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An Approach for Monitoring Environmental Impacts after Tsetse Control in eastern Africa.

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Abstract

The most effective means to control trypanosomosis has been to reduce the population of the insect vectors that transmit the pathogenic trypanosomes to livestock and people. Many approaches have been applied to control the vector including vegetation clearing, bush burning, ground and aerial spraying and recently use of traps and targets. There are direct and indirect environmental impacts associated with tsetse control. Indirect impacts are dominated by the effect of increased human activities in the tsetse and trypanosomosis controlled areas. Tsetse control allows human occupation and one of the consequences is a rapid increase in farming, vegetation clearing, hunting of wild animals, and ploughing. These activities modify the ecosystems.

Although impacts of tsetse control on the environmental have been known to exist for quite some time research to analyse the nature and ways to mitigate these impacts has just begun. There is therefore a general lack of methodologies to guide the analysis of the impacts especially the indirect impacts whose importance has been realized much more recently. This paper discusses an approach for identifying the impacts and suggests ways to conduct monitoring of the changes with a view of providing an early warning for which negative impacts can be reduced.

The starting point in environmental impact assessment is to develop a baseline data upon which changes in various environmental parameters can be deciphered. The entry point is land use and land cover analysis at farm and village level. The next is to scale up the village level analysis into landscape level. Methodologies used combine ground surveys, remote sensing analysis to produce land use and land cover maps at different scales, reconstruction of historical changes from the communities using questionnaires and an assessment of changes in natural resources from GPS referenced plots. Results include maps of land use and land cover, distribution of natural resources, temporal variations in various environmental and socio-economic parameters in the surrounding areas. Information from these analyses will be used to increase awareness among the farmers and extension officers on the environmental effects of land use changes and how the affects could be monitored to reduce negative impacts.

Introduction

Tsetse and trypanosomosis have been known in Africa for a long time. Trypanosomosis however, was discovered in Kenya only by the beginning 20^{th} century (Davies 1993). The link between the disease and tsetse was established some 30 years later. Following the discovery of this link it was found that controlling tsetse populations was an effective way of controlling the disease both the human and the animal diseases (Maitima and Tumba 1998).

Several methods have been used to control tsetse including widespread bush clearing and burning, aerial and hand spraying of bushes and riverine vegetation. These methods were more degrading and polluting to environment due to direct impacts on the environment and non-target organisms. It is these direct impacts that led to a widespread condemnation of tsetse control and an opinion held by a few in Europe that tsetse is a guardian of the wild in Africa. With the adoption of modern tsetse control techniques like the use of traps, targets and pour ons by the communities, the direct impacts were greatly reduced and are now of negligible effect to the environment (Bourn, et. Al. 2001). However, it has recently been realized that indirect impacts associated with changes in land use are now more important as a cause to environmental degradation than the direct impacts (Bourn, et. Al. 2001). When tsetse is controlled and the disease challenge is low there is a gradual increase in human settlements leading to an increase in cultivation, increase in livestock numbers and breeds.

Purpose for tsetse control

The goal is to free tsetse and trypanosomosis infected areas from the disease and make habitable to human beings. The objective for tsetse and trypanosomosis control is therefore to reduce trypanosomosis prevalence among livestock and humans so as to improve on livestock production and human health in the disease prone areas. Areas where tsetse and trypanosomosis are common are usually in the semi- arid areas where life support systems operate at very narrow ecological ranges. For the land use practices to remain sustainable these life systems must be within acceptable thresholds beyond which environmental degradation will reduce sustainability of land use practices. Without an adequate environmental monitoring system to guide land use systems in the tsetse and trypanosomosis control areas, efforts of disease control to enhance food production or alleviate poverty are unlikely to be realized.

Ecological systems in tsetse control areas

All the above underlying purposes for tsetse and trypanosomosis control require that ecological conditions in the project areas allow the processes to proceed sustainably. It is therefore necessary to examine all ecological variables that would affect productivity with a view to provide advice to land management. Land based production systems in tsetse control areas are characterized by narrow ecological ranges typical of semiarid regions. These ranges determine whether agricultural off-take from farms such that farming beyond the limits will adversely affect the sustainability of land use.

Purposes for monitoring
Monitoring of environmental changes in a land use area is for several reasons. First there is a need to assess the trends of change on different environmental variables both at the farm and village or catchment levels. This is necessary in order to provide a mechanism for identifying these changes at an early stage when mitigation measures can be taken to avoid or reduce the negative impacts. The other purpose for monitoring is that at a larger scale it would serve to identify areas in need of interventions to enhance ecological sustainability of land use practices. Monitoring could also assist in developing frameworks for intervention by farmers.

Major elements for monitoring in a tsetse control area

1. Land use and land cover: Monitoring the way people use land is important to provide advice on practices that are less degrading to the environment and would enhance productivity.
2. Vegetation and biodiversity: Vegetation cover is important to maintaining soil fertility, reducing soil erosion and above all to provide the much needed primary productivity to feed on to the grazers and eventually to the detritus food chains. Primary productivity is also important to the biodiversity, which is necessary in order to perform other functions of the ecosystem or to provide environmental goods and services.
3. Soils: In all farming systems the quality of soils is critical to the sustainability of production systems. Areas to be monitored include both physical and chemical properties of soils including soil erosion.
4. Socio-economics of farming: Tsetse control can affect farming systems due to availability of animal traction, healthier animals and subsidies generated from animal production. Tsetse is in many cases aimed at improving human welfare and enabling the farmers to sustain farming practices.

FITCA EMMC Approaches
Developing ecological and socio-economic baselines in selected sites.
As mentioned earlier focus on indirect issues of tsetse control is recent. The need to address changes in land use and the approach to focus on a more holistic state of the environment is a recent focus in analysing environmental impacts of tsetse control. Although tsetse control has been practiced for a long time and in some places environmental concerns addressed, the approach has been only in view of direct the impacts, which were more dependent on the control mechanisms used. Data to address these new dimensions are not available in most of the sites. It is therefore necessary to acquire baseline data in order to understand the ecological processes and develop mechanisms of how farming activities in all these places can be sustainable.

To acquire these baseline data EMMC has developed the following approaches:

i. Land use land cover mapping both at farm and at villages
ii. Field surveys to assess the distribution, composition and structure of vegetation.
iii. Rapid Assessments and appraisals of socio-economics, environmental and land use histories.

iv. Assessment and monitoring of changes in soil fertility

v. Analysis of satellite imagery and scaling out site level observations to wider scale to represent landscape of analysis.

Field mapping of land use and land cover

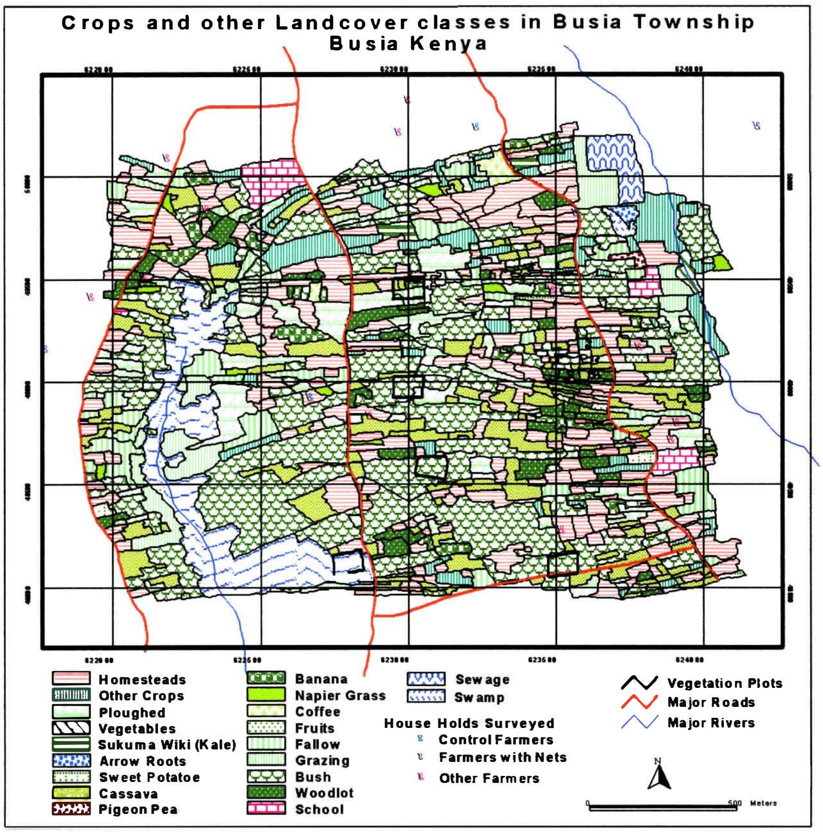
Land degradation occurs at widely varying rates, and to varying degrees, over the landscape. Assessment of the sustainability of land use should therefore focus at all the scales in order to capture the changes at all levels. Examination of field degradation at different scales feeds into different levels of analysis. Each level has its own particular set of uses. The first and most immediate use of information relating to existing or potential degradation is to identify the risks at field and firm level. Mapping of fields and related site characteristics are involved here (Njuguna 2003, Woodwel 1984, Lillesand and Kiefer, 1979)). The next level is to rank the degrees of actual degradation, or future risks of degradation. This allows the land user to prioritise possible responses to land degradation risks and to target parts of the farm where risks are greatest. The field assessor may use this level of analysis to make some quantitative comparisons between sites and situations.

The first step in assessing land degradation is to take stock of visual evidence of degradation in the area under review. The physical aspects of the landscape must be observed and evaluated. Preparing a map of the study area will help to identify areas at particular risk of degradation due to the naturally occurring features in the landscape.

The mapping was accomplished by using hand held GARMIN GPS systems model (CX and XL). This exercise was achieved by a number of people including locals who were trained on site. The locals recruited were trained on how use a GPS. Training included identifying different land cover and land use types on ground, recording waypoints on the GPS and tracking of poly lines to define various land use land cover types. The training also involved field practical in which the trainees were shown the techniques of starting and stopping the tracking of a poly line, recording corners by having a short pause and finally recording and coding the polygon label points. During practical training, various possible land use / cover were identified and the coding system agreed on among the mapping team.

Each GPS reader was assigned a separate area to map so as reduce the possibility of overlap or omissions. The mapped areas were reviewed at the start of day's work for identifying any errors of omission or overlap and setting up the days mapping strategy. Downloads were done in the field as soon as a GPS tracking memory was full using a laptop computer loaded with GPS download software (Ozi-Explorer) and Arc View desktop GIS software for mapping and verification of downloads. The filed group was communicating using personal mobile phones to contact each other and especially to contact the driver and the mapping group leader for GPS downloads.

Figure 1 GIS tracking generated Land Use map of Busia EMMC site



Results of this exercise provide the following information

i. Areas and spatial distribution cropped land parcels with details of different crops
   - Summary table of crops and land covers in Busia
   - Graphs to show variations in crop cover relative to total land cover and total crop cover
ii. Areas and distribution of uncultivated land parcels with different categories of land cover
   - Summary table of non-cultivated land covers in Busia study site
   - Graphs to show variations in non-cultivated land covers relative to total land covers and within non-cultivated land cover types

Rapid Appraisals for Socio-economic, land use and environmental histories

A list of farmers involved in FITCA Kenya programs was obtained from the FITCA office. A questionnaire was developed and administered to a sample of selected farmers in the FITCA-Kenya project area. Data obtained from the questionnaire was entered in the computer using MS access and analyzed using SSPSS statistical package

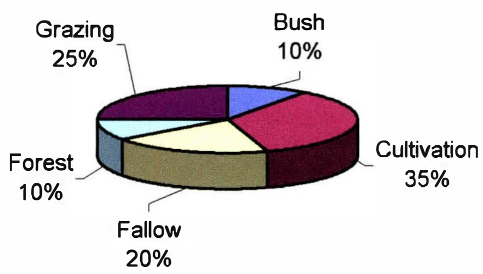
Results of this exercise provide the following information.

Vegetation surveys

In every site several 1 hectare plots have been established. In each of these plots the three major vegetation life forms have been studied to obtain species composition, abundance and canopy stratification including cover. The three life forms studied are trees, shrubs, and herbaceous species. Each of these categories has been studied on the same plot using different quadrat sizes. Trees were sampled using 50x50m quadrat, shrubs by 25x25m (Maitima and Olson 2003) quadrat and herbaceous species by 1x1m quadrats. All the plots are geo-referenced using GPS for future studies and GIS analysis. In each of the plots soil samples have been collected for laboratory analysis.

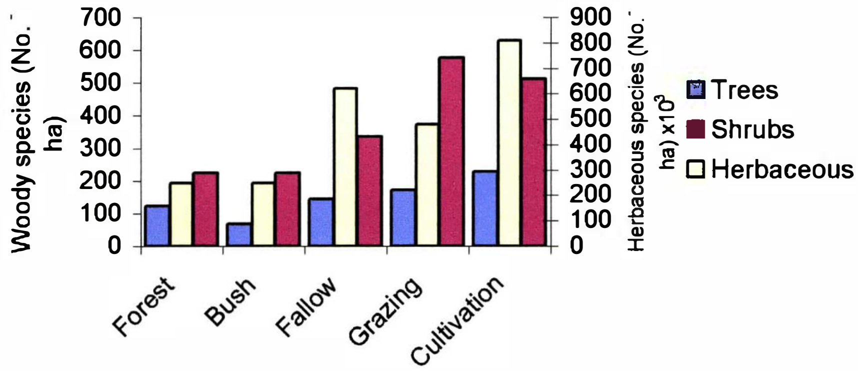
Results of this analysis provide the following information:

Figure 2. Proportion of land under various use-cover types in the Soroti sample



Grazing is one of the most important economic activities in Soroti, second only to cultivation. The amount of land committed to grazing is about a 1/4 of the entire sample area, reflecting the high importance of livestock as a source of livelihood in the region. About 1/5 is under fallow conditions suggesting a possible land management strategy by the residents to allow for natural nutrients replenishment to the soils. However, it is possible that infestation of this area by tsetse may also have rendered it unsuitable for grazing and homestead development.

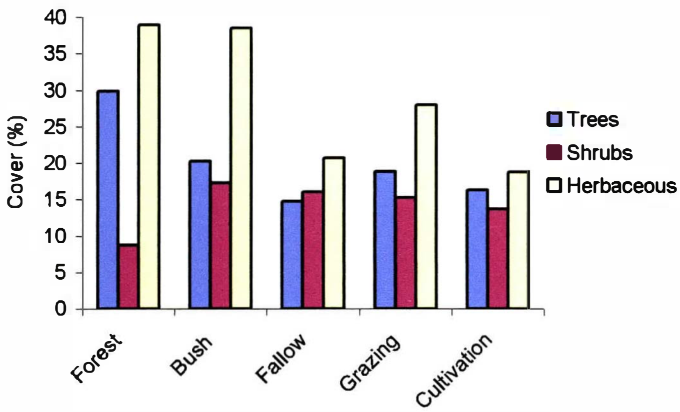
Figure 3. Number of species per hactare by general land use-cover types in Soroti



Land use-cover type

The trend of species richness along the land use/cover types in Soroti is such that diversity is higher in cultivated & grazing than in forest and bush sites. The cultivated and grazing sites are considered intensively used and therefore the higher species richness here is evidence of management interventions occurring at the household level. The percentage vegetation cover, on the other hand, is higher in the forest and bush than the rest of the land use/cover types. This strongly points to deliberate efforts in bush management in the grazing land, perhaps aimed at eradicating tsetse-breeding sites. In addition, grazing may produce a similar net effect where browsing animals may control the vegetative growth of bushes.

Figure 3. Percentage cover of different vegetation types by the general land use-cover types in Soroti



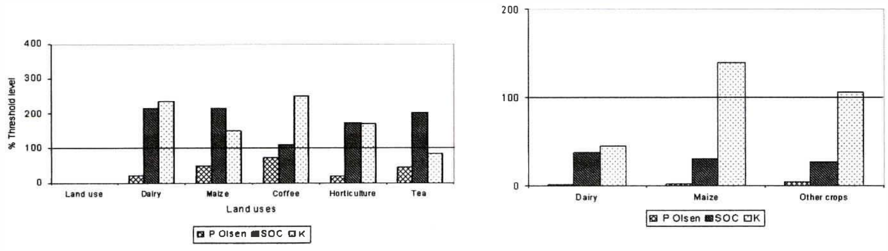
Land use-cover types

Figure __ represents ground proofing of vegetation cover in Soroti. The Coverage of woody vegetation is on average below 20% in all land use/cover types except in the forest, where it approximates 30%. Overall, the coverage of woody species is much lower than that of herbaceous species across all the land use cover types. Although forest and bushy woodlands may have dominated the landscape a couple of decades ago (compare with the map images) this has gradually retreated with the increasing cultivation and grazing pressure. Much of the forest remnants are only fragments mostly in the riverfronts. Land clearing, herbivory and fires are important factors of land use that may be influencing the dynamics of plant communities in this area. A high frequency of these factors may trap the woody vegetation in the regeneration stage and eventually lead to 'land-use type-climax' vegetation characterised by short and sparse bush-like tree species. Overall, the cover type in this region is regressing slowly into herbaceous dominated type, slowly converting to savannah grassland. For instance in the Busia region woody plants are characteristically rare in the cultivated and homestead areas, suggesting greater impact of these use type on woody vegetation unlike grazing and fallowing. This could be related to low recruitment of saplings and unsustainable harvesting pressure on the tree species. On the other hand, lower bush cover in grazing and homestead areas compared to other land use types point to bush control management relatable to tsetse control, also observed in Soroti. The succession trends of herbaceous layer is such that commoners and/or invasive species, which thrive best in highly disturbed land, are gradually dominating these sites. Overall the herbaceous layer may be a major component that influences the ecological dynamics under the prevailing land use-cover types, since it constitutes the dominant vegetation type although it covers less than 40% of land. The consequence of these vegetation changes implies susceptibility of soil to wind and water erosion and nutrient transfer/loss in the area, plus high evapo-transpiration considering that over 60% of land is bare. The organic carbon component may also be low, considering that low soil moisture that is likely to persist here limit decomposition rates of the little organic materials available leading generally to infertile soils. General Lack of woody plants particularly trees species in the area is suggestive of increasing semi arid conditions where composition of woody plant species vary much more markedly as a function of soil moisture than as a function of prevailing land use-cover type. This supports the hypothesis of committing larger areas to grazing in order to meet the feed requirement for the animals while at the same time accommodating fluctuations in forage that is likely to subsist alongside poor rainfall patterns.

Assessing and monitoring of changes in soil fertility

A comparison of fertilities between different land use types.

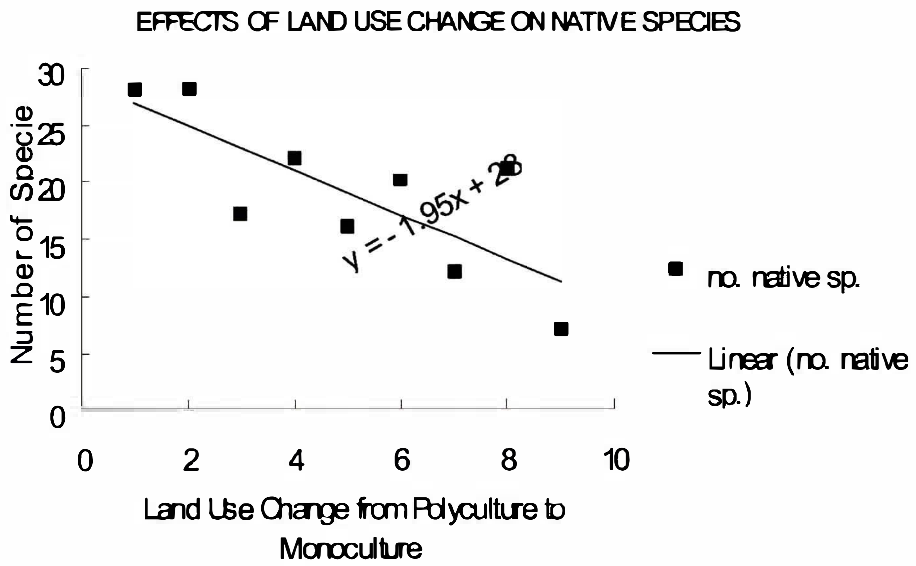
Figure 4. Percent threshold level of phosphorus (P Olsen), soil organic matter (SOC) and potassium (K) with land use



LH1/tea zone

LM4/marginal cotton

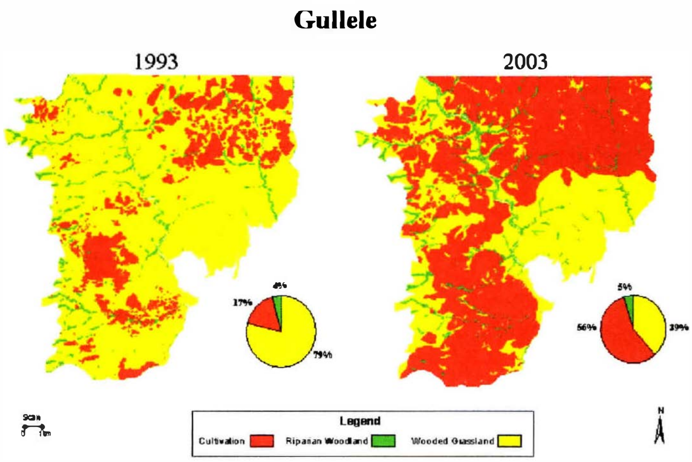
Figure 5. Impacts of land Use Change on Native species



Analysing satellite imagery and scaling out site level observations

Analysis of remotely sensed data is used here to generate a map of the distribution of land cover types in contexts wider than the village level since images cover a wide area. There are a number of types of satellite images with different resolutions. An exercise to select a suitable type of image was conducted through a CIRAD and ILRI consortium of remote sensing expert and Spot 5 was recommended due to its small-scale resolution. IKONOS would have provided a much finer resolution that SPOT but cost was prohibitive and availability was not certain. Land Sat is much affordable but its resolution is much coarse and may not be able to detect changes at farm level especially among the small-scale farmers who own small pieces of land and grow crops in much smaller fields. However, since many projects utilize data from previous projects it is important to maintain consistency on the types of images analysed. For Example ILRI (International Livestock Research Institute) has for several years been using Land Sat analysis to study the impacts of tsetse control in Ghibe Valley in Ethiopia (Wilson 2003).

Figure 6. Land use and land cover in the Gullele study site in 1993 and 2003. Pie charts show the percent composition of each land-use/land-cover type for each year. From Wilson 2003



Socio-economic analysis

The importance of this approach is the ability to focus on changes at farm level and the involvement of farmers in the monitoring. To be able to do this it is important to involve the farmers in recognizing and identifying the changes that have taken place in their environments. This exercise is also important in developing baseline data upon which monitoring of changes can be made.

Developing sustainability indicators

Sustainability of land use practices for agricultural production is determined by a number of dynamic processes mainly involving changing conditions and composition of certain elements that are part of life support systems (Rigby et. Al. 2000). The status of these processes have physical manifestations (sustainability indicators) that if used by the land managers or those charged with the responsibilities of maintaining land can provide easy and accurate diagnostics for the productivity of the land. However, these indicators may vary from place to place depending on the total sum of conditions that affect them.

Although most of these indicators are available in published literature it is important to involve farmers or land managers in developing them so that the indigenous knowledge within the community can be utilized. Furthermore involving farmers is important even though these are available in publications for the purpose of validating the physical characteristics of the variables and put it in the context of farmers perceptions.

To do this first is to list the indicators that are known to the farmers and then validate or update these with scientific information available in literature.

Our approach is to use following steps

- Farmers workshops

Through the workshops the scientists will get to know how much the farmers are aware of environmental issues affecting agricultural productivity in their farms. Our experience is that farmers know a lot but their knowledge is not utilized in the management of their land. Although the farmers are aware of some of the land degradation indications they are not aware how much they loose every season because of land degradation. These workshops are aimed first to create a dialogue between scientists and farmers on processes and problems affecting their land use and secondly to develop a list of land degradation indicators based on their own knowledge. The product of this exercise is a list of well-considered indicators of land degradation developed by the farmers themselves.

- Incorporating scientific findings and evaluation to the farmers perceptions

The knowledge developed above is then supplemented by scientific knowledge on all the indicators mentioned to find out the underlying causes or rather the forces that lead to the observations. Some of the indicators may have sufficient information in published literature, which can be synthesized and incorporated into farmer's knowledge in training. This exercise creates a very useful contact between scientists and land managers or farmers to discuss knowledge from either side to enhance sustainability of land use. The product of this exercise is a list of land degradation indicators whose issues discussed are scientifically acceptable and well understood by farmers, extension staff and all stake holders.

- Training farmers on how to monitor an integrated set of indicators

The final step in this approach is to develop training workshops where the farmers' knowledge on land degradation indicators is broadened. The training includes identification of the indicators and knowledge on interpretation of the indicators. The training includes ways on which to respond to the indicators at farm level. The training is done with full participation of the extension personnel and the relevant government authorities at higher levels.

Discussions

The results presented above in figures 1, 2, 3, 4, 5, and 6 describe some of the outcomes f this approach. The need to have a unified or sets of available methods on how to acquire information on land degradation cannot be over emphasized. Such methods must utilize knowledge from all sectors including the farmers themselves.

Farming in tsetse control areas need a close monitoring of ecological or environmental processes because these processes operate in very narrow ecological limits outside which land use is no longer sustainable. The concern of sustainability of land use practices in tsetse control areas is recent and there is a need to develop an approach of dealing with the problem. Here we propose an approach that uses analysis of changes at the farm level, mapping of farm households and the distribution of natural resources at the village level and a landscape approach that uses remote sensed data to identify environmental situations at the landscape level. These analyses lead to a better understanding of farmers' perceptions on the changes within their environments.

The approach assembles land degradation indicators in all the sites. The purpose of these indicators is to provide a guideline in land management to avoid land degradation. One important reason for developing the indicators is that data on sustainability can be obtained in a similar way across sites at different scales and in different time periods.

Research on sustainability indicators is a complex subject that requires many considerations of factors that influence a particular indicator. There is a large amount of literature available on this subject but stakeholders in each region or situation cannot apply these to all geographical areas without verification and selection of those applicable.

Recommendation

- Land in Tsetse and Trypanosomosis Areas need monitoring to avoid or reduce negative impacts
- Monitoring must include changes at farm/household level, village level and landscape level
- Developing of site specific monitoring indicators
- Indicators must be familiar to farmers and their identification must involve farmers.
- Farmers' involvement in monitoring at farm and to some extends at village level while other stakeholders are involved at all levels.

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