

Mapping the Distribution of Tsetse Flies in Eastern Uganda

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Key words: Mapping, Tsetse Flies, Uganda

SUMMARY

Spatio-temporal mapping of tsetse fly infested area of Eastern Uganda was done using geoinformatics techniques. The primary objective of the study was to show how remotely sensed and other environmental data could be combined in a decision support system to help in forming tsetse control programmes. A relationship assessment was also used to describe both the links between land cover and radiation recorded by a remotely sensed image and the links between land cover and the disease carried by the tsetse vectors. The study demonstrates the ability of GIS and Remote Sensing in capturing spatio-temporal data on land use and land cover classes. The nine land cover classes captured were Built-up area, Secondary forests, Savannah, Grasslands, Shrublands with herbaceous, Rainfed shrub crops, Fresh water swamps, Water bodies and Farmlands. The remote sensed imageries also showed how the land use and land cover classes change between 1986 and 2001 and it helped to identify the suitability of the land cover classes for tsetse fly habitation. The study demonstrated that GIS and remote sensing coupled with statistical analyses could help immensely in mapping tsetse habitats. The study showed that the tsetse fly habitat area in Eastern Uganda has been decreasing with time due to increase in the Savannah and grassland land cover types and urbanization.

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1. INTRODUCTION

Tsetse flies are vectors for both human (sleeping sickness) and animal trypanosomiasis (nagana). FAO, (1998) edited by B.M.N.J. Kityo-Zake indicated that a total of 1046 patients were diagnosed and treated in the districts in Uganda affected by *T. gambiense*, while 225 patients were diagnosed in the districts affected by *T. rhodesiense*. Insurgency in these areas greatly hampered the effective implementation of control activities. Animal trypanosomiasis continues to be reported from all the 45 districts of the country. In South Eastern Uganda, in areas where surveillance for animal trypanosomiasis was carried out, the overall prevalence of 9.9% was obtained; while in Western Uganda 6.5% was registered. *T. vivax* was the predominant species detected and most prevalent followed by *T. brucei* and lastly *T. congolense*. Eastern Uganda is a region that have the highest cases of sleeping sickness recorded from 2000 to 2007 base on statistics (FAO, 1998). An important step in understanding their ecology for the purposes of intervention is to determine the environmental causes of the spatial and temporal variation in the tsetse fly (Glossinidae) numbers.

Previous studies focused on infection of the disease using parametric and non-parametric technique for their analysis. The prominent among these are the studies by Ford (1969); Buyst (1977); Welde (1989); Khonde (1995); Leak (1999). The ability to predict outbreaks in advance based upon the vegetation change indicators may make it possible to implement early vaccination initiatives or aggressive vector control programs. The use of remote sensing for the study of disease has grown rapidly in the past decade. The growth is attributable to several factors. Since the late 1980s, there has been growing use of geographic information systems (GIS) and spatial statistics in studies investigating patterns of disease incidence. It will also guide the relocation of human populations away from trouble spots. Remote Sensing (RS) and GIS enhance the understanding of the relationship between vegetation and vector-borne disease and prepare health professionals for changes in the distribution of important infectious pathogens. This study aims, therefore, at using remote sensing and GIS techniques to examine and map the spatio-temporal distribution of tsetse flies and to assess the relationship between tsetse fly occurrence and livestock distribution in Uganda between 1986 and 2001.

2. MATERIALS AND METHODS

2.1. Study Area

Uganda latitudes is in 4⁰.0' North and 1⁰.30' South of the equator, and longitudes 30⁰.0' East and 35⁰.0' East of Greenwich. Uganda covers a total area of 236,040 sq km. The greater part of Uganda consists of a plateau 800 to 2,000 m (2,600–6,600 ft) in height. Along the western border, in the Rwenzori Mountains, Margherita Peak reaches a height of 5,109 m (16,762 ft), while on the eastern frontier

Mount Elgon rises to 4,321 m (14,178 ft) (Advameg, 2007). By contrast, the Western Rift Valley, which runs from north to south through the western half of the country, is below 910 m (3,000 ft). For example, the surface of Lake Edward, Lake George and Lake Albert (L. Mobutu Sese Seko) is about 621 m (2,036 ft). The White Nile has its source in Lake Victoria and as the Victoria Nile, it runs northward through Lake Kyoga and then westward to Lake Albert, from which it emerges as the Albert Nile to resume its northward course to the Sudan. (Advameg, 2007)

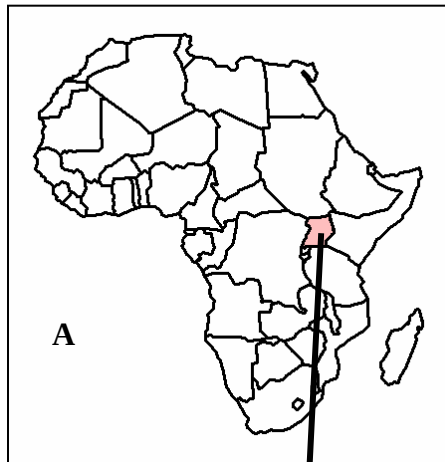


Fig 1A: Map of Africa Showing Uganda

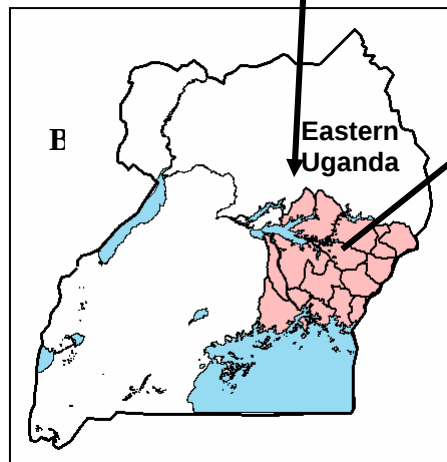


Fig 1B: Map of Uganda Showing Eastern Uganda

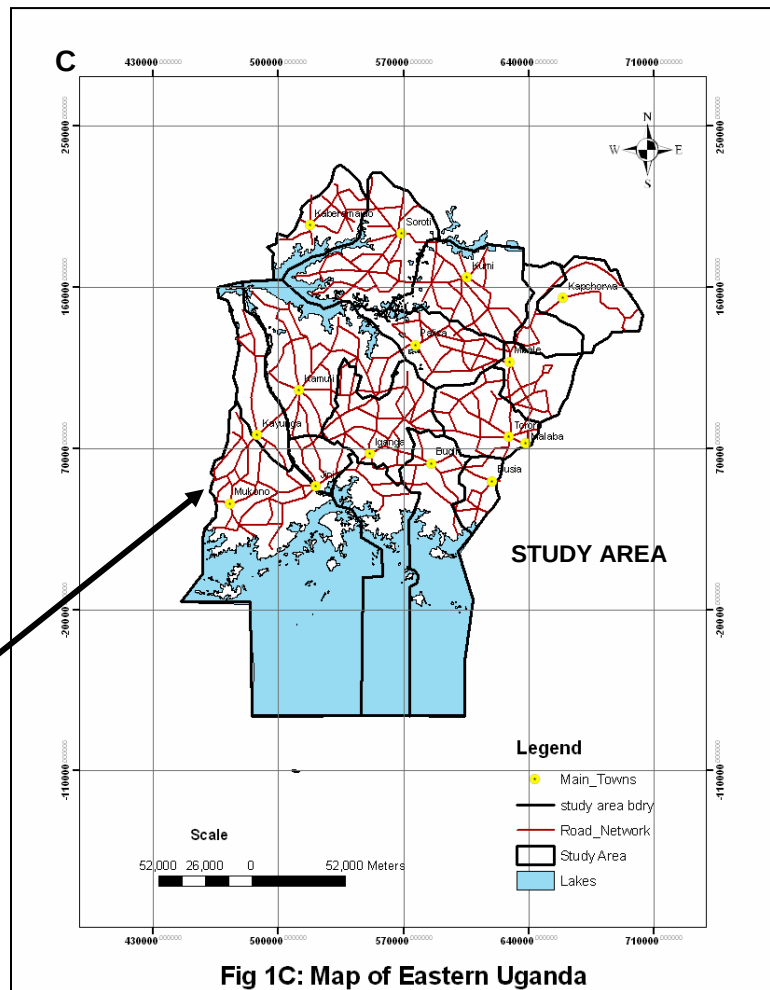


Fig 1C: Map of Eastern Uganda

2.2 Data Acquisition and Analysis

For the study, Landsat satellite images of Uganda were acquired for one Epochs; 1986. 1986 imageries was obtained from the Global Land Cover Facility (GLCF) an Earth Science Data Interface and Landsat satellite images of 2001 were obtained from the GIS section of Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) Uganda. Landsat imageries are suitable for vegetation studies and other criterion for their selection includes: Cover the study area with the period of 1986 and 2001; Similar in the season of image acquisition hence easy land characterization

Raw data on livestock populations in Uganda from 1997 – 2001 was obtained from the statistical abstracts and background to the Budget (several years), Ministry of Finance, Planning and Economic Development; Small Ruminant Development Study Report, Ministry of Agriculture, Animal Industry and Fisheries, 1999. The standard processes for the analyses of satellite imagery such as extraction, restoration, classification, and enhancement were applied for the study. The classification of land-use was aggregated to 5 classes which include: Secondary Forests (Agro-forestry), farmlands (shrubs/fallow), built-up (residential and commercial), Bare rocks and bare soils (exposed rocks) and water bodies (ponds, lakes, rivers, streams). Images covering the study area were loaded onto the computer hard disk memory. Data seaming was done to combine the four different images so as to get one image covering the whole study area. The landsat – TM full scene was then geo-referenced (i.e., geometrically corrected in the adopted UTM map projection system) using ERDAS software with an image that is already geo-referenced. Geo-referencing helps to integrate and maintain consistency with data from external sources. After such correction, the images were exported to ArcGIS and each became super-imposable on the corresponding base map. This was followed by creating a subset of the study area from the image.

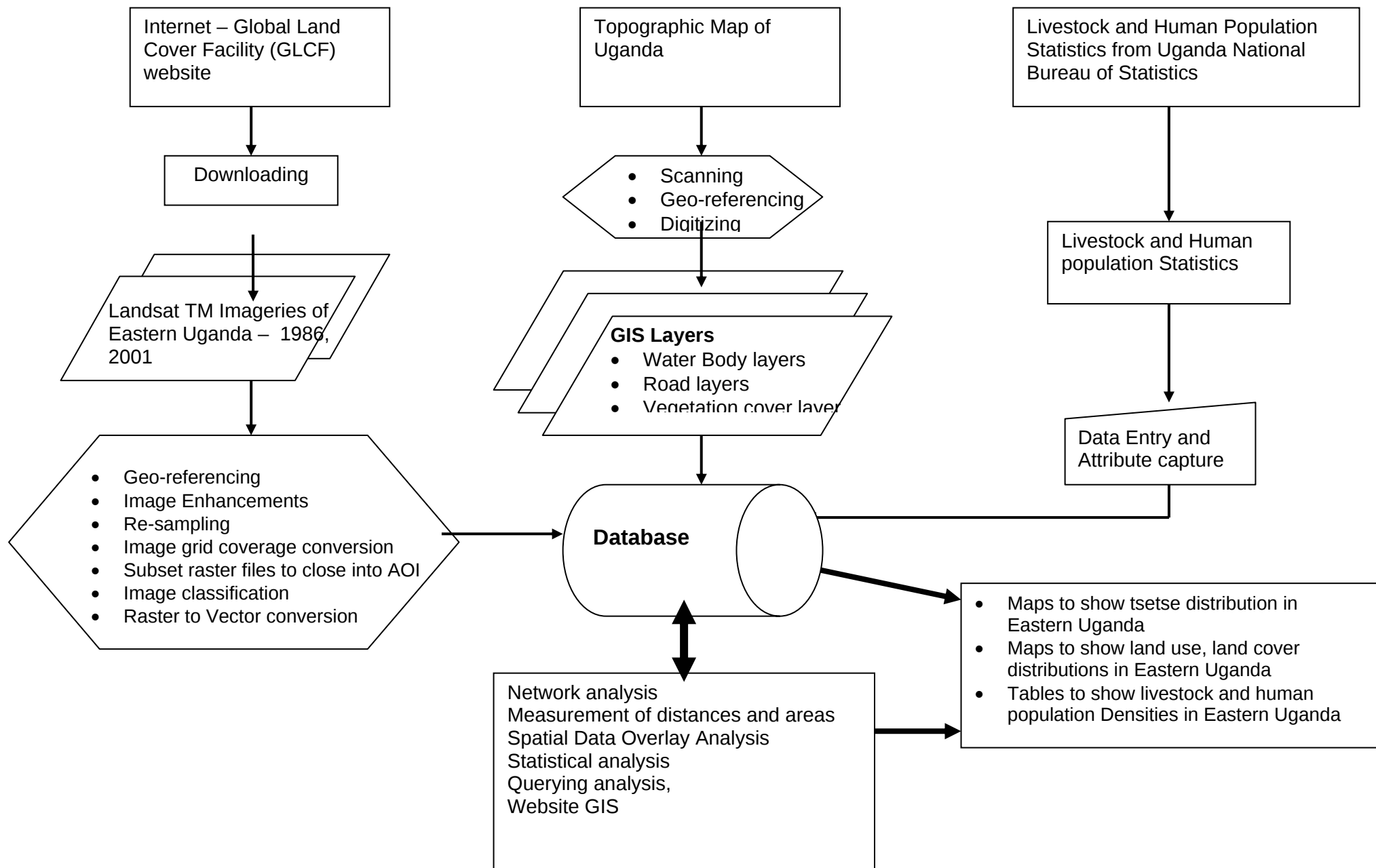


Figure 2: Entity Relationship Model for Linking Remote Sensing, Land Cover And Disease

3. RESULTS AND DISCUSSION

The results show that (Table 1 and 2) showed that Shrub land with herbaceous cover which is moderately suitable for the *morsitans* group and is less suitable for the *palpalis* group, covers the largest portion of 28-30% of the study area. The principal habitat of these forest flies (FAO, 2008) is clearly confirmed by the analysis. Similarly, for the *palpalis* group, the single most relevant land cover class is the shrub lands with herbaceous cover, which accounts for almost 30% percent of the distribution. Irrespective of the year of imagery collection, from the results over 60% of the area in Eastern Uganda is a potential habitat for tsetse flies. Only 20% of Eastern Uganda covered by water bodies is not suitable for tsetse fly inhabitation. The tsetse suitability for each one of the aggregated land cover classes identified for Eastern Uganda is described in the section. The land cover suitability for tsetse habitation of Eastern Uganda is summarized in Table 14. It is worth noting that the degree of suitability was assigned according to the inherent features of the land cover class only.

Table 1: Areas Covered by each Land Cover Type – 1986 to 2001

Eastern Uganda – 1986			
Class Names	Area (ha)	Proportion (%)	Suitability for Tsetse flies
Built up Area	675979.0281	7.314151914	*
Cloud cover	155541.8862	1.682976745	*
Secondary Forests	520476.0624	5.631596292	***
Savannah	791362.7424	8.562613744	*
Grassland	469918.3329	5.084557258	*
Rainfed Shrubs	2845820.255	30.79202283	**
Herbaceous Crops	1143118.437	12.36864097	**
Fresh Water Swamps	793783.5975	8.588807607	***
Water Bodies	1846069.499	19.97463264	*
Total	9242069.841	100	

- *** - Very Suitable
- ** - Suitable
- * - Not Suitable

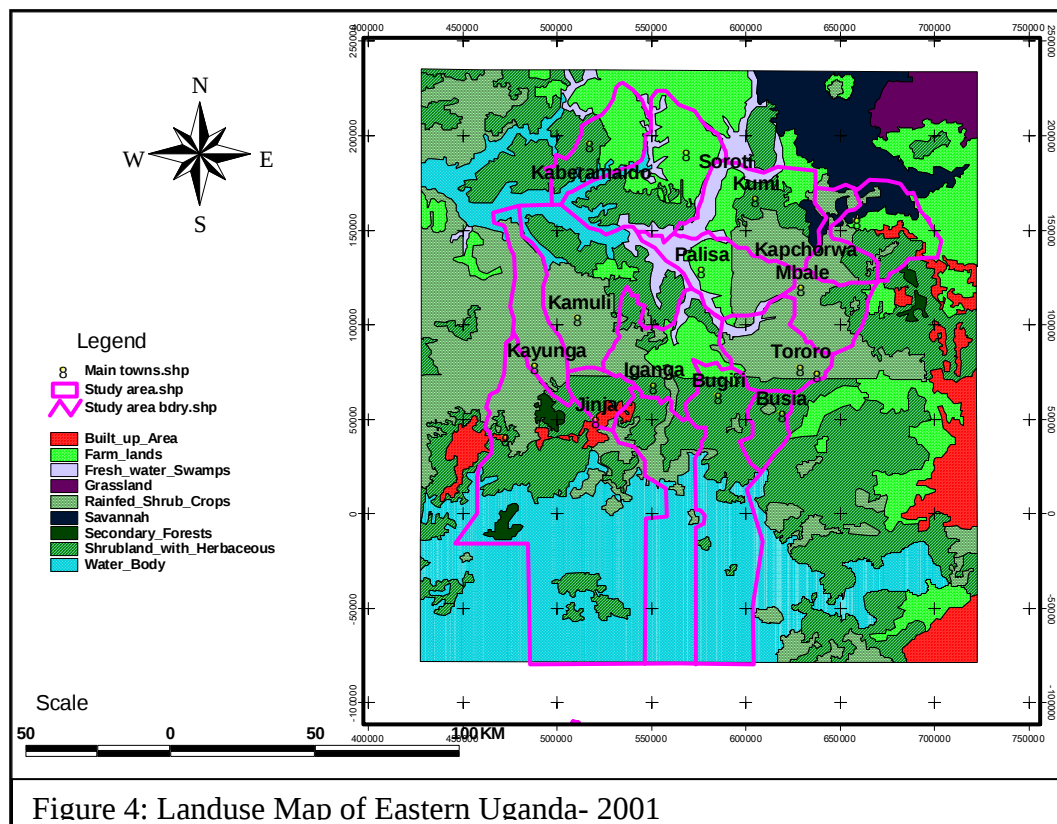
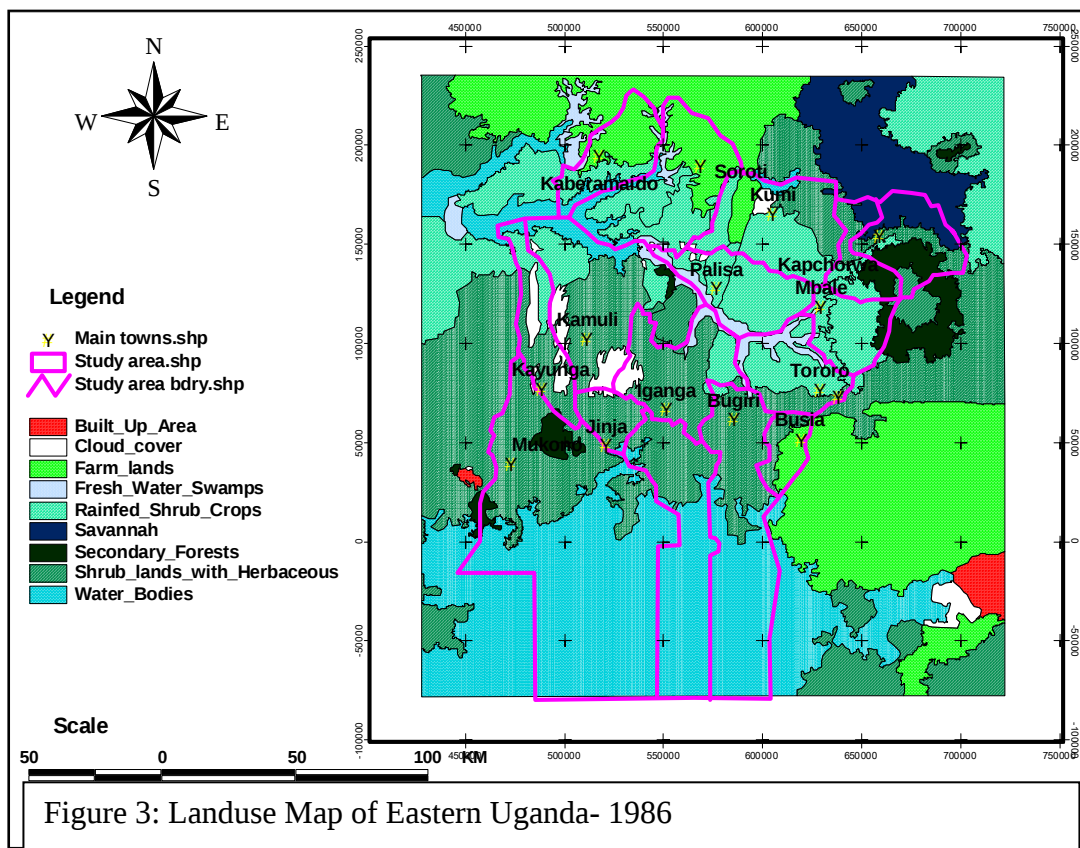
Table 2: Tsetse Suitability for Land Cover Classes in Eastern Uganda

Land Cover Types	Tsetse fly Species		
	<i>fusca</i>	<i>palpalis</i>	<i>Morsitans</i>
Built up Area	0	0	0
Secondary Forests	3	3	2
Savannah	0	1	0
Grassland	0	0	0
Shrub lands with Herbaceous	0	1	2
Rainfed Shrub Crops	1	2	1
Fresh Water Swamps	3	3	2
Water Bodies	0	0	0
Farm Lands	1	2	1

**Tsetse
suitability**

	3	High
	2	Moderate
	1	Low
	0	Unsuitable

The areas covered by built-up areas, farmland, savannab, shrub land with herbaceous cover, rainfed shrub land and water bodies were more extensive in 1986 than in 2001 (Figures 3 and 4). Conversely, the grassland, secondary forests, and freshwater swamps were more extensive in 2001 than in 1986. As shown in Figures 5 and 6, there was generally slight gradual decrease in the tsetse habitats as the Shrub lands tend to decrease with an increase in the grasslands land cover type between 1986 and 2001. Also there was a decrease in the shrub lands with herbaceous cover and rainfed shrub crops which are good habitat to tsetse flies. Conversely, there was an increase in the grassland which are unfavorable for tsetse habitants between 1986 and 2001. There was an increase in the fresh water swamps and a decrease in the water bodies because of the increased growth of fresh water weeds and plants which are known to be moderately favorable for tsetse habitats (See Figures 5 and 6).



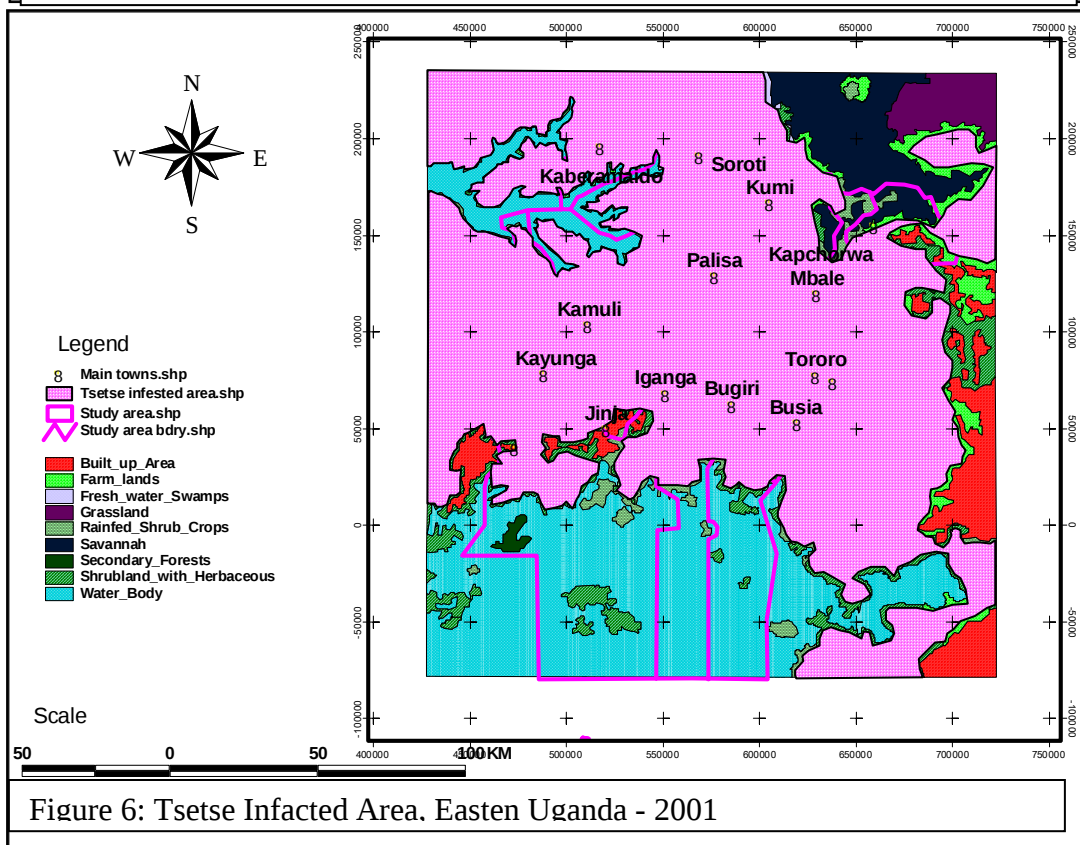
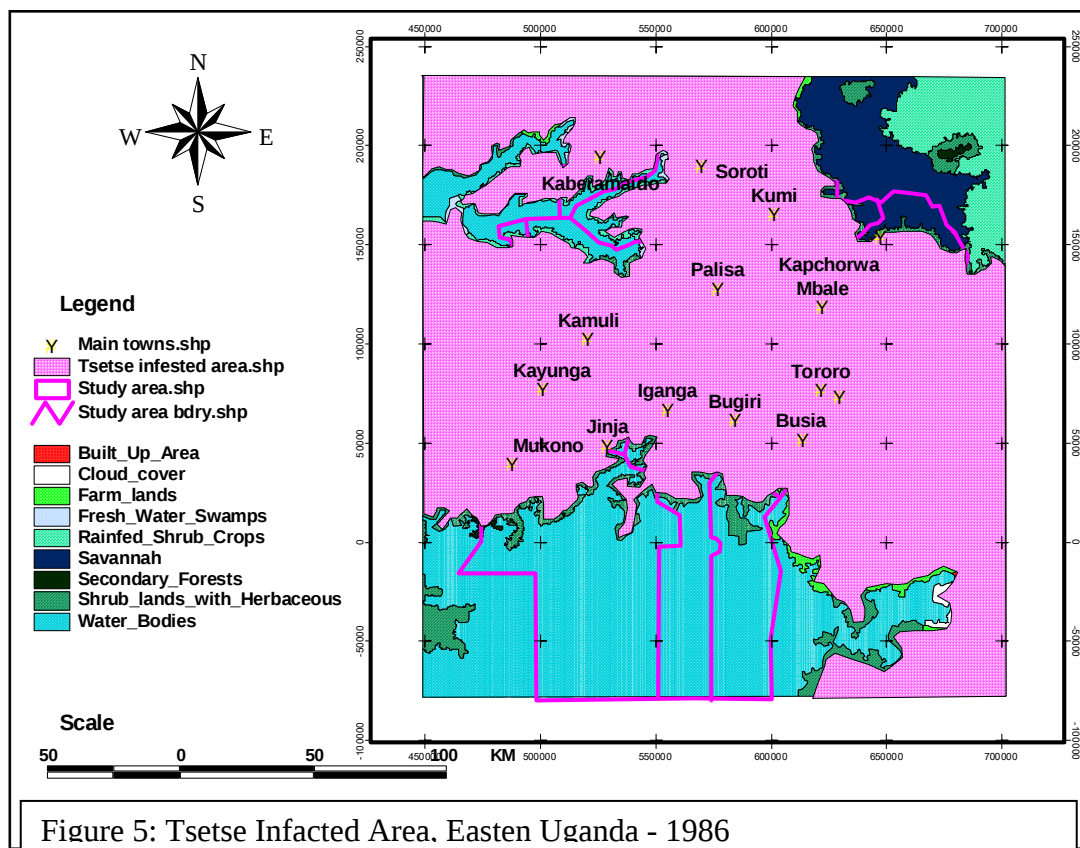


Figure 5 and 6, show a decrease in the tsetse infested areas due to the expansion of the savannah and grassland land cover types which are known not to be favorable tsetse habitats. No geo-referenced database existed that adequately shows the distribution of land-use in Uganda prior to this study. To solve the problem of lack of data, two alternative approaches were used. First, tsetse distribution was related to human population density in Eastern Uganda, using the latter variable as a surrogate for the land-use data. Secondly, agricultural land-use data was obtained and the data related to tsetse distribution. The analysis was conducted by overlaying the data layers of interest that is tsetse distribution and human population. Conversely, areas with low are zones with a semi arid type of climate which are characterized with low rainfall and low soil fertility (Rogers *et al*, 1993).

4. CONCLUSION

This study demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data and attempt was made to capture as accurate as possible nine land use and land cover classes as they change through time and identifying their suitability for tsetse fly habitation. The study demonstrates GIS and remote sensing coupled with statistical analyses, help immensely in spatial and temporal analyses for mapping tsetse fly habitats. It was deduced that the tsetse habitat area in Eastern Uganda is decreasing with time due to the increase in the land cover type of savannah and grasslands which are not favorable for tsetse fly habitation and increase in built up area where land cover is cleared for development hence destruction of the tsetse habitats. Considering the vegetative vigor of the land cover types using that trend, Eastern Uganda is tending to aridity due to the high decrease in vegetative vigor from 1986 to 2001. This arid land would not be favorable for tsetse habitation but would neither be suitable for agricultural or farming activities. The findings of the studies cited above, specifically those on African trypanosomiasis, illustrate how remote sensing and GIS technologies can provide scientists with a new perspective with which to study the factors influencing the patterns of vector-borne diseases at a variety of landscape scales. It is time that vector surveillance and control programs began to exploit some of these opportunities.

The use of statistical and computational methods and techniques, in addition to digital processing of satellite images, expands the prospects for research on the spatial distribution of diseases and the possibility of creating risk maps based on multivariate and hierarchical models. In addition, the role of this technology remains to be explored for supporting the implementation of endemic surveillance activities. The results presented here are of a preliminary nature, but clearly demonstrate the capacity of geographic information systems to make significant contributions to country, regional and continental-level analyses of factors affecting tsetse distribution, human population density and land-use intensity. It is considered that such analyses will play an increasing role in the future in the process of resource allocation to improved food production in the continent through more effective disease control. The areas in Eastern Uganda that are inhabited by tsetse flies are areas that have fertile soil good for agricultural activities, so the government of Uganda should deduce ways of controlling these tsetse flies to improve the livelihoods of the people.

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