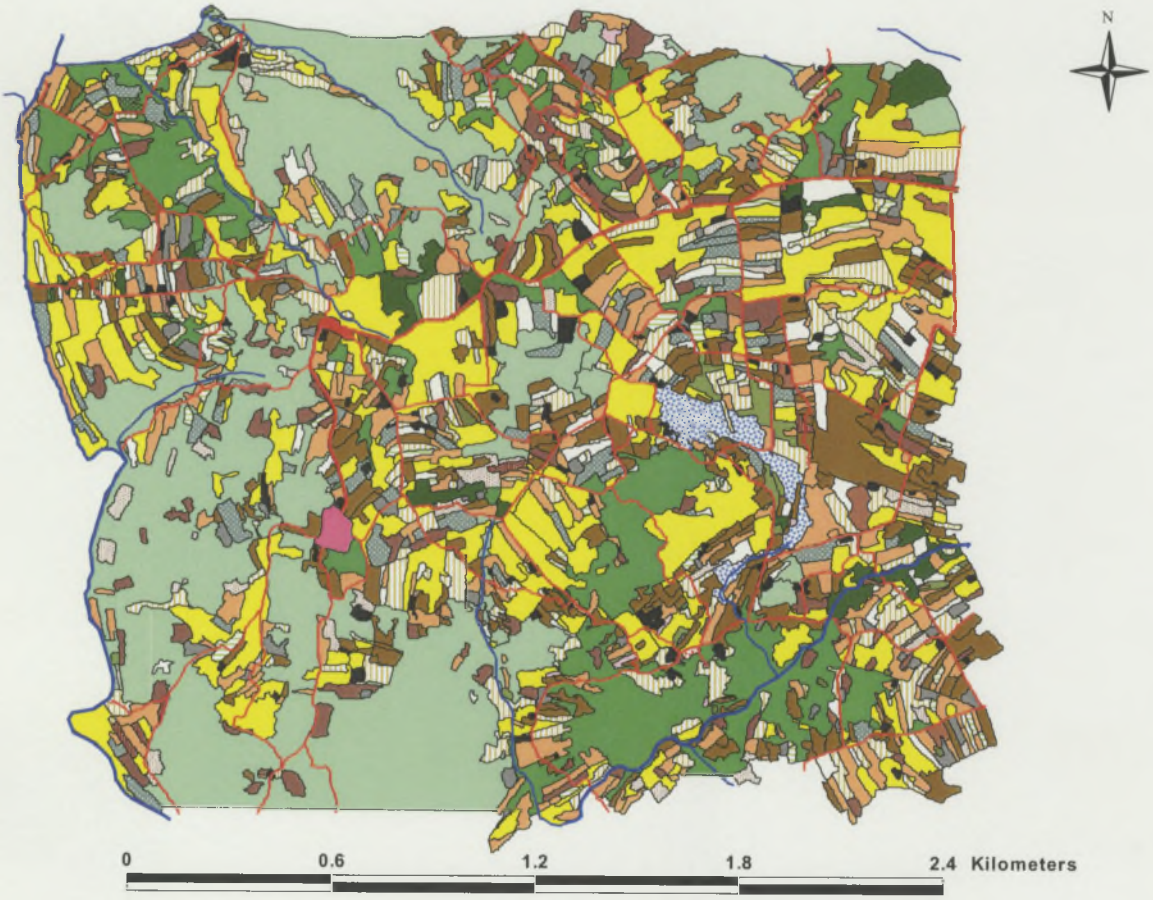
d) Map of the site of study



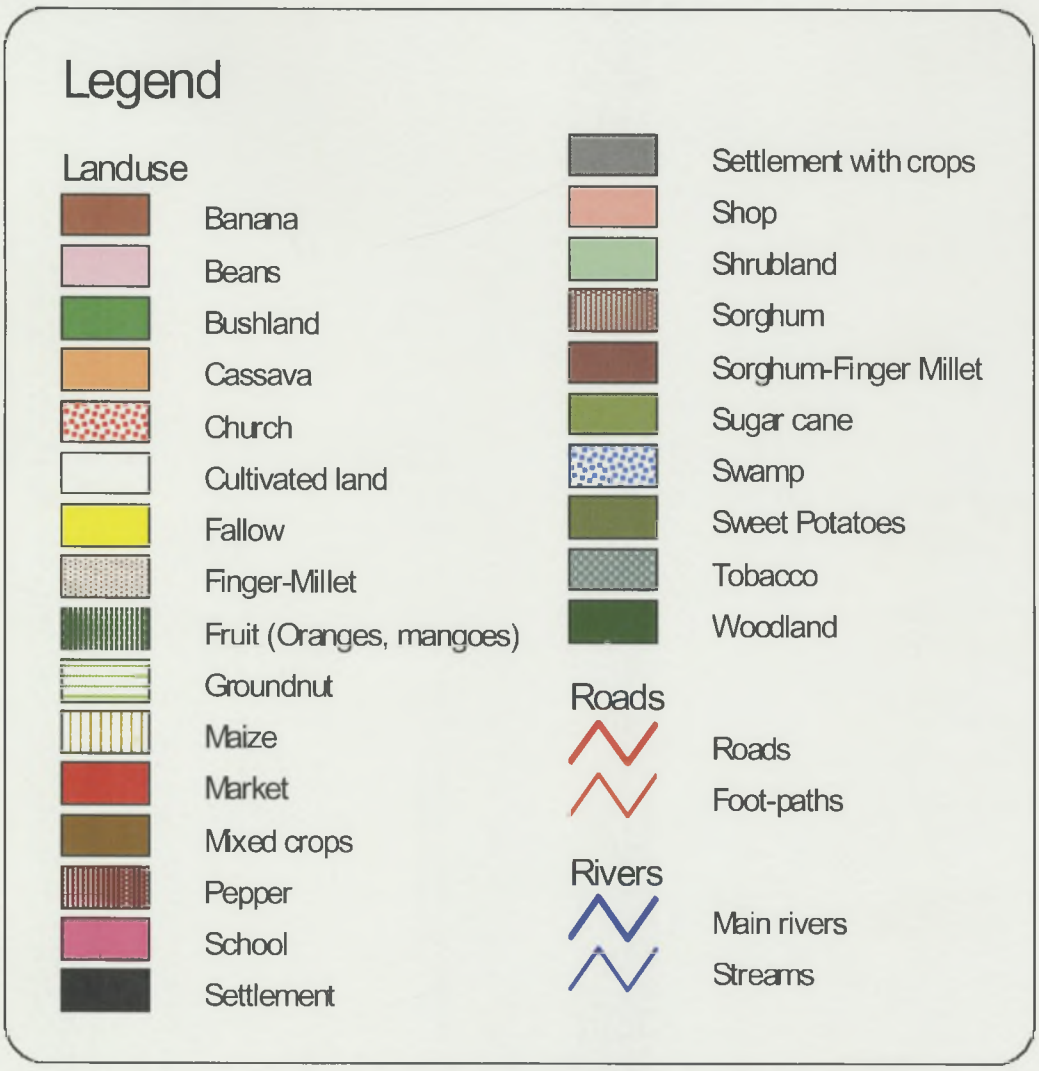
e) Map of accessibility to housings and water resources on the site



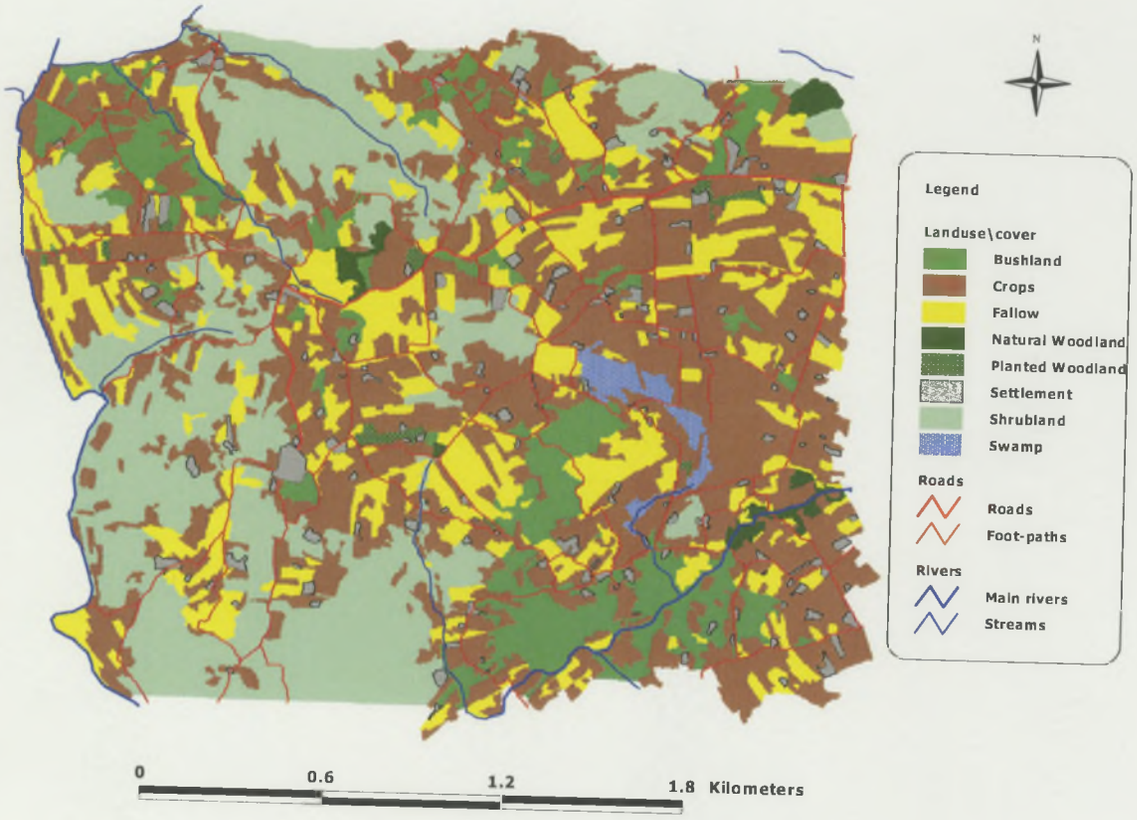
f) Map of land use, site of Angurai



Legend of the map of land use



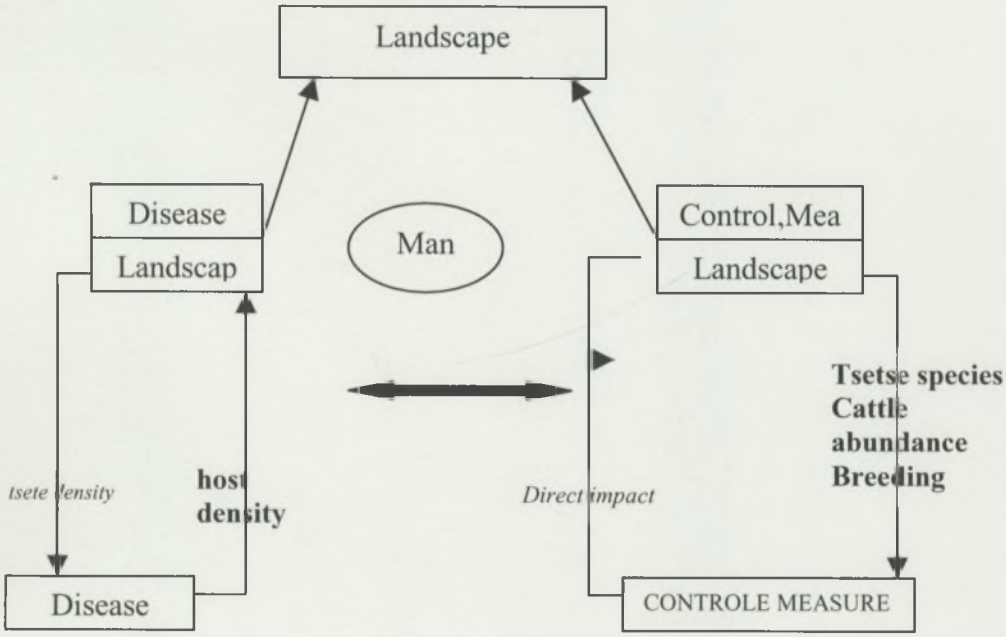
g) Map of the vegetation, site of Angurai



ANNEXE 2

Annex 2: Multidisciplinary approach

a) Relationship between landscape, disease risk and control



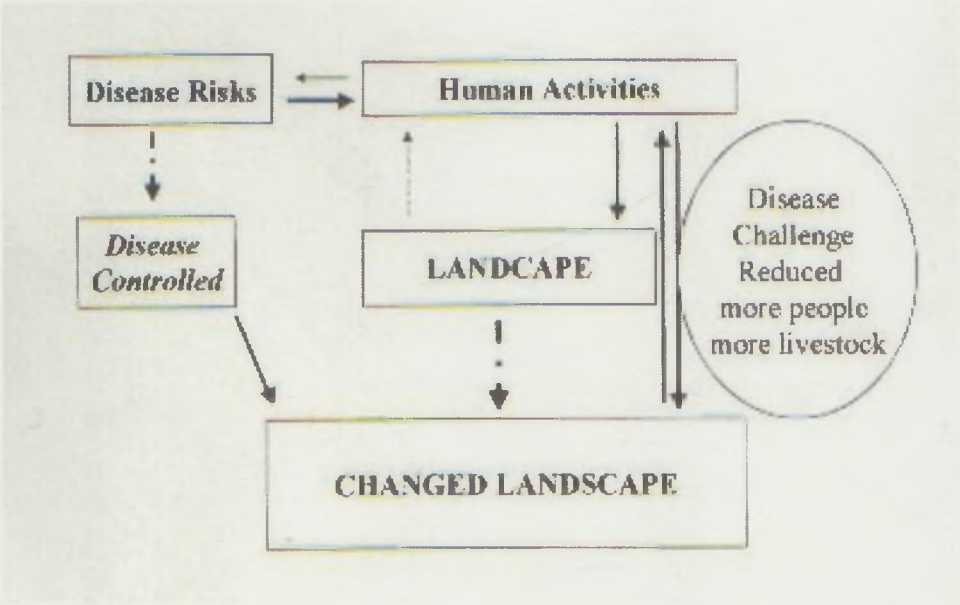
i. Hypothesis

Tsetse density	Tsetse abundance is linked with the vegetation / water / density of available hosts	Direct impact	Toxicology
Host density	Tryp is a main causes of death for cattle Tryp is a cause of departure for people	Tsetse species	The intensity of control and the methods will be different according to the species
		cattle abundance	Bailed technic could be used if the density of cattle is high
		Breeding capacity	O-grazing units could be used in productives area

Fig. 1 below presents a framework under which disease control leads to changes in landscape and fig. 2 gives an outline af landscape components that would be affected by changes in land use because of tsetse control.

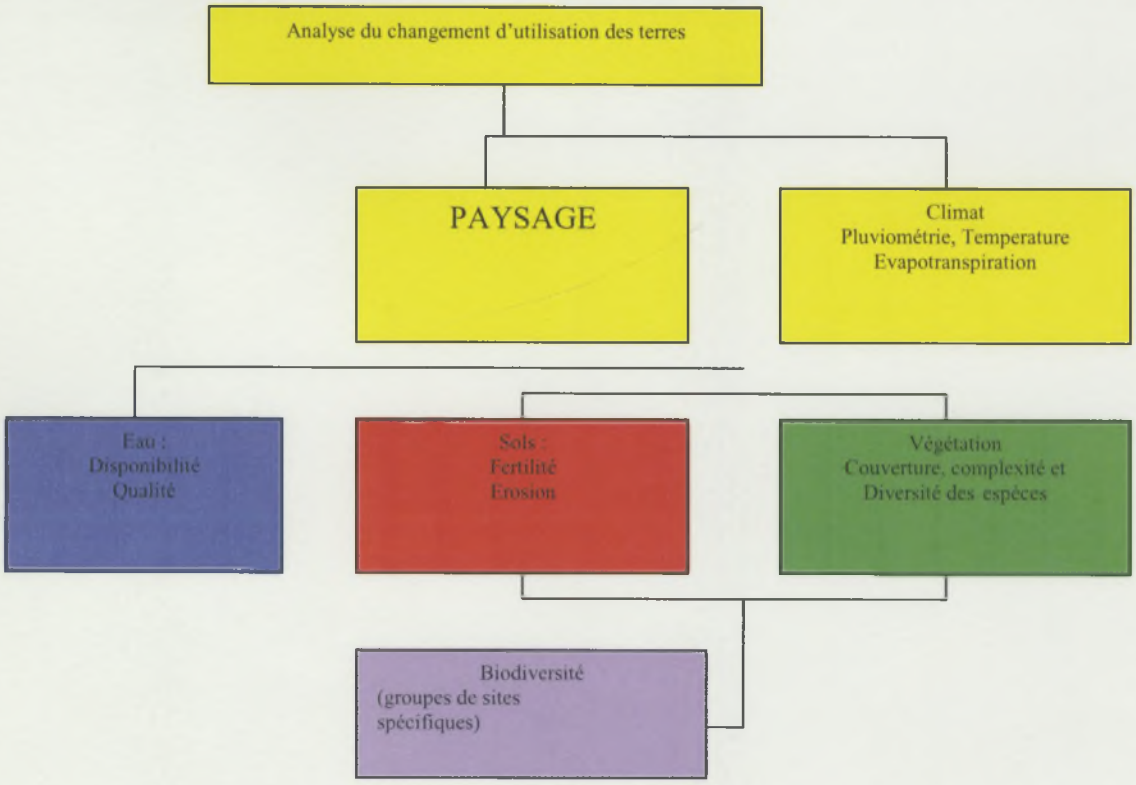
Annexe 2 (b) : Utilité de la méthode pluridisciplinaire d'étude de paysages pour mettre en place une base de données (sources FITCA-EMMC)

b)Pluridisciplinary approach for landscape study



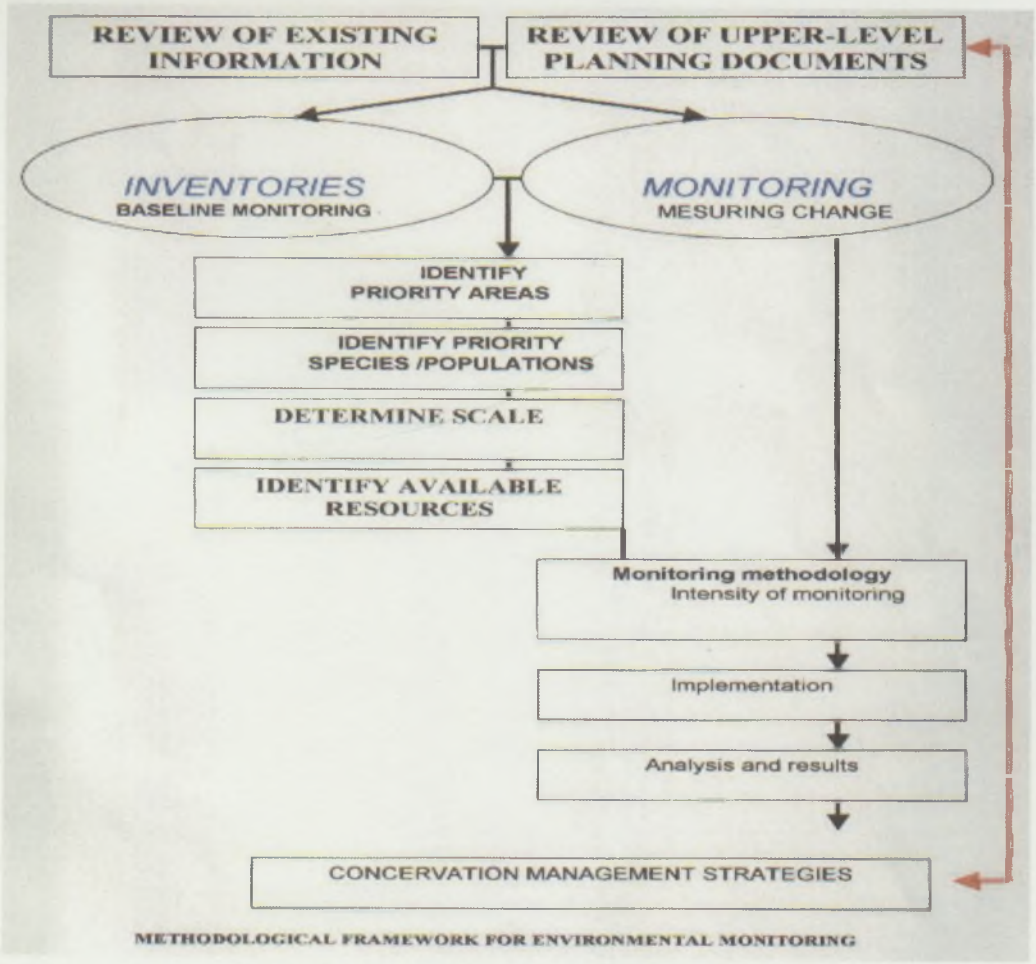
Dans la figure 2, la majeure partie des composantes étudiées sont des sols, de la végétation et de la biodiversité. Sur certains sites, l'eau sera aussi étudiée comme une composante. Le climat affecte l'utilisation de la terre. Donc pour comprendre les interactions entre le climat et la terre, nous allons récolter les données climatiques de chaque site en tenant compte des spécificités de chaque région.

Fig. 2 Composantes du paysage



Annexe2 ©: utilité de faire une base de données pour l'avenir.

Necessity of a database for the future



ANNEXE 3

Annexe 3 (a)

Tableau : Dictionnaire utilise pour coder les differentes point gps repertoriees

Chaque habitations, champs cultivés, jachères ou autres types de végétations sont répertoriés et enregistrés à l'aide d'un GPS, afin de les localiser sur le terrain. Le GPS étant limité à 6 caractères pour nommer les différents points rélévés, un code a été attribué à chacun des points en fonction de leurs caractéristiques. Par exemple les champs de maïs portent le code A. De plus il n'est pas possible d'avoir deux noms semblables dans la liste des noms enregistrés par le GPS, donc des numéros successifs ont été attribués. Par exemple champ de mais 1 code A1, champs maïs 2 code A2. Le dictionnaire utilisé sur le terrain est illustré dans le tableau ci-dessous :

LISTE	CODE	LISTE	CODE
Maïs	A	Ananas	N
Banane	B	Piment	O
Arachide	C	Sukumawiki	T
Tabac	D	Choux	U
Manioc	E	Sésame	Q
Millet	F	Parcelle en préparation	P
Sorgho	G	Habitation	S
Pois	I	Habitation du chef de famille	HH
Cane à sucre	J	Jeune jachère	V
Patates douce	K	Vieille jachère	W
Green gram	L	Très vieille jachère (forêt)	Z
Fruits (abres, liane, etc)	M	Coton	COTTON

Exemple de code pour un champ mixé : Maïs + Arachide + Pois, le premier champ de ce type recontré, le code sera alors ACI1.
Chaque jour les informations emmagasinés dans le GPS sont déchargés et traité par différents logiciels.

Annexe 3 (b) : Liste des champs cultivés à Angurai, Teso district, Kenya

VERNACULAR NAME	NOM LATIN	FAMILY
Banana	Musa sapientum	MUSACEAE
Beans	*Phaseolus vulgaris*	PAPILIONOIDEAE
Cabbage	*Brassica oleracea*	BRASSICACEAE
Cassava	*Manihot esculenta*	EUPHORBIACEAE
Cotton	*Gossypium hirsutum*	EUPHORBIACEAE
Finger millet	*Eleusin coracana*	GRAMINEAE
Green grams	*Glycine max*	PAPILIONOIDEAE
Maize	*Zea mays*	GRAMINEAE
Mango	*Mangifera indica*	ANACARDIACEAE
Millet	*Pennisetum typhoides*	GRAMINEAE
Njugu mawe		
Pawpaw	*Carica papaya*	EUPHORBIACEAE
Pepper (hot)	*Capsicum frutisence*	SOLANACEAE
Pineapple	*Annanus comosus*	
Sim sim	*Sesamum*	PODELLIACEAE
Sorghum	*Sorghum vulgare*	GRAMINEAE
Sugar cane	*Saccharum officinarum*	GRAMINEAE
Sun flower	*Helianthus annuus*	COMPOSITEAE
Sweet potatoes	*Ipomoea batatas*	CONVOLVULACEAE
Tobacco	*Nicotiana tobbacum*	SOLANACEAE

Reference: Kenya trees…

ANNEXE 4: QUESTIONNAIRE

Annex 4: Questionnaire

FITCA-EMMC

District

Village

Location

Household #

Georeference Long. N S
Lat. E W

Watering point

Type Open well depth m
Borehole depth m

Dam/lake Dam
River
Other

Users: Human
Livestock
Both
Wildlife

Permanent Yes
No

If 'Yes' Distance from HH meters

If 'No' Type of Watering point

during the rainy season
distance from HH meters
" " " the dry season
distance from HH meters

Type of landscape in between watering point and HH

Open savannah
Bushy savannah
Woodland savannah
Riverine forest
Swamp
Other

Type of footpath around the watering point

Concrete Stones gravels
Lawn Wood-piece soil
Other

Water quality According to users the water is considered as:

drinkable ☐ drinkable with caution ☐

Polluted ☐ Heavily polluted ☐

We haven't other choice ☐

Tsetse fly habitat

Do you know where the Tsetse flies are leaving?

During daytime Yes ☐ No ☐

During the night Yes ☐ No ☐

During the rainy season Yes ☐ No ☐

During the dry season Yes ☐ No ☐

If the answer is 'Yes' could you describe the site where the Tsetse use to leave?

Open savannah ☐

Bushy savannah ☐

Woodland savannah ☐

Riverine forest ☐

Swamp ☐

Other ☐

What are people using to protect themselves against the tsetse flies?

Nothing ☐ Mosquito net ☐

Smoke ☐ Repellent ☐

Others ☐ Imported

Traditional

Trends in cropping patterns

What are your principal crop productions?

	Quantity of seed used	unit
.....		
.....		
.....		
.....		
.....		
.....		
.....		

10 years ago, what were your principal crop productions?

.....		
.....		
.....		
.....		
.....		
.....		
.....		

Fallow period

Which kinds of fallow are represented on your farm?

	Surface	Unit	Trend (last 10 y.) ↘	→	↗
Grassland fallows					
Shrubby fallows					
Woodland fallows					

Communal grazing patterns

What are the main grazing areas of your farm?

	Rank of importance (1; 2; 3)	Trend (last 10 y.) ↘	→	↗
Communal grasslands				
Fallows				
Crop residues				
Other.....				

FARM NATURAL RESOURCES

Fuel sources

What are your main sources of fuel?

	Rank of importance (1; 2; 3)	Trend (last 10 y.) ↘	→	↗
Dry wood				
Timber wood				
Charcoal				
Gas cylinder				
Other.....				

How long have you to walk to find fuel?

	10'	30'	1 hour	over 2 hours
Dry wood				
Timber wood				
Charcoal				

Where are your main sources of building wood?

	Rank of importance (1; 2; 3)	Trend (last 10 y.) ↘	→	↗
Timber				
Timber factory				
Other.....				

Unconventional resources

Which kinds of produce are you collecting from the bush?

	home consumption	market	other use
Honey	☐	☐	☐
Fish	☐	☐	☐
Wild fruits	☐	☐	☐
Wild animals	☐	☐	☐
Medicinal plants	☐	☐	☐
Craft material	☐	☐	☐
Other.....	☐	☐	☐

Is it easier or more difficult to find these products than it was 10 years ago?

	Easier	More difficult
Honey	☐	☐
Fish	☐	☐
Wild fruits	☐	☐
Wild animals	☐	☐
Medicinal plants	☐	☐
Craft material	☐	☐
Other.....	☐	☐

Why?.....

COMMENTS

ANNEXE 5 : ANALYSE DE LA VEGETATION

Annexe 5 (a) Tableau : Formulaire d'analyse de la végétation

NO PLOT		
TYPE OF LAND COVER		
GPS POINT: EASTING		
NORTHING		
SPECIES		
COMMENT AND DESCRIPTION		

Tableaux des typologies des formations végétales

TYPE DE FORMATION VEGETALE:

1. FORET
2. FORMATION ARBUSTIVE TYPE SHRUBLAND
3. FORMATION ARBUSTIVE TYPE BUSHLAND
4. HEBACEES (jachère)

Les typologie des formations végétales suivantes ne sont représentées que par les principales espèces, rencontrées dans ces formations.

- FORET

Type d'espèce: Arbre

NOM LATIN	FAMILLE
Albizia coriaria Welw. ex Oliv.	Mimosaceae
Combretum machowiancum O.Hoffin.	Combretaceae
Combretum molle R.Br. ex-G-Don.	Combretaceae.
Ficus kitubalu Hutch	Moraceae

- SHRUBLAND

Types d'espèces:

- Arbre

NOM LATIN	FAMILLE
Acacia polyacantha Willd.	Mimosaceae.
Albizia versicolor Welw. Ex Oliv.	Mimosaceae
Chlorophora excelsa Welw.	Moraceae
Combretum elgonense Excell	Combretaceae.
Combretum ghalalense Engl. & Diels.	Combretaceae
Dombeya mukole Sprague.	Sterculiaceae
Myrianthus holstii Eng.	Moraceae
Teclea nobilis Del.	Rutaceae
Vitex doniana Sweet	Verbanaceae

- Shrub

NOM LATIN	FAMILLE
Acacia hockii De.willd	Mimosaceae
Heeria reticulata (Bak-f.) Engl.	Anacardiaceae
Maytenus senegalensis (Lam) Excell	Celastraceae
Piliostigma thonningii (Schumach) Mulne-Redhead.	Caesalpiniaceae
Pterolobium stellatum (Forsk) Brenan.	Caesalpiniaceae
Teclea simplicifolia (Engle) Verdoorn.	Rutaceae
Zizipus abyssinica Hochst ex A. R.	Rhamnaceae

- Liane

NOM LATIN	FAMILLE
Rhoicissus tridentata (L. F) Wild & Drumond.	Vitaceae
Rhynchosia hirta (Andrews) Melka & Verde.	Papilionaceae
Tylosema fassoglensis (Schweinf)	Caesalpiniaceae

- BUSHLAND

Types d'espèces:

- Arbre

NOM LATIN	FAMILLE
Kigelia aethiopum (Fenzl) Dandy.	Bignoniaceae
Pygeaum africanum H.K.f.	Rosaceae
Terminalia mollis (Laws)	Combretaceae

- Shrub

NOM LATIN	FAMILLE
Allophyllus africanus P. Beaur.	Sapindaceae.
Canthium Schimperianum A. Rich.	Rubiaceae
Euclea divinorum Hiern.	Ebenaceae
Harrisonia abyssinica. Oliv.	Simaroubaceae
Maytenus acuminatus (L.F.) Loes	Celastraceae
Mayterus mossambiscerus (Klotzsch) Blakelock.	Celastraceae

- Lianes

NOM LATIN	FAMILLE
Dioscorea schimperana Kunth	Dioscoreaceae
Rhoicissus tridentate (L.F) Wild & Drummond.	Vitaceae

- Bush

NOM LATIN	FAMILLE
Bridelia scleroneuroides Pax	Euphorbiaceae.
Caesalpinia decapetala Harms.	Caesalpiniaceae
Euclea divinorum Hiern.	Ebenaceae
Rhus natalensis Bernh	Anacardiaceae
Toddalia asiatica (L.) Lam.	Rutaceae

- Prairie (jachère)

Types d'espèces:

- Herbacées

NOM LATIN	FAMILLE
Cymbopogon excavatus (Hochst) Straff.	Gramineae
Halopyrum mucronatum L.	Gramineae
Hyparrhenia dissoluta (Stead) Hutch.	Gramineae
Hyparrhenia filipendula (Hochst)Stapf.	Gramineae
Pennisetum polysstachyon (L.) Schult.	Gramineae
Themenda triandra Forsk.	Gramineae

5 (c) Tableau : Localisation des différents types de végétations, définis par les points GPS

Type de végétation	point GPS	
Open bushland	36N06447221	UTM0078411
Open bushland	36N0647089	UTM0080273
Open bushland	36N0646214	UTM0078250
Bushland	36N0647226	UTN0078999
Bushland	36N0647736	UTM0079932
Bushland	36N0647820	UTM0080141
Bushland	36N0647879	UTM0080104
Bushland	36N0645771	UTM0079945
Open shrub land	36N0646276	UTM0079004
Open shrub land	36N0646706	UTM0078484
Shrub land	36N0646120	UTM0079911
Shrub land	36N0646659	UTM0079912
Shrub land	36N0647990	UTM0080240
Shrub land	36N0648083	UTM0080106
Woodland	36N0645774	UTM0078933

5 (d) Tableau : Fiches de descriptions des espèces prélevées (intégrées à l'herbier du FITCA-EMMC, Kenya).

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 19; **Plot No.** 5 **Name:** *Tylosema fassoglensis* (Schweinf) Torre & Hill C. **Family:** Caesalpiniaceae **Description:** Climbers or trailers from a swollen rootstock with or without tendrils and with simple bi-loped leaves. Flowers in racemes, yellow fruits pod, stalked, woody, 1 to 2 seeds. **Habitat:** Bushed wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 20; **Plot No.** 5 **Name:** *Rhynchosia hirta* (Andrews) Melka & Verde. **Family:** Papilionaceae **Description:** A robust twinner with broad leaflets, and racemes of dull, white-green flowers, collora with a crimson flash inside the standard. Fruit is a pod with blue seeds. **Habitat:** Bushed wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.
FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 52; **Plot No.** 10 **Name:** *Rhoicissus tridentate* (L.F) Wild & Drummond. **Family:** Vitaceae **Description:** Small tendrillate shrub or a climber leaflets dentate, obovate, often glabrous above and always tomentose below, no tendril or inflorescence branches. **Habitat:** Bushed grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 53; **Plot No.** 10 **Name:** *Terminalia mollis* (Laws) **Family:** Combretaceae **Description:** Savannah tree to 35ft., bark blackish grey,deeply fissured. Leaves elliptic oblong. Flowers white, foetid in densely tomentose spikes. Fruits oblong or elliptic. Timber brown yellow. **Habitat:** Wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 55; **Plot No.** 10 **Name:** *Harrisonia abyssinica.* Oliv. **Family:** Simaroubaceae **Description:** Much branched prickly shrub or small tree to 20ft. Bark grey, leaves variable, pinnately compound, with winged rachis. Flowers small and yellow in axillery terminal inflorescence. Fruit a small, black berry with 4-5 lobes. **Habitat:** Bushed grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 9; **Plot No.** 10 **Name:** *Mayterus mossambiscerus* (Klotzsch) Blakelock. **Family:** Celastraceae **Description:** Small shrub, twigs slender, pubescent. Leaves variable, ovate, obvate, elliptic or lanceolate; membraneous, glabrous or pubescent below. Flowers white in slender pedicals. Fruits heart shaped. **Habitat:** Wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.
FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 56; **Plot No.** 10 **Name:** *Dioscorea schimperana* Kunth **Family:** Dioscoreaceae **Description:** A robust climber with usually opposite, orbicular, cordate leaves. Male spikes umbellate at nodes, female spikes solitary. Fruit heart shaped. **Habitat:** Wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 32; **Plot No.** 7 **Name:** *Grewia mollis* A. Juss **Family:** Tiliaceae **Description:** Savannah shrub or tree to 20ft high. Black back, rough, deeply fissured. Leaves pale green above, hoary below, lanceolate to oblong in shape. Lateral nerves prominent. Flowers yellow in 2 to 3s. Fruit globose the size of a small pea. **Habitat:** Bushed grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 10; **Plot No.** 3
Name: *Chlorophora excelsa* Welw.
Family: Moraceae

Description: Large deciduous tree occuring in forests and savannah. 50 to 80ft occasionally attaining 160ft. Crown large. back thick, pale grey. Leaves very variable, 5-6 inches long and 3-4 inches broad, oblong elliptic. Flowers green in spicate inflorescence. Fruits caterpillar-like syncarps. Whole individual seeds are achenes.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 7; **Plot No.** 8
Name: *Myrianthus holstii* Eng.
Family: Moraceae

Description: Deciduous understory tree to 30ft. Leaves digitate or deeply digitately lobed; leaflets 5-7, obvate elliptic. Inflorecence usually paired with globose yellow flowers. Fruit spherical bright yellow when ripe.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 38; **Plot No.** 8
Name: *Pterolobium stellatum* (Forsk) Brenan.
Family: Caesalpiniaceae

Description: Large trailing shrub or tree with pegged prickles on the woody stems. Flowers white on axillary racemes. Fruits red winged pods or samara.
Habitat: Bushed wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 43; **Plot No.** 9
Name: *Teclea simplicifolia* (Engle) Verdoorn.
Family: Rutaceae

Description: A shrub in the scrub or forest undergroth, leaves glabous unifoliate, ovate or obvate. Flowers yellow green, unsexual and sessile, in panicle inflorescence. Fruits globose, smooth red.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 15; **Plot No.** 4
Name: *Teclea nobilis* Del.
Family: Rutaceae

Description: A tall forest tree, bark grey. Leaves dark green, normally 3-foliate, occasionally 2 or 1-foliate. Leaflets glabrous, narrowly and obscurely grooved. Flowers polygamous, yellow-green in panicles. Fruit red, glabrous, obovoid and one seeded.
Habitat: Riverline wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 17; **Plot No.** 5
Name: *Vitex doniana* Sweet
Family: Verbanaceae

Description: Deciduous savannah tree, usually 30-40ft, occasionally attaining 50ft. Crown dark green, rounded. Bark pale brown to grey white, with long narrow verticle and shringy fissures. Leaves usually 5-foliate rarely 7. Flowers in axillary cymes, densely flowered white. Fruit glabrous ellipsoid berry.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 21; **Plot No.** 5
Name: *Rhoicissus tridentata* (L. F) Wild & Drumond.
Family: Vitaceae

Description: Small tendrillate shrub or a climber, leaflets dentate, obvate, often glabrous above, always tomentose below. No tendril on inflorescence branhes.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 7; **Plot No.** 2
Name: *Maytenus acuminatus* (L.F.) Loes
Family: Celastraceae

Description: Small tree in dense shade of forest. Leaves ovate-elliptic with almost entire margins. Inflorescence few-flowered and axillary. Flowers red. Fruit non-angled capsule.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 14; **Plot No.** 4
Name: *Maytenus senegalensis* (Lam) Excell
Family: Celastraceae

Description: Savannah shrub or tree to 25ft. Bark grey. Branchlets armed or un armed. Spines (when present) very variable, short and slender or long and stout. Leaves serrulate, pale green or glaucous variable in shape and size. Usually obvate-elliptic. Inflorescence of axillary cymes, single or facided flowers. Fruit red capsule.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 23; **Plot No.** 6
Name: *Rhus vulgaris* Meikle
Family: Anacardiaceae

Description: Bush or occasionally small tree to 20ft. branchlets tomentellous. Leaves trifoliolate. Leaflets softly tomentose beneath, glabrescent above, mostly entire central-leaflet obovate. Flowers small, yellow green. Fruit small, edible.
Habitat: Wooded/Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 25; **Plot No.** 6
Name: *Ficus kitubalu* Hutch
Family: Moraceae

Description: Forest tree to 50ft. Leaves entire, oblong to elliptic verrurose and glabrous above at most slightly pubescent on midrib. Figs sessile and solitary or paired in leaf axils, globose yellow green with reddish spots.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 27; **Plot No.** 6
Name: *Albizia coriaria* Welw. ex Oliv.
Family: Mimosaceae

Description: Deciduous tree attaining 60ft in savannah and 120ft in forest. Bark red brown. Leaves pinnately compound, leaflets 4-12 pairs, glabrous. Flowers white with red stamens. Pods glossy brown straight, flat coriaceous oblong and few seeded.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 18; **Plot No.** 5 **Name:** *Dioscorea schimperana* Kunth **Family:** Dioscoreaceae **Description:** A robust climber with usually opposite orbicular, cordate leaves. Male spikes, umbellate at nodes, female spikes solitary. Fruit heart shaped. **Habitat:** Wooded bushed grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 11; **Plot No.** 3 **Name:** *Hyparrhenia filipendula* (Hochst)Stapf. **Family:** Gramineae **Description:** Slender perennial upto 150cm high. Panicle narrow loose, often over 30co long, with greenish or purplish racemes upto 15mm long. **Habitat:** Open grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 3; **Plot No.** 12 **Name:** *Hyparrhenia dissoluta* (Stead) Hutch. **Family:** Gramineae **Description:** Tufted perennial upto 300cm high. Panicle narrow &stiff. Spikelets large. Awns per raceme. **Habitat:** Open grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.**2; **Plot No.**7 **Name:***Pennisetum polysstachyon* (L.) Schult. **Family:** Gramineae **Description:** Annual or perennial upto 200cm high. Usually glabrous with flat linear leaves. False spike usually dense 2-25 cm long, purple or brownish spikelets surrounded by numerous ciliate bristles. Common on grasslands and sandy soils. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 1; **Plot No.** 4
Name: *Cymbopogon excavatus* (Hochst) Straff.
Family: Gramineae

Description: Slender perennial 60-120cm high with linear leafblades over 30cm long, rounded at the base. Panicle narrow with spatheate ussually reflexed raceme pairs.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No... ; **Plot No.** .....
Name: *Themenda triandra* Forsk.
Vern. Name: Red oat grass
Family: Gramineae

Description: Tufted perennial 45-180cm high. Panicle narrow, spatheate, . upto 45cm long. Racemes reduced to a single awned fertile spikelet 5-6mm long. Pedicelled spikelets often absent. Wide spread in grasslands.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 6; **Plot No.** 1
Name: *Acacia hockii* De.willd
Family: Mimosaceae

Description: Shrub or tree usually less than 15ft high occasionally attaining 40ft. Bark on main stem greenish-brown, peeling in papery rolls. Thorns brownish, rather weak, straight, usually less than 1 inch, sometimes absent. Frowers golden yellow in globose heads. Pods narrow–linear, strongly curved, scarcely or not at all constricted.
Habitat: Wooded/Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 8; **Plot No.** 2
Name: *Toddalia asiatica* (L.) Lam.
Family: Rutaceae

Description: One of the more unpleasant wait abit, scrambling pricky shrubs, in the colony. Leaves 3-foliolate, leaflets glabrous, elliptic to oblanceolate. Flowers in terminal panicles or cymes. Fruit fleshy, obscurely 2 to 5-lobed drupe, the size of a pea.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 28; **Plot No.** 6
Name: *Cumbrous molle* R.Br ex G.Don.
Family: Combretaceae

Description: Tree to 40ft or more. Branches small spread. Bole wavy, young barks smooth grey. Leaves opposite to sub opposite, elliptic to elliptic-oblong. Flowers in terminal panicle of spikes. Fruits 4-5 winged straw colored.
Habitat: Wooded/Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 24; **Plot No.** 6
Name: *Combretum machowiancum* O.Hoffin.
Family: Combretaceae

Description: Tree. Leaves opposite or sub opposite, elliptic-oblong, blade pubescent when young, glabrous when mature. Flowers in auxiliary spikes on lateral branchlets. Fruit a reddish brown to 1.5 inches long.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 5; **Plot No.** 1
Name: *Combretum ghalalense* Engl. & Diels.
Family: Combretaceae

Description: Savannah tree to 3ft. Branchlets orange red. Leaves usually ternate, subsessile, lanceolate-elliptc, usually glabrous. Lowers creamy yellow sweet scented. Fruits yellow about 1" long and1" wide.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 1; **Plot No.** 1
Name: *Piliostigma thonningii* (Schumach) Mulne-Redhead.
Family: Caesalpiniaceae

Description: Savannah shrub or tree to soft. Bark dark brown to grey or nearly black, thick, fissured. Leaves simple, bilobed, cordate at base. Inflorescences are racemes of white flowers, fragrant and dropping. Pods oblong, usually 6 – 8" long red brown.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 30; **Plot No.** 6
Name: *Combretum molle* R.Br. ex-G-Don.
Family: Combretaceae.

Description: Tree to 40ft or more. Branches small, spread. Bole wavy, young barks smooth grey. Leaves opposite to sub opposite, elliptic to elliptic-oblong. Flowers in terminal panicle of spikes. Fruits 4-5 winged straw colored.
Habitat: Wooded/Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 26; **Plot No.** 6
Name: *Rhus natalensis* Bernh
Family: Anacardiaceae

Description: Bush or (occasionally) small tree to soft in savannah. Branchlets grey-brown. Leaves pale green, trifoliolate. Leaflets sessile, abovate to oblanceolate or oblonglanceolate, glabrous beneath. Inflorescence Panicle of greenish, yellow, very small. Fruit globose.
Habitat: Scattered bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 40; **Plot No.** 9
Name: *Allophyllus africanus* P. Beaur.
Family: Sapindaceae.

Description: Savannah shrub or tree to soft. Bark grey, smooth. Leaflets sessile or subsessile, glabrous except of occasional tuffs or hairs. Inflorescence axillary and terminal, usually well branched. Flowers creamy white, fragrant. Fruits glabrous, ellipsoid.
Habitat: Wooded grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 34; **Plot No.** 7
Name: *Bridelia scleroneuroides* Pax
Family: Euphorbiaceae.

Description: Savannah bush or tree to 30ft, with dropping branchlets. Leaves oblong-to-oblong – elliptic, usually rigidly leathery, softly and densely pubescent below. Flowers, in axillary chisters. Fruit globose, purple black berry.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI
Collection Date: June and July 2002.

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** ….; **Plot No.** ….. **Name:** *Halopyrum mucronatum* L. **Family:** Gramineae **Description:** Tufted erect perennial grass, leaves linear, culms cylindrical and hollow. Leaves linear pale green and glabrous. Inflorescence a false spike, spikelets subtended by feather like soft hairs. White in colour. **Habitat:** Open grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 40; **Plot No.** 8 **Name:** *Acacia polyacantha* Willd. **Family:** Mimosaceae. **Description:** Fast growing, flat topped tree to soft. Bark ash grey to yellow rough with yellow brown scales. Thorns strongly recurved with black tips. Flowers creamy white in spikes. Fruits broadly linear flat and persistent in the tree. **Habitat:** Scattered Tree grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 37; **Plot No.** 8 **Name:** *Heeria reticulata* (Bak-f.) Engl. **Family:**Anacardiaceae **Description:** Small tree with grey bark much fissured. Leaves simple ablong to lanceolate, very variable to 8" long, glabrous to velvety above, midrib and laterals branched. Flowers white in erect terminal panicles. Fruit berries Currant – like. **Habitat:** Scattered Tree grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 39; **Plot No.** 8 **Name:***Dombeya mukole* Sprague. **Family:** Sterculiaceae **Description:** Tree to 40ft, very handsome when in full flower. Leaves crenate-serrate, stellate – puberulous on both surfaces, broadly ovate, base cordate. Flowers white in axillary cymes. Fruit 3 – locular capsule. **Habitat:** Scattered wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 36; **Plot No.** 8 Name: ***Zizipus abyssinica*** **Hochst ex A. R.** Family: **Rhamnaceae** **Description:** Wickedly armed savannah shrub or a tree to 25 ft high. Twigs, lowerleaf surfaces and inflorescences densely white to buff tomentose. Bark grey brown, fissure and scaly, spines paired and brown. Leaves more or less densely rusty or grey tomentose, dark green and glabrous above, elliptic to ovate. Flowers in axillary cymes yellow or white. Fruit smooth shiny, spherical red brown drupe. **Habitat:** Bushed grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 46; **Plot No.** 9 **Name:** *Euclea divinorum* Hiern. **Family:** Ebenaceae **Description:** Much branched small tree with elliptic leaves, narrowing from the middle, lamina coriaceous, sometimes glancous. Flowers fragrant, cream coloured in lax racemes. Fruit globose edible drupe when ripe, black – purple. **Habitat:** Wooded/Bushed grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.** 45; **Plot No.** 9 **Name:** *Pygeaum africanum* H.K.f. **Family:** Rosaceae **Description:** Forest tree to 120 ft high. Leaves crenate, glabrous, and elliptic to oblong. Flowers small, creamy white, fragrant, in simple racemes. Fruit, dry red, glabrous, drepressed globose. **Habitat:** Wooded grassland. **Vegetation:** **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 41; **Plot No.** 9 **Name:** *Canthium Schimperianum* A. Rich. **Family:** Rubiaceae **Description:** Shrub or tall tree. Bark granulated, dark grey. Leaves elliptic to ovate – lanceolate. Glabrous, glossy above. Flowers white, in dense fascicles. Fruit a globose berry. **Habitat:** Scattered wooded grassland. **Vegetation:** **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 48; **Plot No.** 10
Name: *Toddalia asiatica* (L) Lam.
Family: Rutaceae

Description: One of the more unpleasant wait-abit, scrambling pricky shrub in the colony. Leaves 3-foliolate. Leaflets glabrous, elliptic to oblanceolate . Flowers in terminal panicles or cymes. Fruit a fleshy, obsarely 2-5 lobed drupe size of a pear.
Habitat: Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 51; **Plot No.** 10
Name: *Caesalpinia decapetala* Harms.
Family: Caesalpiniaceae

Description: A woody climber, with recurved prickles, and rather large acuminate leaflets on the vipinatte leaves. Flowers yellow, male and bisexual flowers. Pods flat orbicular to oblong.
Habitat: Wooded/Bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 50; **Plot No.** 10
Name: *Phullanthus sepialis* Mull. Arg.
Family: Euphorbiaceae

Description: **Shrub to 8 ft with woody branches. Flowering branches some what flattened. Leaves obovate or** ovate – elliptic. Flowers dioecious or sexes on different shoots, axillary and solitary. Fruit a bilobed capsule.
Habitat: Riverline bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM
Flora of Kenya
Sample No. 54; **Plot No.** 10
Name: *Kigelia aethiopum* (Fenzl) Dandy.

Family: **Bignoniaceae**

Description: Low branched savannah tree to 50ft. Back stony grey to pale brown. Leaves in threes, leaflets 7 – 9, Scabrid, elliptic oblong. Flowers unpleasantly scented, reddish purple or maroon. Fruit sancase shaped, thick, grey green, fibrous, slightly rough on the surface.
Habitat: Riverline bushed grassland.

Locality: Angurai Division, Teso District.
Collected By: Stephanie de LACROIX and Alice W. MWANGI

FITCA-EMMC HERBARIUM **Flora of Kenya** **Sample No.**16; **Plot No.** 5 **Name:** *Albizia versicolor* Welw. Ex Oliv. **Vern. Name:** MCHANI-NDOVU (Swahili) **Family:** Mimosaceae **Description:** Low branched Savannah tree to 40ft. Bark dark red-brown. Leaflets pubescent above, velvety golden-tomentose below, obliquely obovate-elliptic to sub orbicular. Flowers white or greenish yellow with crimson stamens. Pods flat, straight, thin, papery, brittle, red-brown and oblong. **Habitat:** Scattered tree grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.	**FITCA-EMMC HERBARIUM** **Flora of Kenya** **Sample No.** 33; **Plot No.** 7 **Name:** *Combretum elgonense* Excell **Vern. Name:** ASENWET (Sebei) **Family:** Combretaceae. **Description:** Savannah tree to 30ft. Branchlets orange-red. Leaves alternate, lanceolate-elliptic to ovate, finely glandular and reticulate, usually glabrous, sometimes hairy. Flowers creamy yellow, sweetly scented. **Habitat:** Wooded grassland. **Locality:** Angurai Division, Teso District. **Collected By:** Stephanie de LACROIX and Alice W. MWANGI **Collection Date:** June and July 2002.

Tableau : Formulaire d'analyse de la végétation

NO PLOT		
TYPE OF LAND COVER		
GPS POINT: EASTING		
NORTHING		
SPECIES		
COMMENT AND DESCRIPTION		

ANNEXE 6 : PHOTOS

Annex 6: photographs

Annexe 6(a): Photos Champ cultivé et récolté le tabac
Photo (haut) : Avant plan champ de tabac, arrière plan formation arbustives.

Annexe 6 (b) : Photo (haut)des haies de Lantana camara et de tithonia diversifolia, entre les différents champs.

Annexe 6 (c) : Photo (haut) de jeune jachère
Photo (bas) de formation arbustive type shrubland

Annexe 6 (d) : Photo de construction servant au séchage des feuilles de tabac. Panier, sur le côté, fait de branches de Lantana camara et de

Photo du chargement des feuilles séchées de tabacs par la BAT (British American Tobacco, compagnie de tabac)

Annexe (e) : Exemple de cultures

Photo (haut) : Champs mixte d'arachides et de maïs, près d'une petit parcelle de canne à sucre. Les trois culture sont marqués comme une mixture d'arachides, maïs et canne à sucre au GPS, pour des raison de précision.

Photo (bas) d'un culture mixte volontaire de manioc et de coton.

Annexe 6 (f): type de travail de champs.

Photo (haut) Travail manuel à la binette d'un champ de maïs.

Photo: Labour de la terre par traction animale, préparation de la terre pour la prochaine saison, après avoir récolté le tabac.

Annexe 6 (g) : Prélèvement d'échantillon de sol

ANNEXE 7 : ANALYSE DU SOL

Annex 7: Soil analysis, visual indicators of erosion

		Maize	Cassava	Tobacco	Ground nuts	Finger millet	Fallow	Ground nuts mixed maize
Slope	**Flat (0-5)**	10%	0%	14%	20%	9%	9%	50%
	Low (5-20)	50%	92%	**86%**	**80%**	73%	73%	50%
	Moderate (20-40)	30%	0%	0%	0%	0%	18%	0%
	High (>40)	**10%**	8%	0%	0%	**18%**	0%	0%
Sheet wash	**No visible**	0%	0%	0%	0%	9%	18%	0%
	Moderate	20%	17%	14%	0%	55%	18%	50%
	Slight	80%	83%	86%	100%	36%	64%	50%
Rills	**No visible**	30%	67%	43%	80%	36%	82%	75%
	Slight	50%	33%	57%	0%	64%	18%	25%
Accumulation of soil	**No visisble**	90%	83%	100%	100%	91%	82%	100%
around vegetaion	**Slight**	10%	17%	0%	0%	9%	18%	0%
	Moderate	20%	0%	0%	20%	0%	0%	0%
Deposite of soil	**Not visible**	10%	8%	0%	0%	9%	18%	0%
on gentle soil	**Slight**	40%	25%	29%	80%	27%	64%	50%
	Moderate	50%	58%	71%	20%	45%	18%	25%
	Severe	0%	8%	0%	0%	18%	0%	25%

(a) Tableau : indicateurs visuelles d'érosion par type de culture

(b) Figure : Graphiques des indicateurs visuels d'érosion du sol par type de culture