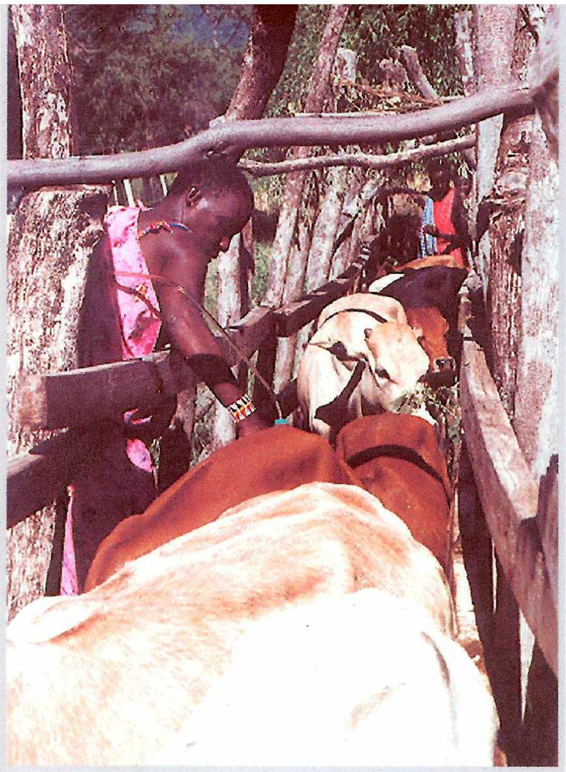
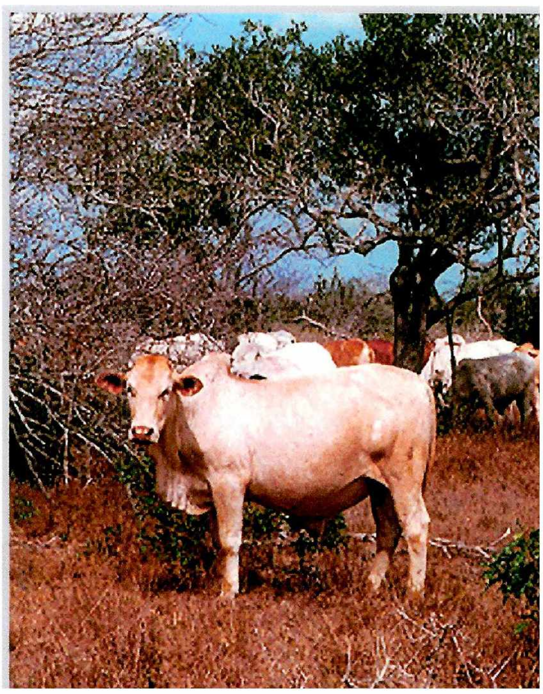
DFID TRYPANOSOMOSIS RESEARCH PROJECT



CASE STUDIES OF ENVIRONMENTAL CHANGE AND TRYPANOSOMOSIS CONTROL IN KENYA



KENYA TRYPANOSOMOSIS RESEARCH INSTITUTE
DFID TRYPANOSOMOSIS RESEARCH PROJECT

CASE STUDIES OF ENVIRONMENTAL CHANGE AND TRYPANOSOMOSIS CONTROL IN KENYA

PREPARED BY STAFF OF THE KENYA TRYPANOSOMOSIS RESEARCH INSTITUTE'S ENVIRONMENT AND SOCIO-ECONOMICS SECTION

COMPILED AND EDITED BY DAVID BOURN
ENVIRONMENTAL RESEARCH GROUP OXFORD LIMITED

REPORT STRUCTURE

This document is in five parts. The first provides a general **Overview**, and highlights the findings of the four case studies of environmental change and trypanosomosis control that follow: **Busia District**, on the boarder with Uganda; **Galana Ranch**, adjacent to Tsavo East National Park; **Nguruman**, in the southern rift valley; and **Olambwe Valley,** near Lake Victoria in western Kenya.

ACKNOWLEDGEMENTS

The findings presented here are based on studies carried out during 1996-7, as part of the third phase of the joint DFID/KETRI Trypanosomosis Research Project (MIS 031-500-065). The views expressed are those of the authors, and do not necessarily reflect those of either DFID, or KETRI. The contributions of case study investigators: Grace Muriki (Olambwe Valley); Jane Rutto (Busia District); George Oloo (Nguruman); and Cathy Wilson (Galana Ranch) are most gratefully acknowledged. Many thanks also to Dr. Mathu Ndung'u, Dr. George Oketch and Dr. Peter Stevenson of the Kenya Trypanosomiasis Research Institute; John Sutherland, the DFID/KARI/KETRI Field Co-ordinator; Dr. Richard Lamprey and Fran Mitchelmore for aerial photography; and last, but not least, to Dr. William Wint of the Environmental Research Group Oxford Limited, for their support and encouragement throughout.

COVER PHOTOGRAPHS

Clockwise from top left: Application of pour-on at Nguruman (David Bourn); participatory rural appraisal in Busia District (Jane Rutto); Orma Boran on Galana Ranch (Peter Stevenson); and visual appraisal of Olambwe valley and Ruma National Park (David Bourn).

ACRONYMS

ADC	Agricultural Development Corporation
AIDS	Acquired Immune Deficiency Syndrome
AWF	African Wildlife Foundation
CBPP	Contagious Bovine Pleuro-Pneumonia
DFID	Department for International Development
DRSRS	Department for Resources Surveys and Remote Sensing
FMD	Foot and Mouth Disease
EATRO	East African Trypanosomiasis research Organisation
ERGO	Environmental Research Group Oxford Limited
EU	European Union
FAO	Food and Agriculture Organisation
GoK	Government of Kenya
GTZ	German Agency for technical Co-operation
HIV	Human Immuno-deficiency Virus
IIED	International Institute for Environment and Development
ICIPE	International Centre for Insect Physiology and Ecology
ILRI	International Livestock Research Institute
ISCTRC	International Scientific Council for Trypanosomiasis Research and Control
ITDG	Intermediate Technology and Development Group
IUCN	International Union for the Conservation of Nature - The World Conservation Union
KARI	Kenya Agricultural Research Institute
KETRI	Kenya Trypanosomiasis Research Institute
KWS	Kenya Wildlife Service
NGO	Non-Governmental Organisation
NRI	Natural Resources Institute
OAU/IBAR	Organisation of African Unity/Inter African Bureau for Animal Resources
OAU/STRC	Organisation of African Unity/Scientific, Technical and Research Committee
ODA	Overseas Development Administration
ODI	Overseas Development Institute
OSCDP	Olkiramatian Shompole Community Development Programme
PRA	Participatory Rural Appraisal
PVO	Provincial Veterinary Officer
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organisation
WWF	World Wide Fund for Nature

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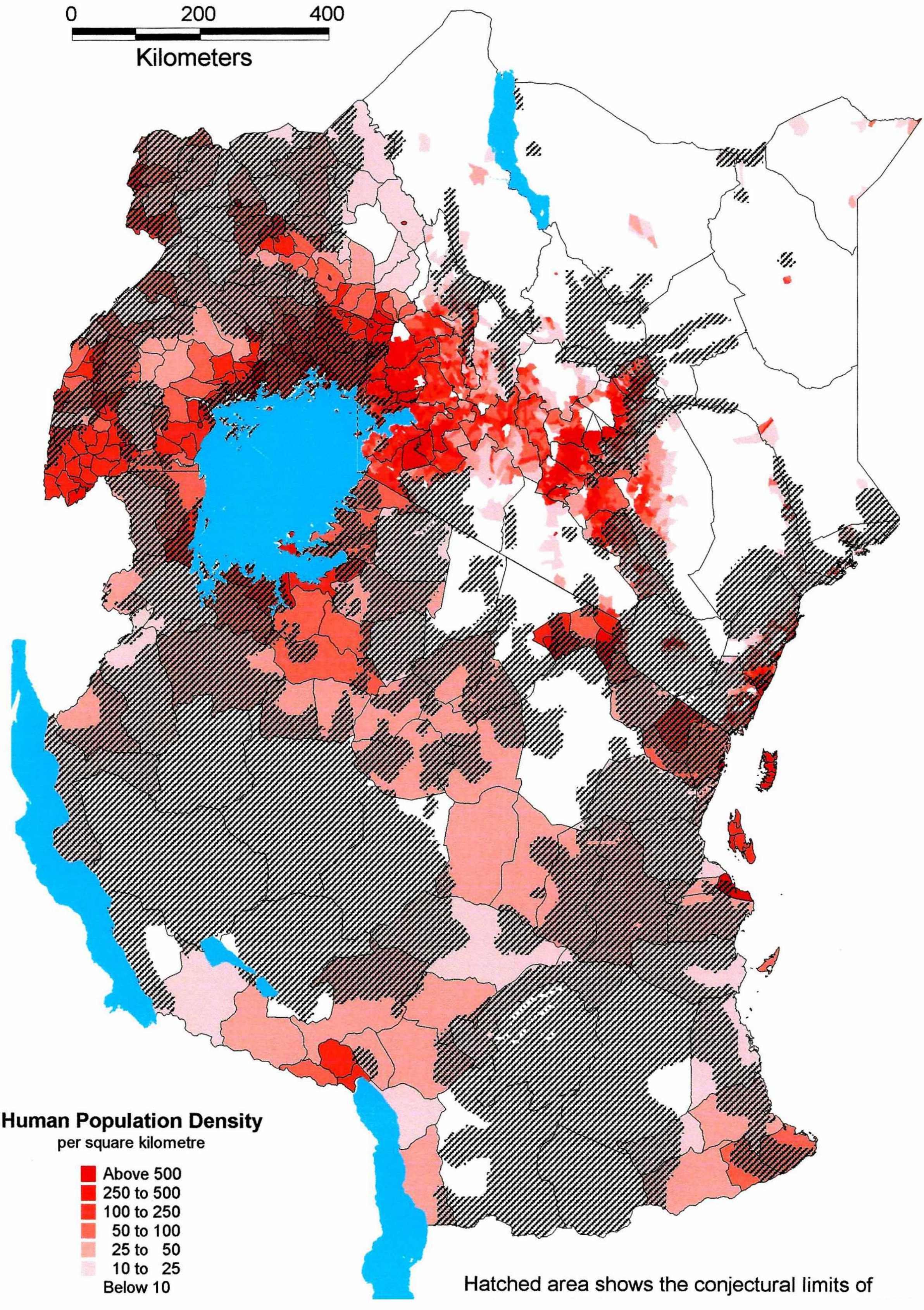


1. OVERVIEW

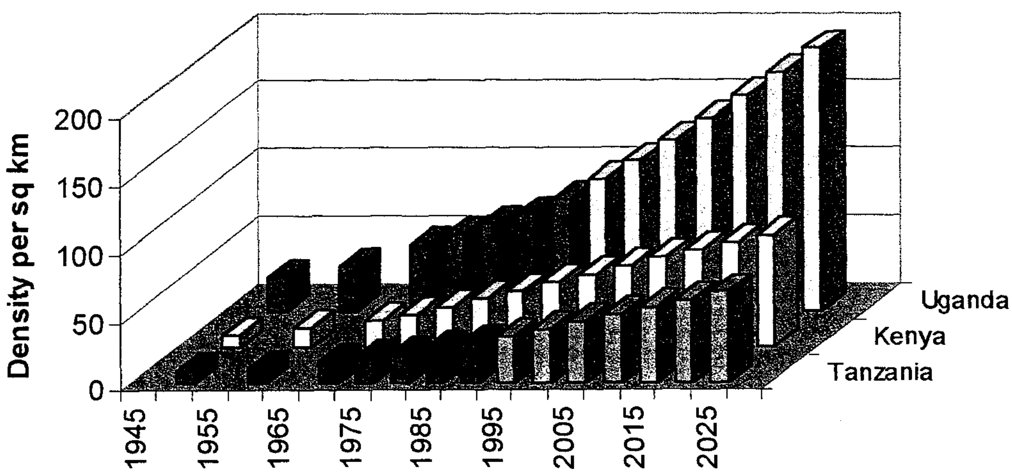
1.1 Regional Perspective

The human population of east Africa is very unevenly distributed across the region and, as can be seen in Figure 1, is concentrated around Lake Victoria, in the highlands, and along the coast. The conjectural limits of tsetse (*Glossina spp.*) in 1973 (Ford and Katondo, 1977) are also indicated. Disregarding the more arid areas of north-eastern Kenya and northern Tanzania, where tsetse are generally unable to survive because it is too dry, there is a reasonably good match between tsetse distribution and areas of low human population density.

Looking more closely at Kenya, it is clear that tsetse are on the eco-climatic limits of their distribution (Map 1), both in terms of increasing aridity to the north-east, and lower temperatures with increasing altitude. Available records indicate that viable tsetse populations are unlikely to be able to survive at heights more than 1,750-2,000m above sea level

Over the past fifty years, the number of people in Kenya, Uganda and Tanzania has quadrupled, and, despite the ravages of HIV/AIDS, is forecast to double again in the next 30-40 years (Figure 2). A striking contrast between the three countries is evident in this figure, with Uganda having twice the mean population density as Kenya, and thrice that of Tanzania. In 1996, mean densities were 100, 50 and 30 people per square kilometre, respectively.

Figure 2: Human Population Growth in Kenya, Tanzania and Uganda

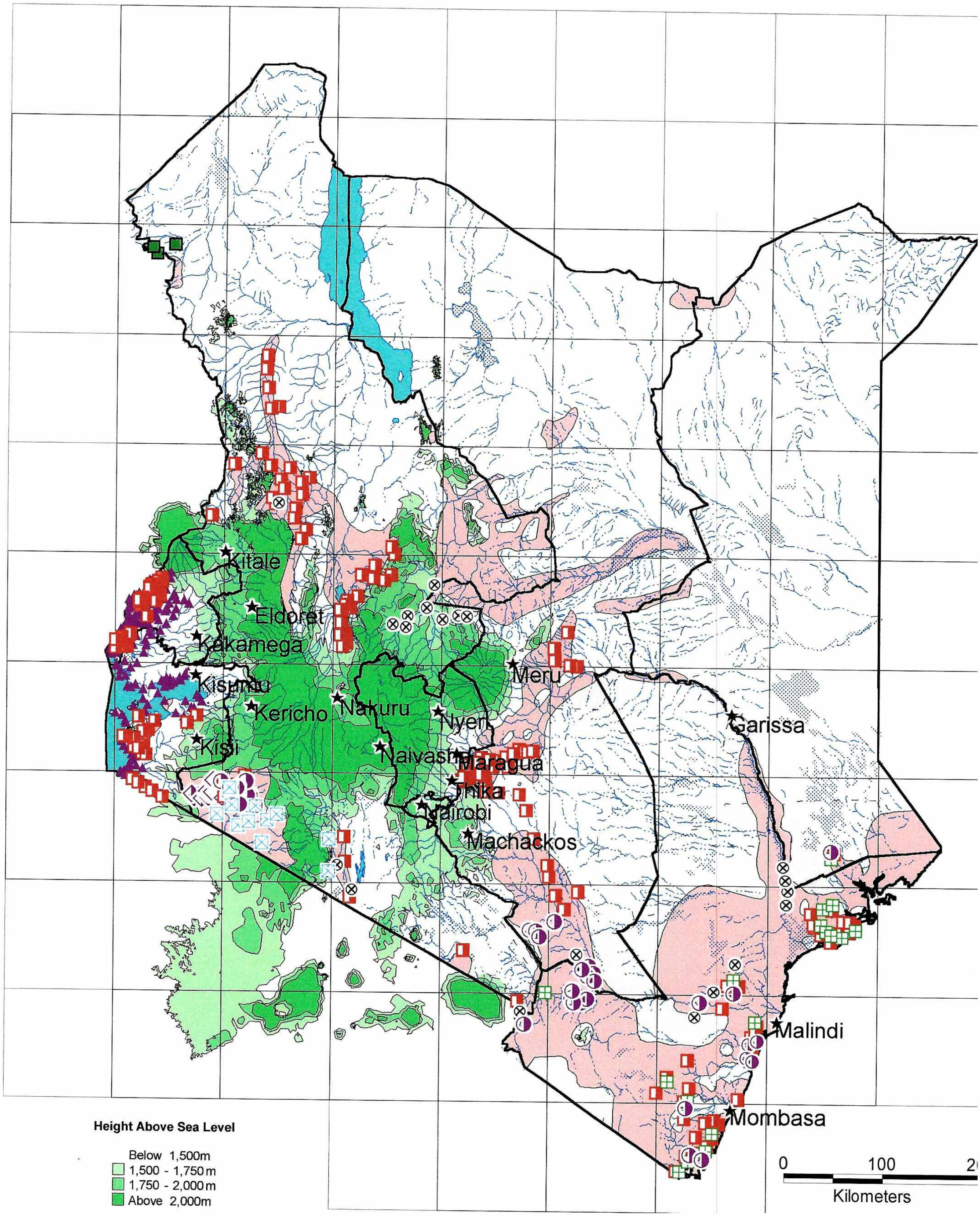


Sources: National Census Reports; and World Bank 1997.

As case studies presented in this report will demonstrate, the growth of human population, agricultural expansion and economic development have wide ranging and cumulative impacts on the environment, including loss of natural habitats and hosts of tsetse. Tsetse are widely distributed across tropical Africa, and are the primary vectors of trypanosomosis (formerly trypanosomiasis). Tsetse and trypanosomosis have been extensively studied, and an array of vector and disease control measures have been developed and applied, with varying degrees of success.

The significance of human sleeping sickness has waned since the major epidemics at the turn of the century, and the disease in livestock is now the primary focus of attention. Informed sources estimate that trypanocides currently account for about 7% of the total veterinary drug market in

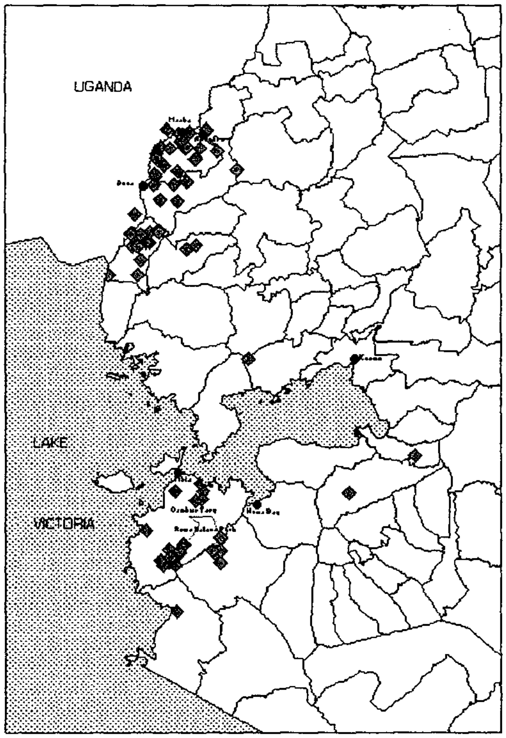
Map 1: Tsetse Distribution in Kenya



1.1.1 Human Sleeping Sickness

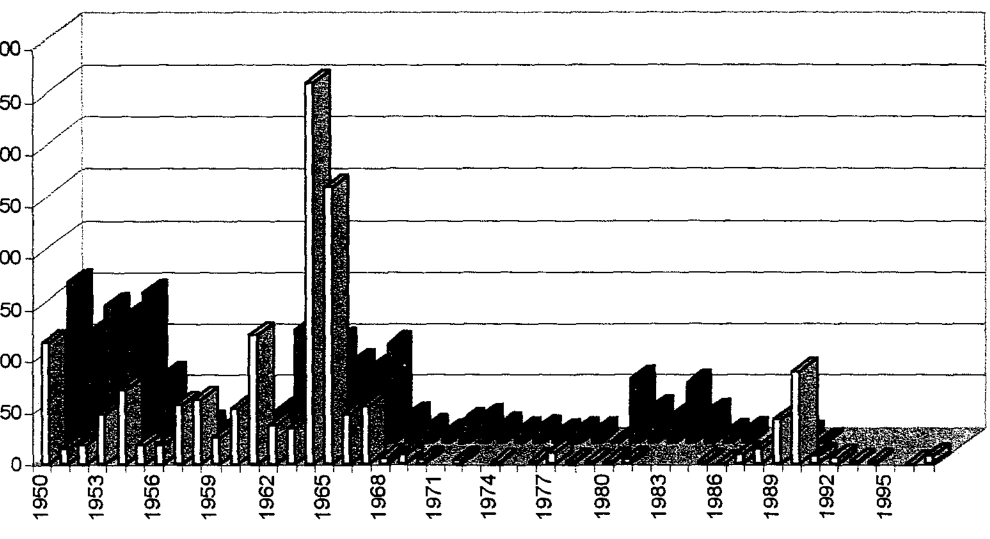
Over the past fifty years the number of reported cases of sleeping sickness in Kenya has never exceeded 500 a year, and since 1968 there have been less than one hundred cases reported each year. See Figure 3 and Figure 4. Whilst there is likely to be some under-reporting of sleeping sickness, these figures pale into insignificance compared with those for malaria, HIV/AIDS and road traffic accidents.

Figure 3: Location of All Known Cases of Sleeping Sickness in Western Kenya 1978-97



Source: KETRI Alupe Sleeping Sickness Referral Hospital Records

Figure 4: Human Sleeping Sickness Cases in Central and Southern Nyanza: 1950-97



1.1.2 Case Studies

Four case study areas were selected for investigation by KETRI staff, reflecting different facets of the disease and various control strategies; the objective being to examine the historical record and highlight the lessons of past experience. Case study locations are shown in relation to human population in Figure 5. Busia and Olambwe are densely populated, with a relatively high rainfall and a history of human sleeping sickness. Galana and Nguruman are thinly populated and are much drier, with limited potential for arable farming. Galana lies to the east of Tsavo National Park, and is managed as a state owned cattle ranch. Nguruman is a transhumant pastoral production system in the southern rift valley, west of lake Magadi. Case study attributes are summarised Table 1.

Figure 5: Location of Case Study Areas

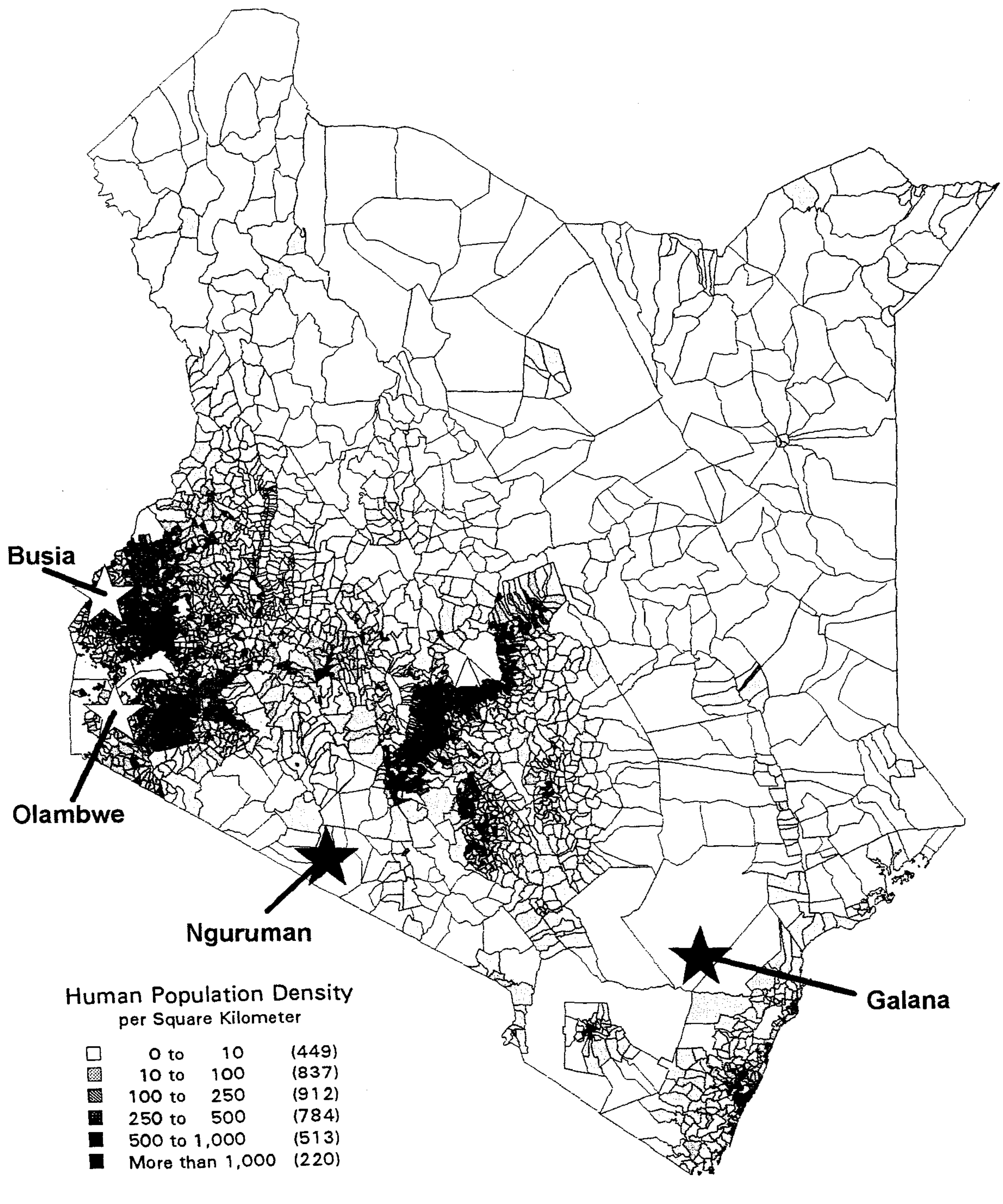


Table 1: Characteristics of Case Study Areas

Name	Busia	Galana	Nguruman	Olambwe
Land Area	1,700 km^2	6,000 km^2	600 km^2	1,400 km^2
Annual Rainfall	750-2,000 mm	400-600 mm	400-600 mm	1,000-1,400 mm
Agro-climatic Zone	Mainly I & II; some III & IV	IV and V	IV and V	Mainly IV
Protected Areas Nearby	None	Adjacent to Tsavo East National Park	Magadi Concession, Lake Natron	Ruma National Park is centrally located
Farming Systems	Mixed	Commercial Ranch	Pastoral Group Ranch	Mixed
Human Density 1989	230 km^{-2}	<1 km^{-2}	5 km^{-2}	110 km^{-2}
Cattle Density 1996	87 km^{-2}	2 km^{-2}	15 km^{-2}	50-75 km^{-2}
Tsetse Species Present	G.f. & G.p.	G.p., G.b. & G. l.	G.p. & G.l.	G.p.
Dry Season Infestation	10-20%	25-33%	<10%	<10%
Form of Disease	Animal & Human	Animal	Animal	Animal & Human
Disease Control Measures	Ground Spraying, Bush Clearance, Trypanocides, Community Trapping, and Pour-on	Trypanocides, Targets and Pour-on	Trypanocides, Community Trapping, and Pour-on	Settlement, Ground Spraying, Bush Clearance, Trypanocides and Community Trapping

1.2 Nguruman

1.2.1 Geographical Setting

The Nguruman case study area lies on the floor of the rift valley in southern Kenya, 600-800m above sea level, between the Nguruman escarpment to the west and Lake Magadi to the east. The study area extends southwards to Lake Natron on the border with Tanzania, and includes both Ol Kiriamatian and Shompole Group Ranches.

The Ewaso Ngiro river, with headwaters in the Mau range in central Kenya, flows from north to south through the case study area into Lake Natron. In its northern reaches, the river forms a narrow valley deeply incising lacustrine deposits, which gradually widens and spreads out into several branches in the swamps immediately to the north of Lake Natron. Mount Shompole, a steep sided and heavily eroded dormant volcano, rises to an altitude of 1,565m at the southern extremity of the study on the Tanzanian border overlooking Lake Natron.

Nguruman's climate is classified as arid, and agricultural potential is generally low. Rainfall, however, is greater on the adjacent escarpment and highlands, and perennial rivers flowing from them support limited areas of forest, dense woodland and, increasingly, irrigated agriculture along the Oloibortoto. Otherwise, the vegetation of the southern rift valley is classified as wooded and bush grassland. *Acacia tortilis* (Ol Tepesi in Maa) is the most common and conspicuous tree, with *Cordia sinensis* (Ol Doroko in Maa) occurring only in areas of enhanced ground water. Annual grasses are more common and extensive than perennial grasses, and are by far the most important

1.2.2 People and Agriculture

The great majority of inhabitants of the Nguruman area are Maasai. Transhumant pastoralism is the norm, with some agro-pastoralism and limited irrigated agriculture, where perennial rivers descend the escarpment. Land tenure was formerly communal through group ranchs established in the early eighties. Recently, however, land with potential for irrigated agriculture has been sub-divided and transferred to individual ownership.

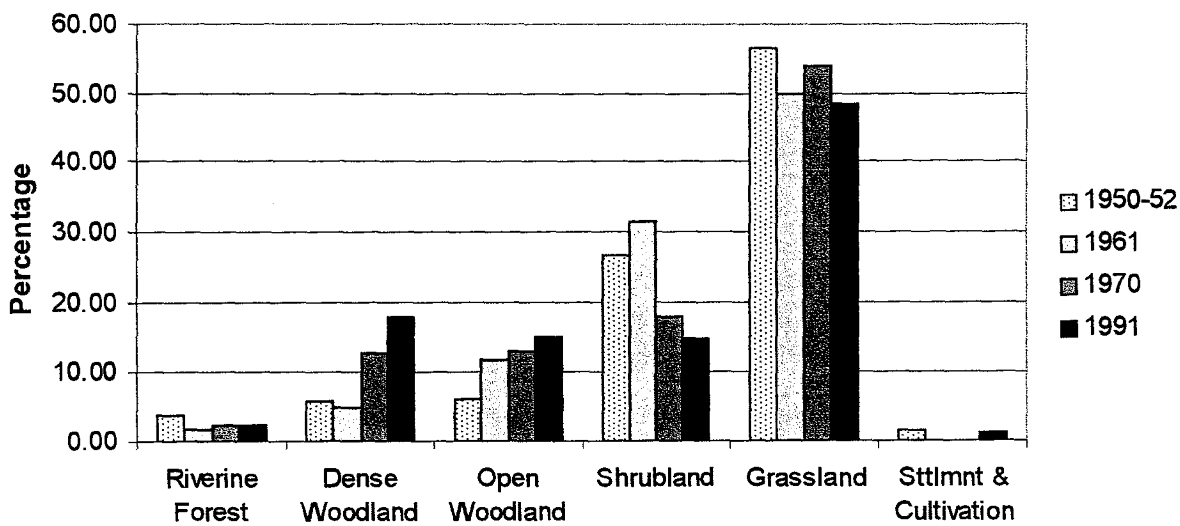
1.2.3 Livestock and Wildlife

Livestock populations in Kajiado District as a whole have remained relatively stable over the past twenty years or so, with no discernible trends for cattle or small ruminants to increase, or decrease, in number. Most wildlife species on the other hand appear to have increased in Kajiado District, in marked contrast with most other rangeland areas of Kenya, except Laikipia.

1.2.4 Land Cover Changes

Comparative air-photo interpretation of four separate sets of aerial photographs has revealed an overall increase in woody vegetation over the four decades from 1950/52 to 1991, with matching declines in shrubland and grassland cover, as shown in Figure 6. Dense woodland has increased from 6% to 18%; open woodland from 6% and 15%; shrubland has declined from 27% to 15% and grassland from 56% to 49% in the initial period. Cultivation is barely detectable at less than 1%.

Figure 6: Land Cover Changes at Nguruman 1950/52-1991



The substantial increase in woodland vegetation, from 12% to 33% overall, was unexpected, to say the least, for a semi-arid rangeland area. As these woodlands are the primary haunt of tsetse at Nguruman, this increase indicates that there has been a two to three fold increase in area of infestation. This expansion of tsetse habitat and increased risk of disease transmission over the past 40 years is attributed to natural recovery, following cessation of fuel wood collection by the Magadi Soda Company in 1949. Company records confirm that at least 190,000 tons of firewood were extracted from the Nguruman area to fuel the production process from 1935-1949, instead of imported oil.

Although cultivation occupies only a very small percentage of the study area, the production of high value horticultural crops for export to Europe is transforming the local economy. Further air-photo

1.2.5 Tsetse and Trypanosomosis

1.2.5.1 Tsetse

Studies of vector ecology and disease epidemiology began at Nguruman in the early eighties, and monitoring has continued intermittently since then. Two species of tsetse, *Glossina pallidipes* and *G. longipennis,* are found in the Nguruman woodlands and on the adjoining escarpment, where *G. swynnertoni* has also been recorded. Low-cost traps, baited with acetone and cow urine, have been developed and demonstrated to be highly efficient at suppressing local tsetse populations. However, a subsequent tsetse control programme, based on the use of these traps, has not been maintained by the local community.

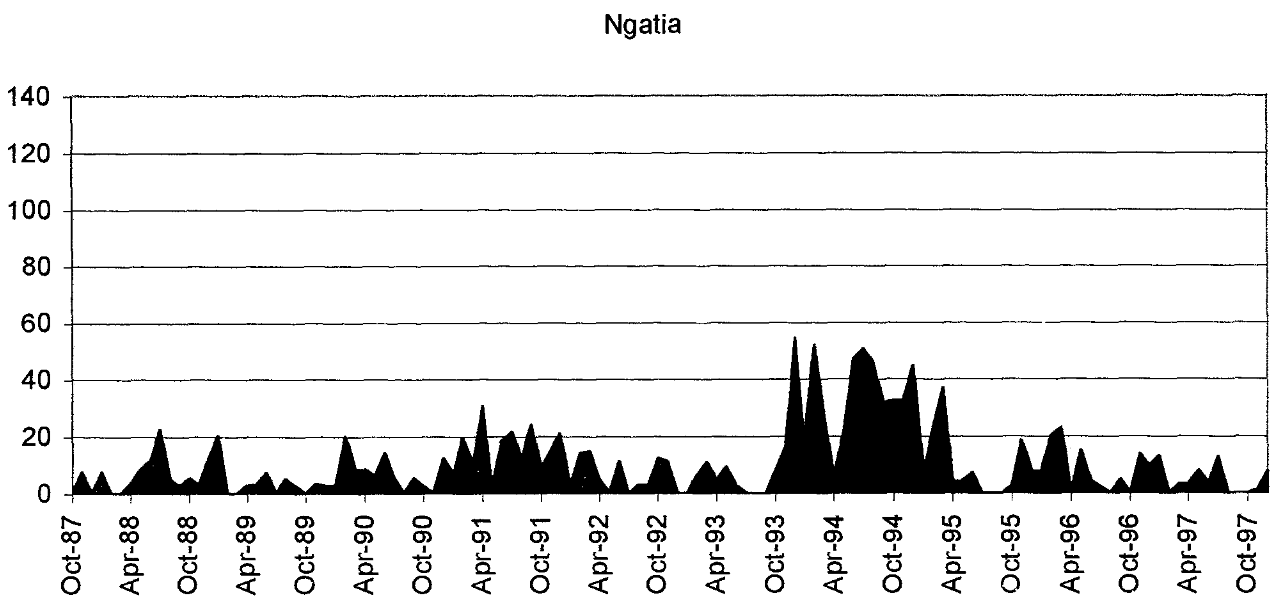
1.2.5.2 Trypanosomosis

No cases of human sleeping sickness have been reported from the Nguruman area, or the wider southern rift valley region. A few isolated cases have been reported in the past from the Maasai Mara region further to the west, but it is believed that these were contracted elsewhere in other more distant foci of infection (Wellde et al., 1989).

The incidence of trypanosomosis in cattle at Nguruman varies from zero to 50%, depending on the mode of herd management, breed, season and year. Sedentary livestock production is the exception rather the rule at Nguruman. The great majority of Maasai practice seasonal transhumance to and from wet and dry season pastures, avoiding areas of tsetse infestation as best they can.

The annual variation in trypanosome infection rates in a transhumant herd, representative of the great majority of Maasai at Nguruman, is illustrated in Figure 7. Several treatments per animal were required in 1994, when a severe drought forced the farmer to move his herd into an area of tsetse infestation and up the escarpment for much of the year.

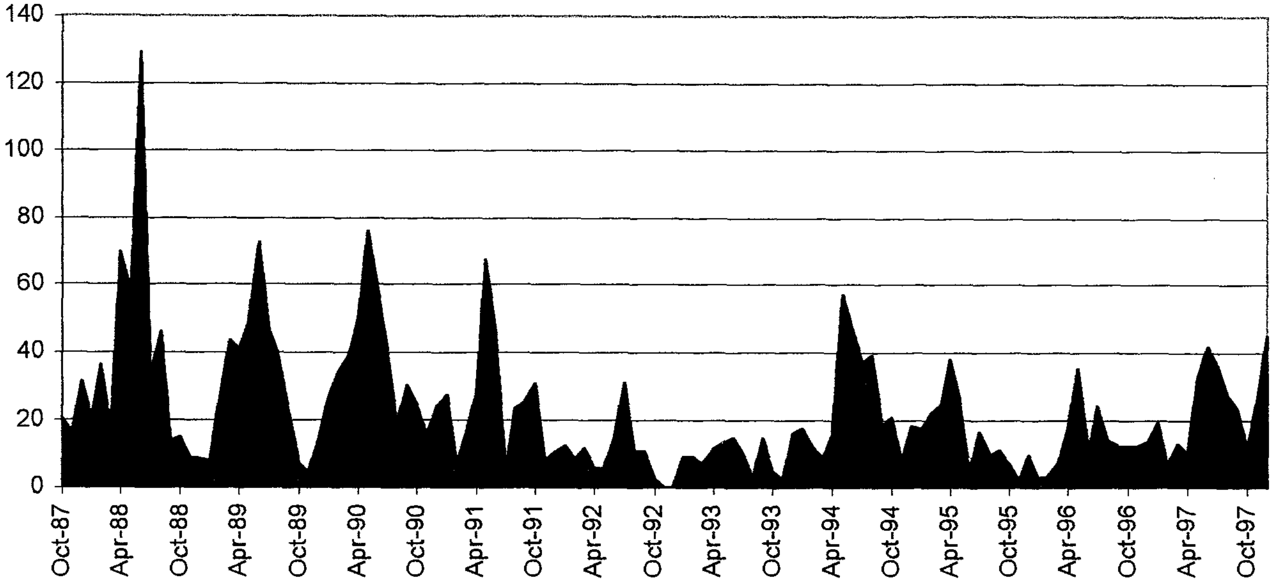
Figure 7: Monthly Incidence of Trypanosomosis in a Transhuman Herd



(Source: Stevenson, 1998)

The incidence of trypanosomosis in a sedentary herd, resident in an area of moderate tsetse infestation, requiring 3-5 treatment a year is shown in (Figure 8). Treatment requirements fell to around one treatment per cow per year in 1992 and 1993, when the trapping scheme was still

Figure 8: Incidence of Trypanosomosis in a Sedentary Herd



Source: Stevenson, 1998.

The great majority of livestock owners are able to control the incidence of trypanosomosis in their cattle for much of the year, through strategic avoidance of tsetse infested areas, except when no other alternative is available. On average, cattle are treated about once a year for trypanosomosis at a cost US$1. A few livestock owners have settled within or close to areas of tsetse infestation and their cattle are treated every three of four months for US$3-4 per year. Clear alternative methods of disease control must be highly effective to compete with this. One such innovation is the use of pour-ons, which are also effective against ticks and other biting flies.

1.3 Galana Ranch

1.3.1 Geographical Setting

Galana Ranch covers some 6,000 square kilometres of southern-eastern Kenya. For the most part the terrain is very flat, rising gradually from 130m above sea level in the east, to some 300m above sea level in the west, where it adjoins Tsavo East National Park. The perennial Galana, or Sabaki, river forms the southern boundary.

The ranch spans three eco-climatic zones (Pratt and Gwynne, 1977), from sub-humid and semi-arid in the east to arid in the west, which roughly coincide with three broad categories of vegetation. The eastern third of the ranch is covered with **Thick Coastal Bush,** comprised mainly of *Combretum, Euclea, Grewia and Strychnos* species. The dominant grasses in this area are *Panicum sp., Setaria sp.* and *Schoenfeldia transiens.*

Further to the west the coastal vegetation gives way to more open ***Combretum*** **Wooded Grassland.** *Combretum aculatum* is the most common woody shrub. *Schoenfeldia transiens* and *Bracheria sp.* are the most common grasses. Common trees include *Dobera glabra* and *Terminalia parvula.*

The western third of the ranch is predominantly ***Acacia/Commiphera*** **Woodland.** Other common trees include *Euphorbia robechii* and *Delonix elata*. Dominant grasses are *Aristida sp.* and lightly wooded grassland in which *Chloris roxburgiana* became the dominant grass. Shrubs in this area include *Cordia gharaf* and various *Grewia spp.*. Large concentrations of elephants maintained this open grassland, until poaching during the late seventies and early eighties eliminated the herds. Considerable regeneration of *Acacia senegal* and *Commiphora sp.* has taken place since then.

1.3.2 People and Agriculture

Galana ranch was established in 1967, when Galana Game and Ranching Limited took over from the Galana Game Management Scheme. The later had been established on land adjoining Tsavo East National Park by the Kenya Government in 1960, to utilise the skills of the Wata, a traditional elephant hunting community, who had been displaced by the creation of the park.

During the early years, attention focused on infrastructural development and the establishment of water supply and road networks. Dams, storage tanks, roads, bridge, airstrips, offices and accommodation were constructed and bore holes were sunk. During this period the ranch employed a workforce of more than 300. Construction of a causeway across the Galana river began in 1967, but initial attempts were washed away, and a permanent crossing was not completed until 1972.

Following an extended period of insecurity and general uncertainty during the eighties, Government revoked the company's lease on the land in 1989, and the Kenya Agricultural Development Corporation took over management of the ranch.

Settlement and grazing within the ranch by Orma pastoralists is legally prohibited, but has been difficult to prevent and has been on the increase in recent years. Nevertheless, the ranch and its immediate environs to the north and west remain sparsely populated, with a mean density of less than 10 people per square kilometre. Population density increases to the east and south.

1.3.3 Livestock and Wildlife

1.3.3.1 Cattle

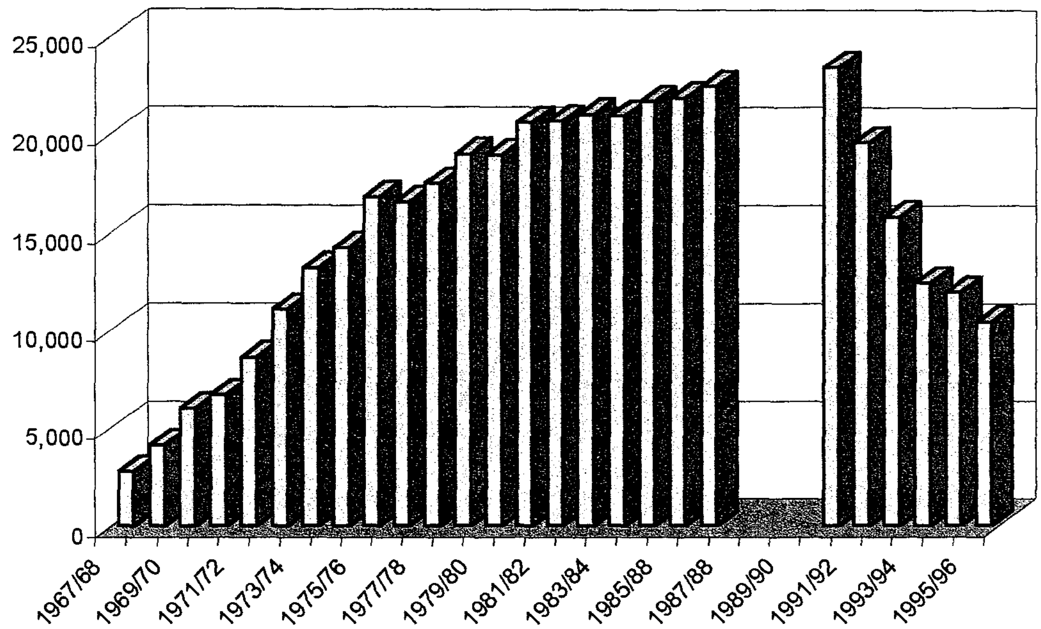
Over the years Galana Ranch has maintained a variety of livestock, including camels, cattle, goats and sheep, and experimented with the domestication of buffalo, eland and oryx. Except in the early years, when licensed hunting of wildlife was permitted and generated substantial returns, the primary activity and source of ranch income has been the rearing of cattle for beef production. Cattle were kept under one of two management regimes: either as balanced herds of breeding animals, and their offspring; or as trading herds, made up of cattle purchased from elsewhere, normally Tana River and Garissa Districts to the north, and brought onto the ranch for fattening.

The balanced herds of breeding animals were made up of "improved" Boran cows that came from ranches in Laikipia, and bulls purchased from top Boran breeders in Laikipia. In 1977 the ranch decided to breed their own bulls and established a herd of stud cows registered with the Kenya Stud Book, with the express purpose of breeding sufficient acclimatised bulls for the commercial herds. Experimental herds of trypanotolerant Orma cattle were also maintained, in collaboration with the Kenya Trypanosomiasis Research Institute, for selective breeding to improve weight gain.

Most trading steers were purchased on the Tana River, and then walked down to the ranch quarantine area. Immediately on arrival the animals were dipped and then branded with a number indicating the lot number. Large groups of cattle were then graded according to size, with the larger animals placed into the number one herd and the remainder into the other herds. The ranch preferred buying in lots of between 1,000 and 1,500 animals, and these would then be separated into weight of trading steers on purchase was 200kg, and these remained on the ranch for up to two years before they were large enough to sell at an average weight of 330kg, compared with an average weight of 360kg for Galana steers.

The first 321 cattle brought to Galana Ranch arrived on 5 November 1967 from Luoniek Ranch in Laikipia District, with a further 641 arriving by the end of the year. Numbers increased progressively over the next 20 years to exceed 22,000 head in 1986/87, as indicted in Figure 9.

Figure 9: Mean Cattle Holdings on Galana Ranch: 1967/68 - 1995/96



Unfortunately, no records are available for the troubled period 1988-1990. For most of 1988, cattle numbers hovered around 27,000, and for a short period in early 1989 the herd exceeded 28,000 head, but by the time the ranch was taken over by the Agricultural Development Corporation the herd numbered around 22,000 animals. This figure was maintained for the next two years, until progressive de-stocking commenced in 1991/92. By early October 1996 there were only 8,832 cattle left on the ranch, although a further 1,760 trading steers were purchased during that month to give a closing balance of 10,060 head. Since then, numbers have been further reduced through de-stocking and losses due to an outbreak of CBPP.

1.3.3.2 Wildlife

When Galana Game and Ranching Limited was first established in 1967, the letter of allotment specifically stated that the grantee "shall be permitted to carry out professional hunting in accordance with the provisions of the Wild Animals Protection Act (Cap 376)". The letter also allowed for trapping and export of wild animals, game cropping and the undertaking of wildlife and range research projects, including those that necessitated the killing of game. Not altogether surprising, given the proximity of Tsavo National Park. The ranch employed its own hunter, and for 10 years professional hunting safaris were a very lucrative component of ranch activities. Indeed, hunting supported the cattle operation for the first few years.

The main attraction to hunting clients was elephants, and up to 25 animals a year were taken in the early seventies. The trophies were exceptional and Galana offered some of the best elephant hunting in the world. Other animals hunted for their trophies included rhino, lion, leopard, buffalo, crocodile, lesser kudu, impala, gerenuk, dikdik, Peter's gazelle, eland, ostrich, fringe-eared oryx became a major problem in the late seventies and early eighties, as reflected in the declining number of elephant and buffalo. The current status of wildlife on the ranch is not known, but is unlikely to have recovered to its former levels.

Table 2: Wildlife Population Estimates

Species	1972	1976	1980	1988	1989	1991	1994
Oryx	5,279	9,676	11,895				
Elephant (live)	2,166	6,293	1,810	90	94	50	46
Elephant (carcasses)	0	131	0				
Elephant (skeletons)	0	1,214	0				
Eland	1,300	1,570	945				
Giraffe	855	1,586	1,450				
Peter's Gazelle	2,608	2,511	13,215				
Zebra	1,603	3,338	3,760				
Warthog	0	836	2,415				
Lesser Kudu	497	351	690				
Gerenuk	790	411	3,860				
Buffalo	3,444	3,754	3,790	667	389	842	3
Ostrich	743	448	1,790				
Rhino	134	60	0				
Waterbuck	321	119	460				

Sources: Heath (1996); and Douglas-Hamilton *et al.* (1994).

1.3.3.3 Game Domestication

The Kenya Game Department was invited to conduct a study of game domestication on Galana Ranch and their Capture Unit caught the first oryx, eland and buffalo in February 1970. A research area was set aside for the domestication programme 12 kilometres north of the main ranch headquarters, and four 100 acre "game proof" paddocks were erected. The Galana game domestication research programme was managed and financed by the African Wildlife Leadership Foundation (now African Wildlife Foundation) (King, 1975 a&b; 1977; and 1978; Lewis, 1974, 1975, 1977 and 1978; Stanley-Price, 1976).

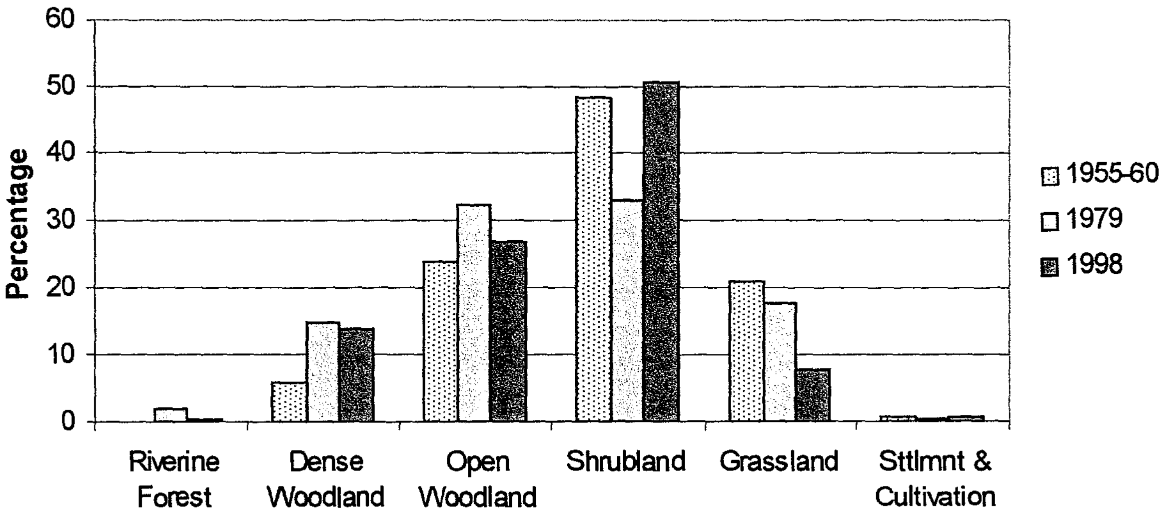
By the end of 1972, 7 buffalo, 16 eland and 17 oryx had been domesticated. Initial research indicated that although eland were temperamentally suitable for domestication, they were not physiologically suited, as they required great mobility, and domestication constrained them to the extent that they did not grow as well as expected. Buffalo were found not to be suitable for domestication because of temperament and slow growth rates. Oryx, however, were found to be very promising, and the project began to focus on them, increasing the herd up to 139 by 1977.

Unfortunately, the domestication project suffered a major setback in 1977, when Government banned all forms of wildlife utilisation (Kenya Gazette Supplement No 30 of 20 May 1977). This effectively prohibited all forms of wildlife utilisation, including the slaughter and sale of domestic oryx. Despite the ban, the ranch maintained support for the domestication programme and encouraged research, but gradually management lost interest and the herds began to decline through death and attrition to the wild herds.

1.3.4 Land Cover Changes

Comparative air-photo interpretation has revealed an overall increase in woody vegetation cover and a progressive decline in grassland over the past four decades from 1955/60 to 1998, as shown in Figure 10. Dense woodland has increased from 6% to 14%; open woodland has fluctuated between 24% and 32%; and shrubland has declined from 48% to 33% in the initial period, but has subsequently increased.

Figure 10: Land Cover Changes in Western and Eastern Galana Ranch 1955/60-1998



These gross changes in land cover proportions mask considerable variation from area to area within the ranch. Vegetation dynamics in the Galana region is a complex issue, with a collection of interacting factors at play, including: fire, elephants, rainfall, livestock, fire and man (Pratt and Gwynne, 1977; Delany and Haphold, 1979; Eltringham, 1979; and van Wijngaarden, 1985). Opinions differ as to their relative importance, and this is almost certain to vary from place to place, and time to time. Parker (1996a) is convinced that the former presence of Orma pastoralists maintained open woodland and grassland in what is now Galana Ranch, and that when they ceased to use the land woody vegetation encroached and tsetse habitat expanded.

During the late sixties to mid seventies there was a major increase in the number of elephants on Galana. Heath (1996) considers that elephants were responsible for maintaining the open grasslands of the central portion of the ranch, until they were virtually eliminated by poaching in the late seventies and early eighties. However, in Heath's view, elephants on their own never really controlled *Combretum,* which coppiced easily and grew back more strongly after physical damage. Fire is one of the most effective ways of controlling the re-growth of woody vegetation and was used for that purpose by ranch management. However, it was only after exceptionally wet years that there was sufficient biomass to fuel "hot" fires, and have significant impact on otherwise fire tolerant woody vegetation. A particularly devastating fire, covering 2,500 square kilometres, took place in 1962 and again in 1978. Large concentration of cattle may also have contributed to the spread of *Combretum*, by keeping biomass levels down and reducing the potential for hot fires.

1.3.5 Tsetse, Trypanosomosis and Trypanotolerance

1.3.5.1 Tsetse

Four species of tsetse are found on Galana Ranch, infesting up to half the land area at maximum dispersal during the wet season. *Glossina pallidipes* favours the eastern dense coastal bush, moving out into the more open *Diospiros* parkland in the rains. *G. austeni* and *G. pallidipes* frequent the denser vegetation of the Galana river, whilst *G. longipennis*, "the example *par excellence* of arid, almost desert, conditions" (Ford, 1971), tends to be found in open, drier sections of riverine vegetation and more densely wooded upland areas. Occasional catches of *G. brevipalpis* have also been recorded around Dakabuko hill.

Whilst far from conclusive, available information indicates a broadly similar pattern of tsetse distribution in the early sixties and the early nineties, with tsetse being confined to the eastern half of the ranch, and along the Galana River. In the sixties, the north-western region adjacent to Tsavo National Park, was also thought to be infested, but had not been formally surveyed. Recent investigations, however, have failed to detect the presence of tsetse in this more arid north-western zone, but they do indicate a westward expansion of the coastal *G. pallidipes* belt into areas formerly considered to be the preserve of *G. longipennis.*

In the seventies and eighties, the central and southern parts of the ranch were thought to be virtually fly free, but more recent surveys indicate an extensive infestation of *G. longipennis,* stretching from Lali hills in the south-west through to the *G. pallidipes* in the east. Local infestations of *G. pallidipes* have also been identified in pockets of denser vegetation around Minjilla dam and Didima hill.

Various authors (Makumi, 1994; Heath 1996; and Parker 1996 a&b) have commented on the increasing density of woody vegetation in central and southern areas of the ranch, which has followed the decline the region's elephant population, and a reduction in the frequency and extent of bush fires.

1.3.5.2 Trypanosomosis

In the early years, the ranch controlled trypanosomosis using Antricyde Pro-salt (Quinapyramine sulphate), but by mid-1970 the Provincial Veterinary Officer recommended the use of Samorin (Isometamidium chloride, May and Baker) in preference to Antrycide Pro-salt. In June 1972, management reported that they were able to treat cattle with Samorin every six months. The ranch continued with three or four yearly treatments of Samorin for all cattle until 1977. It was then suggested by the PVO's office that the ranch should give sanitive treatments with Berenil (Diminizene aceturate, Hoechst) two weeks before every third Samorin treatment, and this practice was instituted.

By May 1978, the first hint of possible resistance to Samorin was recorded in the Kapengani area. In this instance a very acute "Haemorrhagic" form of *T. vivax* was confirmed, in animals that had been given Samorin 40 days previously, by veterinarians from KETRI. This was the first time that this form had been recorded on the ranch, although it was first identified in Machakos and had been known from the coast as the 'Likoni' strain of *T. vivax*. This haemorrhagic strain continued to appear periodically, and when it next appeared in January 1980 killed 50 cattle in three bomas at Kapengani. This, despite the routine Berenil followed by Samorin regime that had been practised for three years. The next major outbreak occurred in cattle purchased from Witu in May 1984, and this again resulted in the death of many cattle.

strategic use of Samorin, and increasing the dosage from 0.5 to 1mg/kg. They also suggested that Berenil should only be used as a curative. By early 1981, there were concerns about resistance to Berenil, and Samorin only appeared to give 25 days prophylaxis. The ranch employed their own microscopist, and started keeping records on animals sampled and the quantity of trypanocidal drugs used.

By 1984, trypanosomosis appeared to be more prevalent than ever and one group of 1,306 cattle from Garsen had an infection rate of 30%, the worst ever encountered until then. This group of cattle was possibly the first to show signs of what was to become known on the ranch as *"Korobo"* disease, a gradual wasting accompanied by jaundice and a distinctive smell. In early 1985, there were grave concerns about resistance to Samorin, and one group of cattle from Tana River were given Samorin twice in two weeks in an attempt to clear up trypanosomosis. Resistance to trypanocides was confirmed in trials held in February 1985, and it was decided to use Novidium (*Homidium chloride*) in preference to Samorin. 1985 was the worst year on record for trypanosomosis and the number of treatments increased threefold from 1983. In this same year there were records of trypanosomosis at Tank E, the first cases in this area for many years.

In August 1985 the first definite cases of *"Korobo"* disease were seen in the Alango Shira/Korobo area of the ranch. Severe liver damage was the single most important post mortem lesion, and at that time Leptospirosis was suspected. Algae on the water holes and plant poisoning were also considered as possible causes, and there were suspicions that the disease could possibly be related to the very high incidence of trypanosomosis and repeated treatments with Samorin. This disease spread to other parts of the ranch and there were some cases in the breeding herds that had also been frequently treated with Samorin. A further outbreak of *"Korobo"* in April 1987 reinforced the feeling that increased trypanosomosis infections and frequent Samorin usage were somehow linked to the disease. There was a further outbreak of *"Korobo"* in July and August 1987. A ranch experiment on the disease pointed strongly to drug toxicity, with the combination of Berenil and Samorin in quick succession being the most probable cause of the syndrome. However, this realisation came too late to prevent a major disaster in November and December of the same year in which over 1,200 cattle died.

By December 1987, there was still no officially recognised cause of *"Korobo"* although ranch management was convinced that it was associated with trypanosomosis and the administration of Berenil and Samorin. A meeting was held at Kabete with top veterinarians in the country, but there were no new leads on the possible cause. At this stage the ranch was recording breakthroughs to Samorin after two weeks, and KETRI reported breakthroughs after 11 days for Samorin and 18 with Ethidium (Homidium bromide). By April 1988, breakthroughs to Samorin were recorded in as little as 8 days by KETRI, and in May a representative from May & Baker, the manufacturers of Samorin, advocated increasing the dosage rate for Samorin to 1.5 mg/kg. He denied any possible Samorin toxicity, although conceded that Berenil in conjunction with Samorin could possible cause liver damage. This was later confirmed as the cause of *"Korobo"* in a trial performed at the KETRI Nguruman Field Station.

Following the disaster in November, it was decided to adopt a new approach to the problem through tsetse control and the use of insecticide impregnated targets, a technique originally developed in Zimbabwe. In December 1987, 10 traps were in place to monitor tsetse numbers in the Alango Shira quarantine area, and by February 1988 there were 240 targets in place. In March 1988 a further 200 targets were installed and there were indications of reduced tsetse numbers in the traps. In April tsetse numbers in the traps continued to decline, although tabanids were caught in large numbers, with up to 1,200 flies caught in a trap in one day.

By August 1988, no tsetse were being caught in the traps, and only 6 cases of trypanosomosis were recorded in 2,000 cattle over a period of three months in the Alango Shira quarantine area. There were no cases of *"Korobo"* and the animals had only been treated with Novidium prior to leaving the Tana River. The greatest problem with the targets was not in administering them but with theft; 150 cloths were stolen by Somali or Wata hunters in the first six months.

1.3.5.3 Trypanotolerance

In addition to epidemiological field research and advising on vector control and the use of trypanocidal drugs, KETRI has also collaborated closely with ranch management on a long term cattle breeding programme, selecting for improved weight gain and enhanced trypanotolerance in Orma Boran. The programme is of considerable strategic importance to livestock production and sustainable utilisation of marginal tsetse infested land in east Africa.

The Boran cattle, owned by the Orma people of Tana River District, sometimes known as the Tanaland Boran, are thought to have originated from the Borana region of southern Ethiopia and to have arrived in the semi-arid rangelands of eastern Kenya 400-500 years ago. Tsetse infestation in that region is confined largely to riverine habitats and land adjacent to the Tana river. The Orma people practice a seasonal transhumance into the rangelands away from the river during the wet season, but return to riverine areas of tsetse infestation during the dry season. Their cattle have, therefore, survived the challenge by tsetse and trypanosomes for many generations, and have developed a tolerance to trypanosomosis through natural selection.

Galana Ranch operates two regimes of livestock management (see Section 1.3.3.1), one for fattening traded Orma cattle purchased from Tana River District; and the other of keeping balanced breeding herds of improved Kenya Boran, originating from tsetse free highlands of Laikipia District. Differences between these two types of Boran cattle, maintained under tsetse challenge, were first recognised in the early eighties (Dolan et al., 1985; Njogu et al., 1985), and since then various studies have been carried out comparing the performance of both steers and breeding animals (Dolan, 1993, 1996 & 1997).

In all cases it has been found that the Orma cattle do better than the improved Boran under tsetse challenge. They become infected less often, and once infected succumb less easily to the disease. Infection and mortality rates in the Orma are approximately half those observed in Kenya Boran. Under both prophylactic and curative treatment regimes the Orma cattle require fewer drugs. Kenya Boran, however, are a better beef animal. They generally grow faster and reach a heavier mature body size than the Orma Boran, and this trend is only reversed in years of very high tsetse challenge.

A selective breeding programme for Orma cattle was initiated in 1983 with the aim of improving the beef production characteristics, whilst at the same time maintaining their disease resistant qualities. Galana Ranch purchased the foundation stock of cows, heifers and five bulls from the Orma people between 1983 and 1987. These animals, some with calves at foot, were trekked on to the ranch and held initially in the ranch quarantine area for a three to four month period. They were then handed over to KETRI for ear-tagging, and recording commenced on the first group of 83 cows in October/November 1983. Subsequently, the breeding herd of cows has expanded through recruitment of Orma females born from original stock. After weaning, male calves are maintained in a separate herd on the same regime as cows and calves. Breeding bulls are selected from these weaners on the basis of their post weaning growth rates.

The Orma cattle provide the only well documented case of east African cattle with a degree of resistance to trypanosomosis. Evidence for trypanotolerance has also been found in Maasai cattle, and it is likely to occur in any breed with a long history of exposure to the disease. The Orma have an advantage over

1.4 Olambwe Valley

1.4.1 Geographical Setting

For its size and relative economic importance, the Olambwe valley in Nyanza Province of western Kenya has received an extraordinary degree of scientific attention, with epidemiological studies and vector control activities spanning more than 60 years. Until recently, however, the valley has remained relatively isolated from mainstream economic activity.

Olambwe valley is located just south of the equator in Suba District, formerly part of Homa Bay District. The valley is a major geographical feature of the area, extending over some 350km^2, with Ruma National Park occupying 120km^2 of its central and upper reaches. To the north are the shores of Winam gulf, formerly the gulf of Kavirondo; to the west, the immense expanse of lake Victoria; to the south, the border with Tanzania; and to the east, the densely settled and intensively farmed Kisii highlands.

The valley separates two mountain zones of volcanic origin, the Gwassi and Gembe hills to the west, and the Kaniamwa escarpment to the east. The Gwassi hills rise to 2,273m at Wiratha, and separate the valley from the shores of Lake Victoria. The Kanyamwa escarpment slopes gradually from 1,758m at Gendo in the south, to 1,464m at Kamgwagi in the north. The valley floor itself lies about 75m above the level of Lake Victoria (some 1,200m above sea level), but during a relatively recent stage of tectonic activity the valley submerged below the waters of the lake. Deep porous lacustrine deposits have since been overlain with dark clays, with an extensive area of poorly drained "black cotton" soil extending over much of the valley floor. Elsewhere, fertile volcanic soils predominate on hillsides, although slopes are generally steep and rocky.

1.4.2 People and Agriculture

The human population of Homa Bay District has quadrupled in the four decades from 1948 to 1989, with an overall population density of 110 per square kilometre in 1989. A variety of ethnic groups are represented in the area, the majority of whom are Luo (59%) and Abasuba (38%), with some Luhya (2%), Kisii (1%) and Kipsigis. The Abasuba are of Ugandan origin and are concentrated around Kaksingiri.

The region is classified as sub-humid to semi-arid with medium agricultural potential. There have been two major initiatives to encourage people to settle and promote rural development in the valley: the Lambwe Valley Development Scheme in the early fifties, and the Lambwe Valley Settlement Scheme in the mid sixties.

Plans for the settlement and development of the Olambwe valley were formulated in the forties after the end of the Second World War, but implementation did not begin until the early fifties. The Lambwe Valley Settlement Scheme was jointly undertaken by the East African Trypanosomiasis Research Organisation (EATRO) and the Kenya Government's African Settlement and Land Utilisation Board. Prospective farmers were allocated land in four settlement blocks at the northern end of the valley, and a strategy of discriminative bush clearance was employed to remove tsetse habitat. Bush clearance on uncultivable land was undertaken by paid labour, but settlers were expected to clear their own land themselves. Bush clearance by settlers was slow, and at the end of 1953 it was decided that paid labour should be employed to speed up the process.

Large scale settlement did not really get underway in the valley until the mid sixties, when 1,400 arose, however, when Homa Bay Council decided that the valley should remain in its natural state, as a game reserve and potential tourist attraction. The plan could, therefore, not be implemented as originally envisaged, and many new settlers abandoned their holdings for fear of further outbreaks of sleeping sickness. However, many landholders returned when it was learnt that the World Health Organisation had begun experimental tsetse control in 1969. New immigrants joined them, and the population of the valley increased substantially during the 1970s.

1.4.3 Livestock and Wildlife

In the early thirties there were an estimated 500 elephants in the area, with 200 being counted in a single herd. Lion, cheetah and rhinoceros were also present in the valley (Lewis, 1936). An initial attempt to drive the elephants out of the valley was unsuccessful, even though many elephants were killed in the process (Nimmo, 1931). A further attempt in 1948, with the combined efforts of Game Department staff and Police from surrounding locations, eventually succeeded in driving the elephants through Gor Lango, over the Kaniamwa escarpment, and on into Maasailand. The former seasonal migration of wildlife to and from the Mara-Serengeti plains no longer takes place because of dense settlement of the land separating the two areas (Wellde, 1989b).

In 1966, whilst plans to clear and develop the southern Olambwe valley for agricultural purposes were being prepared, as part of the Lambwe Valley Development Scheme, an eminant local politician prevailed upon the Homa Bay Council to preserve the area in its natural state as a protected area. The success of the National Reserves and Parks in other parts of the country in attracting tourists, and the supposed economic benefit to be derived from them, are likely to have influenced the Council decision.

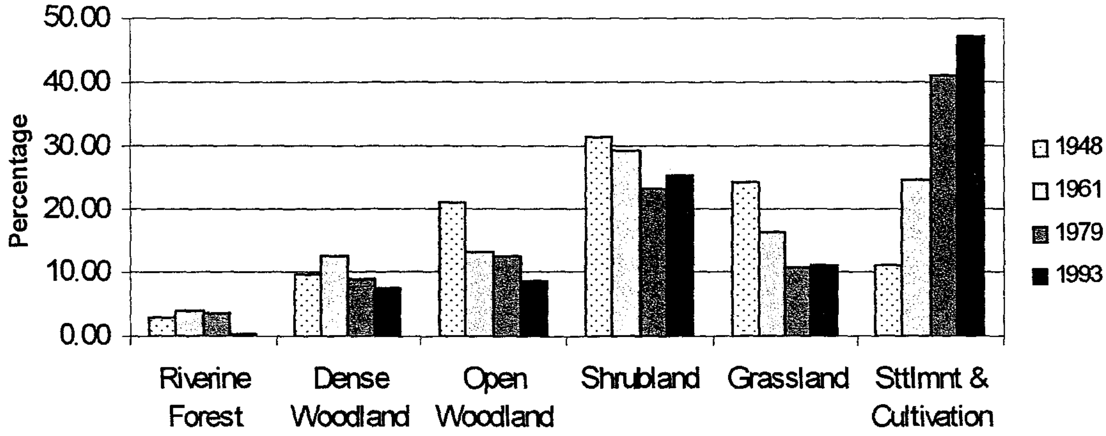
The interest of the Game Department in acquiring a large area of the valley for their purposes also played a role in the decision by local authorities to abort the government's development plans for he Olambwe valley. The establishment of the 120 square kilometre Game Reserve prevented further land and bush clearance for agricultural purposes, which had been so successful in eradicating *G. pallidipes* and sleeping sickness from the northern and Roo areas of the Olambwe valley. Members of the Ministry of Agriculture, especially those in the Veterinary Services Division responsible for tsetse control, were opposed to the establishment of the reserve, because of warnings made previously by others of the serious medical risk which would be incurred if *Glossina pallidipes* were not eradicated (Ivens and Cochrane, 1956).

Subsequently, in 1968, a major national and international tsetse control initiative was launched, which ultimately failed to eradicate the vector. The status of the game reserve was upgraded to the Lambwe National Park in 1975. For reasons, which remain somewhat obscure, the area was downgraded to game reserve status in the following year. Seven years later, however, in 1983, the area was reinstated as the Ruma National Park.

1.4.4 Land Cover Changes

Comparative air-photo interpretation has revealed a major increase in cultivation and settlement in the Olambwe valley from 11% in 1948 to 47% in 1993, with reciprocal reductions in forest, woodland, shrubland and grassland cover. See
Figure 11. The four-fold increase in cultivation matches the growth in human population. Ruma National Park is centrally located within the Olambwe valley and is surrounded on three sides by farmland, which in many cases comes up to the very edge of the fenced park boundary.

Figure 11: Land Cover Changes in Olambwe Valley: 1948-1993



Forests and woodlands, the primary habitat of tsetse, have declined from 33% to 16% since 1948, and are now largely confined within the boundaries of the Nation Park. In the park, there has been a substantial increase in woody vegetation cover over the same period.

1.4.5 Tsetse and Trypanosomosis

1.4.5.1 Tsetse

Nowadays, *G. pallidipes* is the only species of tsetse to occur in Olambwe valley, with records of its presence dating back to 1910 (Lewis, 1936). It used to be more widely distributed, but is now confined largely to dense thicket vegetation on the valley floor, most of which lies within the Ruma National Park. *G. brevipalpis* was also recorded in the valley in the sixties, but has since disappeared. *G. fuscipes fuscipes* occurs around the lake shore and riverine forest habitats, but not in the valley proper.

1.4.5.2 Trypanosomosis

Since 1950, there have been a total of 1,799 recorded cases of human sleeping sickness from Olambwe valley and the wider South Nyanza District. See Figure 3 and Figure 4. Two periods of relatively high incidence of sleeping sickness are apparent. The first peak, between 1962 and 1967 coincides with implementation of the Lambwe Valley Settlement Scheme. The second, between 1980 and 1984 corresponds with increasing field presence of various agencies. ICIPE began studies of tsetse ecology and population dynamics in 1979; and the Walter Reed Army Institute of Research's trypanosomosis project established a sleeping sickness diagnostic unit at health centre in 1982. The motivation for this flurry of activity is perhaps questionable, given that a disease survey of 1,340 inhabitants of Olambwe valley in 1978 indicated infection rates of 33% for malaria and 0.1% (sic) for sleeping sickness (Wellde et al., 1989b).

1.4.5.3 Tsetse Control Measures

Attempts to control tsetse in the Olambwe valley date back more than sixty years to the mid thirties and have been summarised by Baldry (1972) and Wellde (1989). Experimental methods for the control of *G. pallidipes* by trapping and selective bush clearance began in 1935, and continued with encouraging results until the outbreak of the Second World War. Despite initial success, vegetation recovered and tsetse bounced back during the war years, and by 1948 the situation had reverted to

New plans were drawn up for bush clearance and settlement of the area by the East African Trypanosomiasis Research and Reclamation Organisation, and implemented in collaboration with the African Settlement and Utilisation Board, the Game Department and the District Tsetse Control Team. The Lambwe Valley Development Scheme began in the early fifties with settlement in four blocks and bush clearance of uncultivable land by paid labour to provide a protective barrier. Initially, settlers were allocated 50 acre parcels of land, but this proved to be too large for effective clearance and control of regeneration, and the allocation was subsequently reduced to 25 acres.

A second barrier of 2,000 acres was cleared between the Kaniamwa escarpment and Ruri hills in 1959. Heavily wooded gullies on the Ruri hills were also cleared. 500 acres of the Sikiri peninsula were reclaimed in 1959 by ground application of dieldrin along paths cut at 200 yard intervals. Aboricides were also used on an experimental basis to reduce the Ruma thicket vegetation, but were unsuccessful.

Further efforts to encourage settlement and development at the southern end of the valley during the sixties, were undermined by the establishment of a Game Reserve in 1966. Objections that the reserve would protect tsetse habitat and maintain a focus of human sleeping sickness were to no avail. A new round of bush clearance followed in an attempt to isolate the reserve from areas of settlement. Problem areas away from settlement in the Gembe hills were ground sprayed with dieldrin.

Experimental aerial application of insecticide was initiated in 1968 with the technical and financial support of the World Health Organisation and the United Nations Development Programme. Over the next three years dieldrin was applied to all major thickets in the Olambwe valley by helicopter, or fixed wing aircraft. The Tsetse Control Section of the Department of Veterinary Services also undertook an extensive programme of bush clearance and ground application of dieldrin.

Despite this onslaught, tsetse persisted. New plans were drawn up in 1972 and spray paths were cut throughout the Ruma thicket, but because of budgetary constraints, the thickets were not sprayed. However, protective barrier and limited habitat spraying of dieldrin continued until 1975, but thereafter were suspended until an outbreak of sleeping sickness occurred in 1980. The initial response was ground application of dieldrin to the periphery of the Lambwe National Park, upgraded from reserve status in 1975. This had a marked effect on the prevalence of sleeping sickness, but concern about the use of dieldrin caused the cessation of the programme and justified the aerial application of endosulfan in 1980/81. Endosulfan application greatly reduced fly numbers and the prevalence of the disease, but flies persisted and recovered to their former levels within a year. A further round of aerial application of insecticide took place in 1983, this time using pyrethrum, but this had no significant effect on tsetse numbers or in the prevalence of sleeping sickness and was a complete failure. Subsequent field operations reverted to the ground application of insecticide (dieldrin and cypermethrin) and bush clearing, primarily within the park.

A tsetse suppression trial, using baited insecticide-impregnated targets, was initiated KETRI in 1988 and achieved a 95% reduction in fly numbers within the first twelve months. The trial was extended over a wider area with 99% suppression and continued until July 1996, when management was handed over to the Kenya Wildlife Service. During the same period ICIPE initiated a study to promote and assess the sustainability of community-managed tsetse-trapping in a limited area of tsetse infestation centred on the Nyaboro thicket, adjacent to the south-western boundary of the Ruma National Park.

Follow up field surveillance indicates that tsetse population suppression was still effective in early 1998, although how much of this was due to exceptional El Niño rainfall and extensive flooding of the valley remains to be seen. Certainly on past experience, with extensive thicket habitat and numerous wildlife hosts within the park, tsetse population recovery seems likely, unless control measures are maintained.

1.5 Busia District

1.5.1 Geographical Setting

Busia is one of four Districts in Kenya's Western Province on the border with Uganda. Most of the District lies within the Lake Victoria basin, rising from 1,130m above sea level on the lake shore to a maximum of about 1,500m in the Samia and north Teso hills to the north-east. The central part of Busia District is a peneplain, marked by low flat divides of uniform height, often capped by laterite, with a shallowly incised drainage system. Large granite out-crops, weathered to form hills, are a feature of the northern central region. Ninety per cent of the district is considered suitable for agricultural production. Busia and Siaya Districts have been selected as intervention sites for farming in tsetse infested areas, sponsored by the European Union.

Few areas of natural forest remain in Busia District and only 579 hectares of forest reserve have been gazetted within the District. Most natural vegetation has been cleared for agriculture, or otherwise transformed by timber extraction and fuel wood collection. Much of the land adjacent to river courses is subject to season flooding and is densely vegetated with bamboo, papyrus and other wetland species. Secondary bush encroachment is apparent in many areas, notably *Tithonia diversofolia* and *Lantana camara*, found mainly on fallow land, as hedges between fields and along watercourses.

1.5.2 People and Agriculture

At the last census in 1989 Busia District had a human population of some 420,000 people and a population density of 230 per square kilometre, making Busia the most densely populated case study area examined. The inter-census growth rate between 1969-79 was 4.0%, possibly reflecting instability and an influx of people from neighbouring Uganda during that period. Between 1979-89 the growth rate declined somewhat to 3.5% per annum. If that rate of growth continues, the population will be 591,000 (325 per square kilometre) by 1999,and 1.17 million by 2019 (644 per square kilometre).

Two ethnic groups predominate: the bantu Luhya people (60% of the population in 1979), inhabiting eastern and southern areas of the District; and the nilotic Teso people (30% in 1979), who live mainly to the north of Busia town. Minority groups include Luo (7% in 1979); Kikuyu; Kalenjin; Kisi; Akamba; and others.

More than 80% of the District is classified as humid, or sub-humid, with good to very good agricultural potential. Rainfall distribution and reliability are reflected in the prevailing forms of agricultural production in different parts of the District. In central divisions, where rainfall is generally more reliable, there is a diverse range of arable cultivation, with maize, millet and sorghum grown mainly for subsistence needs, and sugar cane, cotton and tobacco as cash crops. Further south towards Lake Victoria, where annual rainfall is lower and less reliable, more drought resistant crops are grown, including cassava and sorghum, with some maize and cotton.

1.5.3 Livestock and Wildlife

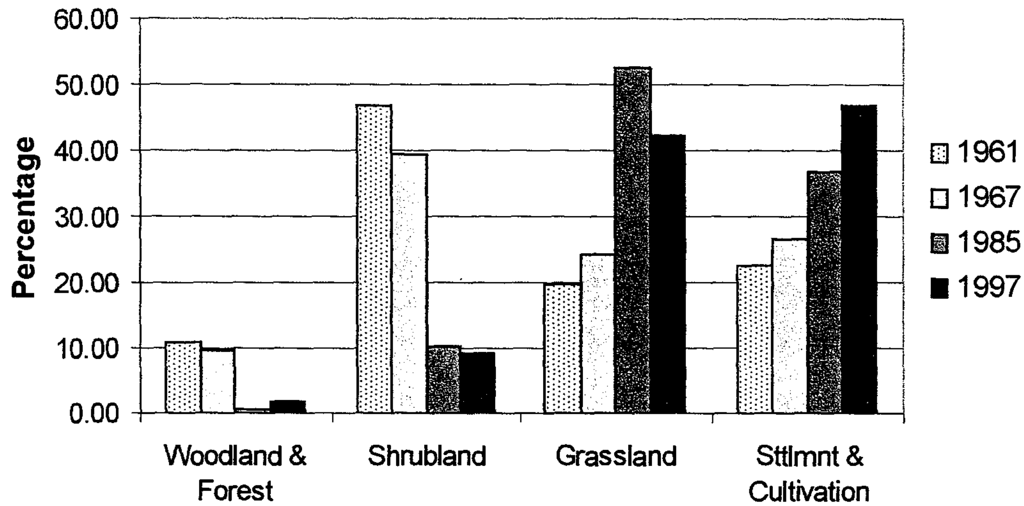
Livestock are kept throughout the District for economic as well as social reasons. Population estimates for indigenous Zebu cattle in Busia District have fluctuated around 150,000 head over the past two decades, with around 25,000 sheep and 45,000 goats. Features of interest include the relatively static population of indigenous cattle, and the ten-fold increase in cross-bred dairy, or grade, cattle from 469 in 1977 to 4,466 in 1996. The increase in grade cattle appears to have accelerated during the nineties. Nevertheless, despite this positive sign of agricultural

There are no Game Reserves or National Parks in the District. Wildlife is generally absent or very rare, except near Lake Victoria and to a lesser extent along major rivers, where hippopotamus, crocodiles and monitor lizards are found.

1.5.4 Land Cover Changes

Cultivation and settlement in Busia District has doubled form 23% in 1961 to 47% in 1997. Grassland has also increased, whilst woodland, forest and shrubland have all declined. The increase in grassland cover is probably a reflection of increasing fallow. Taken together grassland, cultivation and settlement account for 89% of the Busia District land area.

Figure 12: Land Cover Changes in Busia District: 1961-97



Woody vegetation cover, in the form of bush/shrubland, woodland and riverine forest, has declined from 58% in 1961, to 11% since 1997. As woody vegetation is the primary haunt of tsetse, it is evident that there has been a substantial reduction of natural tsetse habitat in Busia District over the past 30-40 years. Riparian forest and dense woodland, the preferred habitat of *G. fuscipes fuscipes,* which in 1961 accounted for 2% and 4.5% of the land area, respectively, have virtually disappeared. Open woodland has also declined from 4.2% to 1.6%.

1.5.5 Tsetse and Trypanosomosis

1.5.5.1 Tsetse

Two species of tsetse are found in Busia District. *Glossina fuscipes fuscipes* is essentially a riverine and lacustrine species. The linear extent of potential riverine infestation is put at 545 kilometres, variously equated to be between 109-272 square kilometres of infestation. *G. pallidipes* is, typically, a species of drier woodland savannahs, and is reputed to have invaded Busia District from Uganda in recent years.

With an estimated 40% of the land area under cultivation and 45% grassland, it is clear that very little natural tsetse habitat remains in Busia District. A few riparian forest patches survive and harbour limited populations of *G. fuscipes fuscipes,* but this habitat and species have been in decline for many years. In upland areas, scrub and woodland have been turned to farmland and fallow, with varying degrees of bush regrowth. This would appear to have created conditions suitable for the expansion of *G. pallidipes.*

1.5.5.2 Trypanosomosis

Since 1950, there have been 1,639 recorded cases of human sleeping sickness from Busia and Siaya (formerly Central Nyanza). See Figure 3 and Figure 4. A year-long epidemiological investigation of the role of village livestock as reservoirs for human sleeping sickness in four villages in Busia District has recently been completed (Angus, 1996). The study confirmed that village livestock were potential reservoirs of human sleeping sickness. Monthly prevalence rates for all forms of trypanosomes varied from 3% to 37%, depending on season and location. Rates tended to be higher after the long rains from March to June, and lower in the drier months from November to December. *T. vivax* infections predominated, followed by *T. brucei* and *T. congolense*.

1.6 Discussion and Conclusions

The findings presented here are broadly in line with those of other studies of environmental change associated with trypanosomosis control in Nigeria and Zimbabwe (Putt et al., 1980; Bourn, 1983; Pender and Rosenberg, 1995; and Pender, Mills and Rosenberg, 1997).

An important distinction, however, is that the Kenya case studies were selected to reflect a range of environmental conditions, farming systems and epidemiological circumstances, including densely populated mixed farming areas with a history of sleeping sickness, and semi-arid rangelands. Assessments of change in the Kenyan studies have also been over a substantially longer period of time, going back to the turn of the century, and are based on a combination of air-photo interpretation, participatory rural appraisal and historical review.

With the continued growth of Kenya's human population and mounting pressure on limited land resources, future development priorities must focus on the intensification of agricultural production, and measures capable of achieving greater productivity in the context of existing farming systems.

Human sleeping sickness no longer ranks as a disease of major importance in Kenya, compared for instance with malaria, or HIV/AIDS. Trypanosomosis in animals, however, is common, and is a constraint on livestock production in many areas. It is also a constraint on the use of draught power and, thus, limits the potential for intensification of agricultural production.

The relative importance of trypanosomosis, compared with other livestock diseases and other constraints on production (e.g. fodder, water, management and finance), is difficult to assess. This is because of a general lack of reliable up to date information about the incidence of major diseases and associated production losses in different parts of the country. Recent attempts to quantify livestock production by system (KARI/ODA, 1996) have gone some way towards this aim, but have been hampered by unreliable population figures and limited disease incidence data. Such information is of paramount importance for strategic planning. A national survey of livestock diseases, including an assessment of the relative importance of trypanosomosis, is required.

An array of measures are available for controlling animal trypanosomosis, ranging from vector control by traps and targets, to the use of trypanocidal drugs, and the application of pour-ons. The direct impact on the environment of these methods is considered to be marginal, compared with those associated with ongoing expansion of agriculture and rural development.

The reality of the situation in Kenya today is that producers make decisions about livestock management and disease control, based on information and products available, their relative costs, and other calls on limited household income and labour. If disease control measures are too expensive, too time consuming, or too complex for the benefits perceived, they will not be adopted.

Studies by KETRI at Nguruman suggest that the cattle of Maasai transhumant pastoralists in the southern rift valley get by on an average of one trypanocidal drug treatment per animal per year, costing about US$1. Clearly, alternative methods of disease control must be highly effective to compete with this.

Given the importance of wildlife and tourism to the Kenyan economy, the problem of tsetse and trypanosomiasis control within and in the immediate vicinity of National Parks and other protected areas demands particular attention. In years to come, many of these areas will be surrounded by agricultural land and human settlement (as some are already), and will be threatened by encroachment, unless local communities see some benefit from their continued existence.

Kenya Wildlife Service has adopted a policy of encouraging community participation in wildlife conservation and the integrated development of peripheral buffer zones around protected areas. Such initiatives should include strategies for the control of trypanosomosis and other diseases of livestock and wildlife. Successful interventions of this kind, leading to the long-term co-existence of people, livestock and wildlife, obviously have relevance beyond Kenya.

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DFID TRYPANOSOMOSIS RESEARCH PROJECT

BUSIA DISTRICT

ON THE BORDER WITH UGANDA

JANE RUTTO

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2. BUSIA DISTRICT

2.1 Introduction

2.1.1 Geographical Setting

Busia is one of four Districts in Kenya's Western Province, with Bugoma District to the north, Kakemega District to the east, Siaya District in Nyanza Province to the south-east, and Uganda to the west. The District lies between latitudes 0^0 and 0^0 45' North and longitude 34^0 24' East. See Map 1. The District has a total area of 1,819 square kilometres, including 137 square kilometres of permanent water.

2.1.2 Topography and Soils

Most parts of Busia District lie within the Lake Victoria basin, rising from 1,130m above sea level on the lake shore to a maximum of about 1,500m in the Samia and north Teso hills. The central part of the District is a peneplain marked by low flat divides of approximately uniform height, often capped by laterite and a shallowly incised drainage system. The northern part of the central region features large granite out-crops, weathered to form hills, or tors, such as at Amukura, where the villages of Apatit and Katelenyang are located.

Low lying lands associated with the formation of Lake Victoria in the southernmost part of the District are occupied by the Yala swamp, with extensive papyrus reed beds, broken by regular water channels, occasional small lakes with grassy islands, and lacustrine and alluvial deposits of recent or Pleistocene origins. To the west of these lowland plains lie the Samia and Funyula hills running south-eastwards to Port Victoria on the lakeshore.

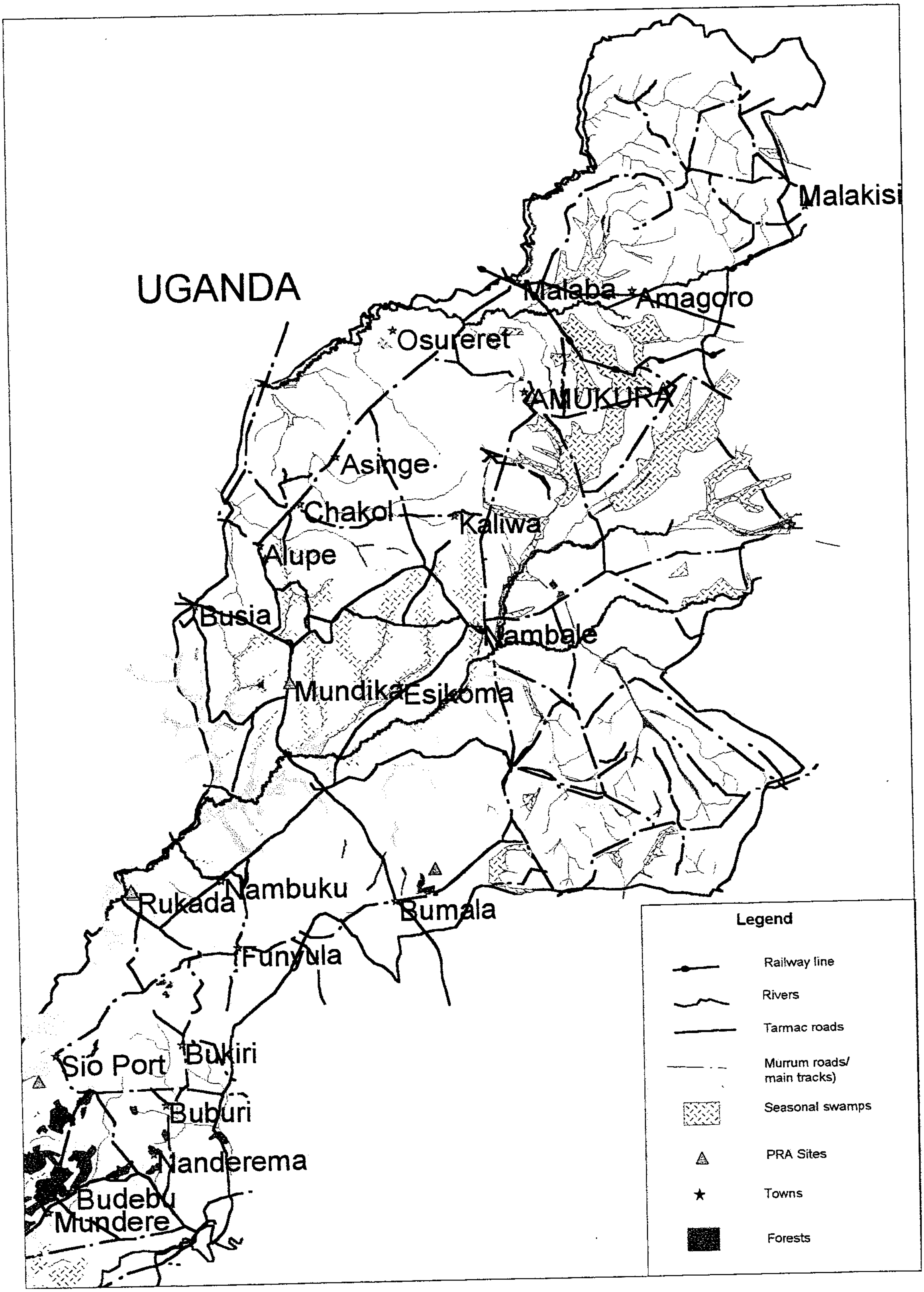
90% of Busia District is considered suitable for agricultural production. The upland soils of North Teso, Amukura and the Samia hills are thin to moderately deep sandy red clays, with reasonable natural fertility, but they are also rocky and stony. Soils of intermediate lowland areas are generally deeper, brownish, sandy clays of high natural fertility. Lowland areas are composed mainly of deep, firm, fine textured clays, with a relatively high organic content. These fertile lowlands, however, are subject to frequent flooding. Most of the central region of the District is considered to be of high agro-ecological potential. With lower rainfall and less fertile soils the southern region has medium agricultural potential.

2.1.3 Rainfall and Climate

Mean annual rainfall decreases from north to south, with northern and central parts of the District receiving between 1,400-2,000mm per annum, and southern lakeshore areas receiving half that amount: 750-1,000 mm. Rainfall distribution is bi-modal, with long rains extending from March to late May, and short rains from August to October.

Seasonal temperature variation is limited, with mean annual maxima ranging from 26-30^{0}C, and mean annual minima between 14-18^{0}C. Due to the proximity of Lake Victoria, humidity is relatively high throughout the year. Potential evaporation is in the order of 1,800-2,000mm per annum.

Map 1: Busia District



2.1.4 Agro-climatic Zones and Vegetation

More than 80% of the District lies within agro-climatic zones I and II, which have exceptionally high plant growth potential. See Table 1.

Table 1: Agro-climatic Zones

Zone		Area km^2	%	Mean Rainfall mm	Plant Growth Potential
I	Humid	924	57	1,000 - 2,700	Very High
II	Sub-Humid	374	23	1,000 - 1,600	High
III	Semi-Humid	192	12	800 - 1,400	High to Medium
IV	Semi-Humid to Semi- Arid	121	7	600 -1,100	Medium

Source: Ottichilo (1985)

Few areas of natural forest remain in Busia District and only 579 hectares of forest reserve have been gazetted within the District. Most natural vegetation has been cleared for agriculture, or otherwise transformed by timber extraction and fuel wood collection. Much of the land adjacent to river courses is subject to season flooding and is densely vegetated with bamboo, papyrus and other wetland species.

Secondary bush encroachment is apparent in many areas, notably *Tithonia diversofolia* and *Lantana camara*, found mainly on fallow land, as hedges between fields and along watercourses.

2.2 Historical Perspective

2.2.1 Administrative Jurisdiction

Busia District was created in 1963, when Marachi, Bukhayo, North and South Teso Locations, formerly under Elgon Nyanza (now Bugoma) District, Samia and Bunyole, then under Central Nyanza (now Siaya) were amalgamated. The District is divided into six administrative divisions namely Amukura, Nambale, Amagoro, Butula, Funyula, and Budalangi. These divisions are divided into 25 locations, which are further sub-divided into 89 sub-locations. In 1996, a new Teso District was created from Amukura and Amagoro Divisions, with southern Divisions remaining within a smaller Busia District. This case study relates to the area encompassed by the former Busia District.

2.3 People and Agriculture

2.3.1 Population Size, Growth Rate and Density

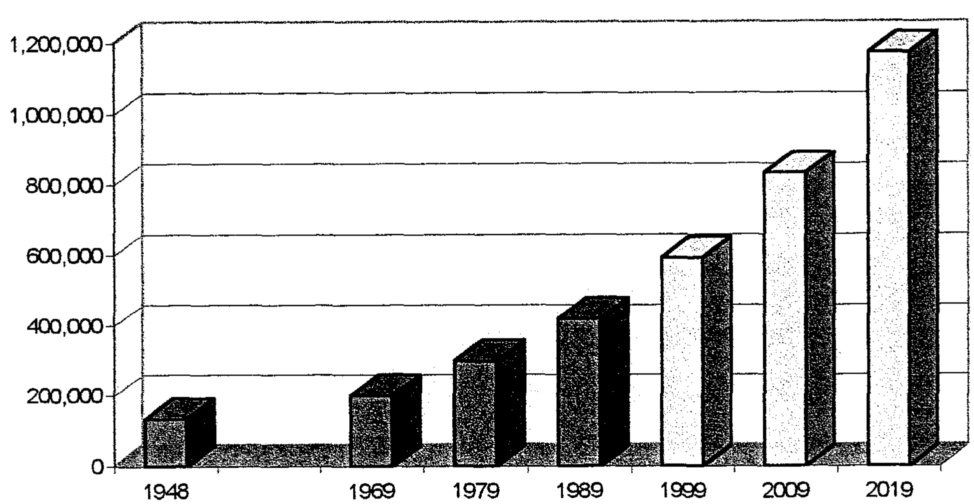
At the last census in 1989 Busia District had a human population of some 420,000 people and a population density of 230 per square kilometre, making Busia the most densely populated case study area examined. The inter-census growth rate between 1969-79 was 4.0%, possibly reflecting instability and an influx of people from neighbouring Uganda during that period. Between 1979-89 the growth rate declined somewhat to 3.5% per annum. If that rate of growth continues, the population will be 591,000 (325 per square kilometre) by 1999,and 1.17 million by 2019 (644 per square kilometre).

Table 2: Human Population Census Returns and Projections: 1948-2019

		Area	Census Year				Projections		
		km^2	1948	1969	1979	1989	1999	2009	2019
Northern Division									
	Amagoro	341	33,626	19,673	40,851	52,724			
	Amukura	235	(Iteso)	35,675	40,675	73,860			
Central Division									
	Nambale	390	25,597	45,014	58,731	105,464			
	Butula	238	(Marach)	41,761	55,662	71,429			
Southern Division									
	Funyula	268	45,521	32,284	47,514	60,180			
	Budalangi	304	(Samia)	25,022	30,065	38,001			
	Busia Town & Environs	43	27,604	1,057	24,857	98,181			
Busia District Total		1,819	132,348	200,486	298,355	420,000	591,242	832,303	1,171,648

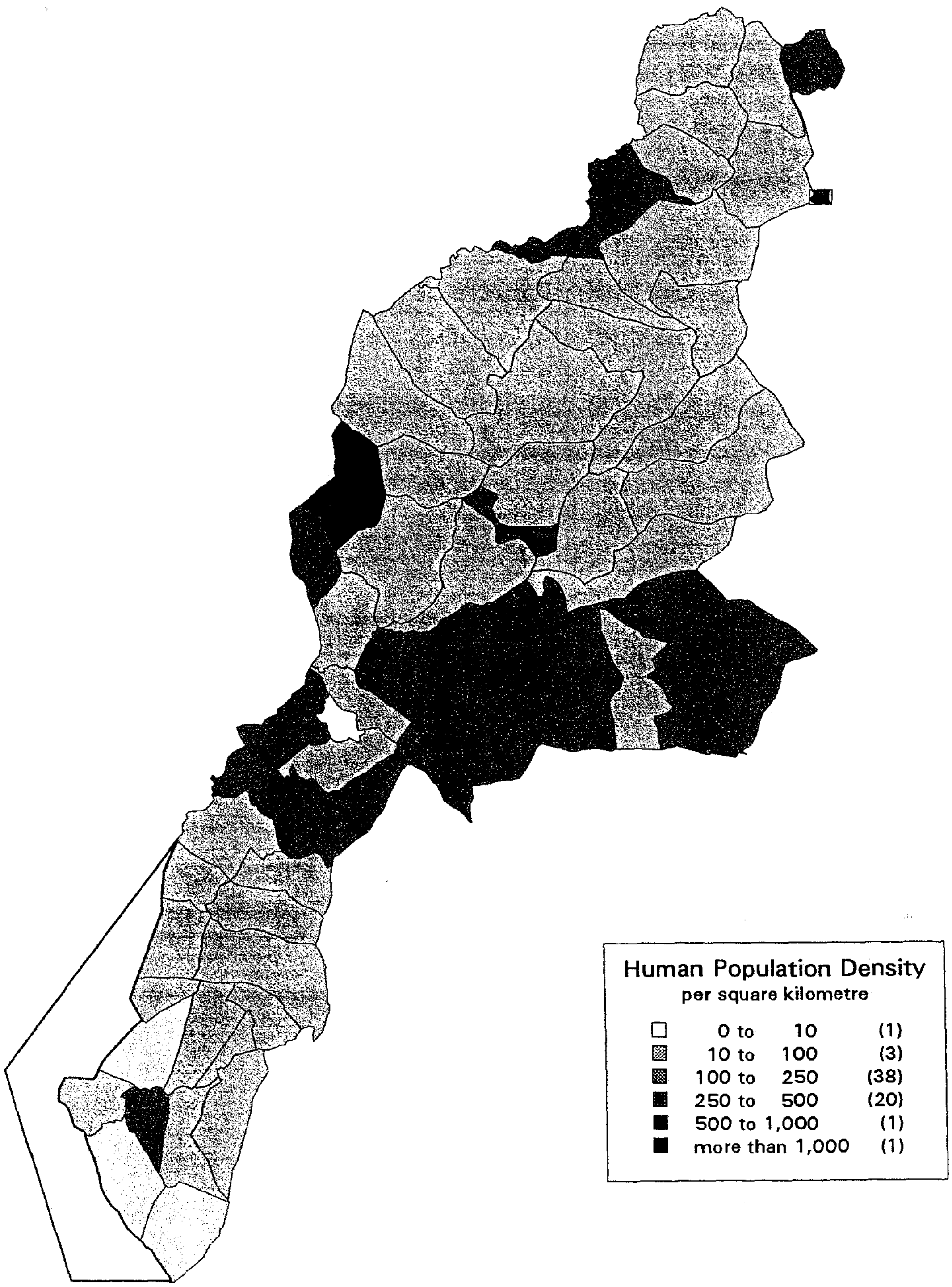
Sources: GoK (1989 & 1990).

Figure 1: Human Population Growth: 1948-2019



2.3.2 *Population Distribution*

Map 2: Human Population Density



Source: Derived from GoK (1990)

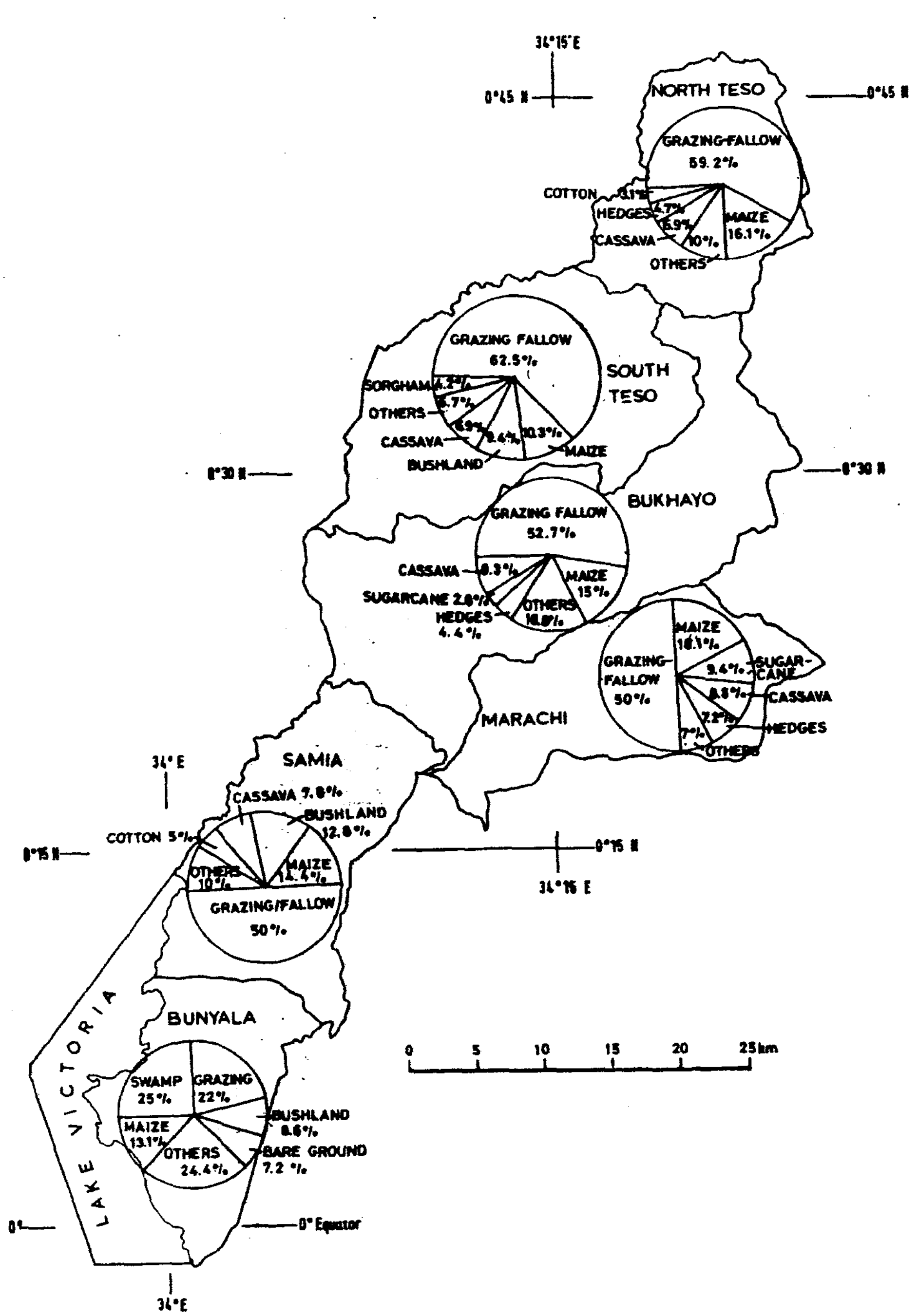
2.3.3 *Ethnic Composition*

Two ethnic groups predominate in Busia District: the bantu Luhya people (60% of the population in 1979), inhabiting eastern and southern areas of the District; and the nilotic Teso people (30% in

2.3.4 Farming Systems

Rainfall distribution and reliability are reflected in the prevailing forms of agricultural production in different parts of the District. In central divisions, where rainfall is generally more reliable, there is a diverse range of arable cultivation, with maize, millet and sorghum grown mainly for subsistence needs, and sugar cane, cotton and tobacco as cash crops. Further south towards Lake Victoria, where annual rainfall is lower and less reliable, more drought resistant crops are grown, including cassava and sorghum, with some maize and cotton. Livestock are kept throughout the District for economic as well as social reasons.

Map 3: Land Use and Cropping Patterns by Location in 1984



Source: Kenya Rangeland Ecological Monitoring Unit (Otichilo, 1985)

The Kenya Rangeland Monitoring Unit assessed land use and cropping patterns in Busia District in 1984, using low level aerial sample photography (Otichilo, 1985). 31% of the total land area was under active cultivation, with maize being the dominant crop (14%), followed by cassava (8%), sorghum (3%), cotton (2%), sugar cane (2%), and unidentified (3%). Fallow and rough grazing accounted for 51% and various miscellaneous categories the remaining 18%. See Map 3 for a breakdown of land use and cropping proportions by location.

2.3.5 *Participatory Rural Appraisal*

The primary purpose of Participatory Rural Appraisal (PRA) is to learn from, with and by members of the community (Theis and Grady, 1991). Methods and tools used in Busia District are described in Appendix I Community perceptions of change and important historical events are summarised in Table 3 and Table 4.

Table 3: Trend Analysis

Parameter Assessed	1930s	1940s	1950s	1960s	1970s	1980s	1990s
Human Population	+	+	++	++	+++	+++	+++
Household Income	+	+	+	++	++	++	++
Human Diseases	+	+	++	+++	++	+++	+++
Education/Schooling		+	++	++	+++	+++	+++
Rainfall	+++	+++	+++	+++	++	++	+
Temperature	+	+	+	+	++	++	+++
Extent of Cultivation	+	+	+	++	++	+++	+++
Extent of Pastures	+++	+++	+++	+++	++	++	++
Extent of Forests	+++	+++	++	++	+	+	-
Rivers/Streams	++	++	++	++	++	++	++
Ponds	++	++	++	+++	++	++	++
Swamps	++	++	+	-	-	-	-
Roads and Tracks	+	+	+	+	+	++	++
Hospitals and Clinics	-	-	-	-	-	+	+
Cattle Numbers	+++	+++	+++	++	++	+	+
Cattle Diseases	++	+	+	++	++	++	+++
Wildlife Numbers	+++	+++	++	+	+	+	+
Tsetse Numbers	+	+	++	+	+	+	++
Animal Trypanosomosis	-	+	+	++	+	+	+
Human Trypanosomosis	+	+	++	++	+	+	++

+ Few, small or little
++ Average to middling
+++ Many, abundant or extensive

2.3.6 Summary of Community Views

Human Population

The population in the 1930's was low due to low reproductive rates and plagues, which uses to occur and there was no treatment. The only hospitals were in Kakamega and Lumino in Uganda. The number of households has increased with an average of 5-8 people per household. The human population has increased tremendously. The population has been increasing since 1930's though it accelerated in 1970's (~1967). The household numbers (Akai in Teso) has increased.

Farming Practices

In all eight PRA sites the production unit is the household. Emphasis is put on planting food crops and traditional methods of farming are practised. Livestock keeping is carried out under traditional methods. Local Zebu cattle are predominant and improved breeds are limited, only kept in major towns and Nambale Division under zero grazing. There is a high demand for milk in Busia District and people are, therefore, interested in improving animal husbandry practices and upgrading their livestock. Major constraints are trypanosomosis and East Coast Fever. Commonest grazing management practices are tethering and free range. Most grazing areas are near tsetse infested bush. Cattle also come into contact with tsetse while drinking water at the river. During the dry season they graze along rivers and swamps. Luhya community in Busia District keep more livestock than Teso people in Teso Distinct.

Cattle Mortality

Many cattle in the District have died because of trypanosomosis. Decline in the number of animals for ploughing and reduction in area that can be cultivated. Reverted to tilling by hand. Less manure and reduction in crop yields. Reduced incomes for households depending on sale of livestock products, especially milk, live animals and other farm produce. Had problems to pay dowry due to lack of animals. Fewer wives per husband has led to reduction of family labour. Livestock have also declined because of increased human population, land demarcation, reduced grazing land and poor management due to death of *wazee*.

Pasture

In 1930's there was plenty of pasture, but reduced after land demarcation in 1968, when people were given title deeds. Overgrazing not a major problem in District since most animals had died due to trypanosomosis. In the past people used to take their animals to "Esirongo" to take salt from the soil which acted as a de-wormer.

Cattle Diseases

Ticks was the most common disease up to 1990's and it has increased at the moment. Ticks were controlled by bush burning, or plucking from the animal and burnt. Apatit community thought that veterinarians did not assist them to contain trypanosomosis.

Human Diseases

Diseases have been quite few from 1930's-1960's. The common diseases were diarrhoea, plaques, measles, smallpox, snake bites and jiggers. However, disease problems have increased since 1970's due to human interactions either emigration immigration from the District. Human trypanosomosis was experienced in 1949 in Mundika, though they thought that the person concerned had contracted the disease whilst living in south-east Uganda. Also in Sisenye in 1950's and 1960's, when the inhabitants ran away and went to live across the hills in Bulemia. Another outbreak occurred in the 1990's, when fatal cases were reported. Have hospitals, dispensaries and herbalists for treatment. Most common human diseases at the moment are HIV and malaria.

Cultivation

Cultivation started increasing in 1950's due to population growth. Cultivation has been increasing steadily since then and by 1970's cultivation was very high since oxen were available. This was also when tobacco was introduced (1977). Food crops grown are maize, sweet potatoes, millet, cassava and sorghum. The cash crops grown are tobacco and sugar cane, which was introduced in 1990's.

Cultivation has reduced in 1980s and 1990s, due to loss of draught animals, and further sub-division of land to children. However, in some parts of the District, such as Bujumba, some people use tractors depending on availability and affordability. Soil erosion was low in the District. The inhabitants in some parts the District, such as Apatit, were forced to make terraces in 1954. This practice appears to be coming more widespread.

Wildlife

Wild animals, such as elephants, leopards and hyena, were plentiful in the 1930's to 1950's. They started decreasing by 1960s and had mostly disappeared by the 1970s. Nowadays, the commonest wildlife in the District are monkeys, mangooses and rodents.

Climate

It was much cooler in the 1930's, 1940's and 1950's. Temperatures increased with land demarcation and clearing of bushes/forests.

Forests

Forests and woodland were more abundant in 1930's to 1970's. Now, there are no forests, only bushes on hill tops and only a few riverine trees are left in the District.

Soil Fertility

Soil fertility was low as seen in the growth of crops e.g. maize, which looked retarded and yellow in colour. The people only used fertiliser for planting tobacco. Soil erosion was present in some areas, where the people cultivated up to the hill top, with no or few terraces installed down hill.

Tsetse Control Measures

No bush clearing has been carried out in sites visited. Only limited ground spraying 1980's (1987) and, more recently, trapping. There appeared to be no reduction in tsetse numbers or positive effects on Nagana.

Table 4: Community Time Line

YEAR	EVENT
1930's	Eclipse of the sun in 1930 Locusts invasions in 1931, 1933 and 1937 Wrestling among young men Panyako fight Onjoro tsetse camp was started in 1956 (?) in Sisenye Marked entry of churches and schools Local blacksmith made hoes and arrows for hunting and cultivation Army worm infestation
1940's	Eclipse of the sun in 1942 which lasted the whole day Kedereyo hunger in 1943 Osembo hunger in 1944 Forced labour of Africans End of Second World War on 15/8/1945 Dini ya Msambwa was introduced Wrestling and Panyako fight Forced schooling
1950's	Wrestling Floods in 1951 Mau-Mau fight in 1952 Mau-mau hunger of 1953 Bush clearing using bulldozers in Sisenye and surruonding areas Land demarcation in 1956 Era of forced marriages
1960's	Floods in 1961 Independence in 1963 Inoculation of smallpox Era of night dances Land demarcation started and adjudication
1970's	Intensive farming carried out Increased formal education Njaa (hunger) wa makonge were sisal was exchanged for food Coffee boom in 1977 Mzee Kenyatta died in 1978 and President Moi took over
1980's	Intensive farming carried out Increased formal education Yellow maize hunger of 1984
1990's	Increased crime rates Increased poverty especially after 1992 Structural Adjustment Programme Most livestock died after Government assistance was withdrawn Multi-party politics Hunger and drought in 1997

2.4 Livestock and Wildlife

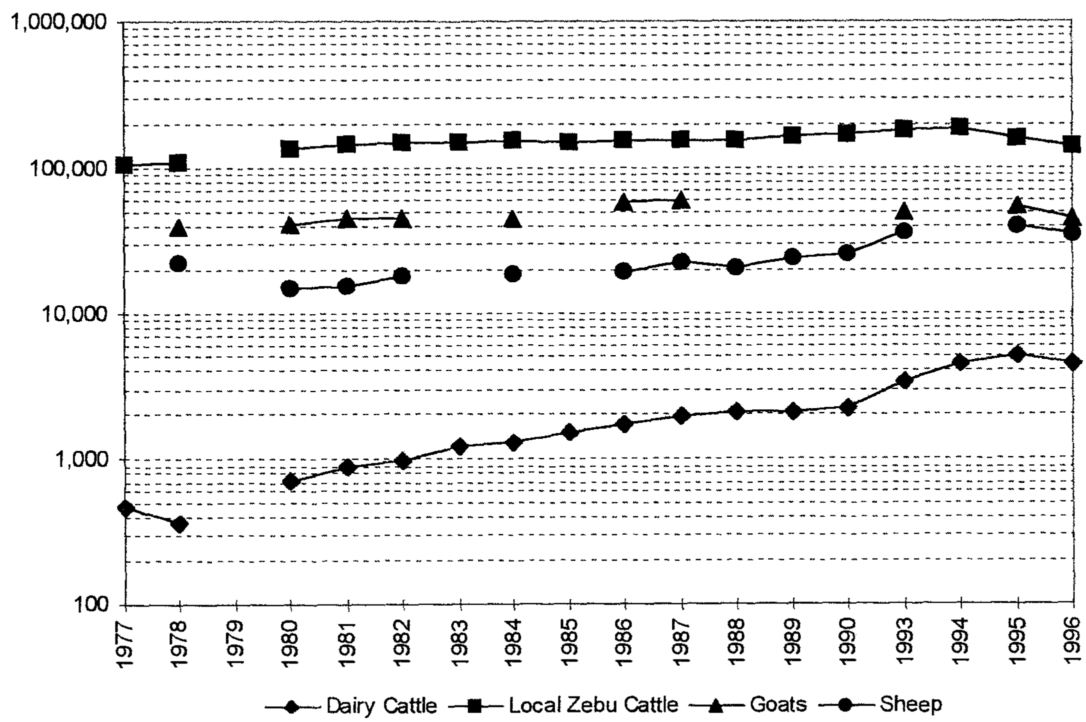
2.4.1 Livestock

Population estimates for indigenous Zebu, dairy cattle, sheep and goats in Busia District for the period 1977-1996 are plotted in Figure 2. Features of interest include: the relatively static population of indigenous Zebu cattle; and the ten-fold increase of cross bred dairy, or grade, cattle from 469 in 1977 to 4,466 in 1996.

The Busia District Livestock Production Office has attributed the recent doubling in grade cattle numbers, from 2,560 in 1991 to 5,030 in 1995, to the activities of the Finish sponsored Livestock Development Programme, which started in 1991, and the importation of cows form Trans-Nzoia. It is evident from Figure 2, however, that the progressive increase in dairy cattle in Busia District dates back to the late seventies, and that the rate of increase has accelerated during the nineties.

Despite this positive sign of agricultural intensification, the figures demonstrate the preponderance of indigenous stock, and that for every grade animal there are 30-40 Zebu.

Figure 2: Livestock Populations Trends: 1977-1996



Source: Busia, Annual Report for 1996 (District Livestock Office).
Note Log Scale

2.4.2 Wildlife

There are no Game Reserves or National Parks within the District. Wildlife is generally rare, except

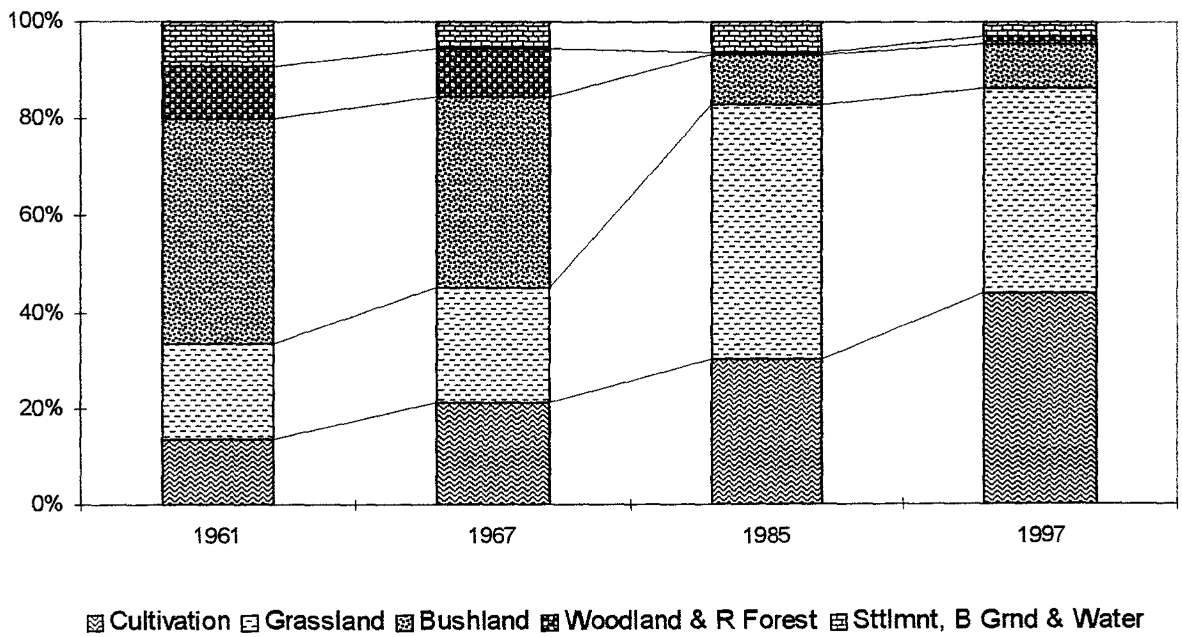
2.5 Land Cover Change

Changes in the land cover of Busia District since 1961 to the present day were assessed by comparative air-photo interpretation. For details of the method used see Appendix II. Aerial photographic coverage was available for 1961, 1967, 1985 and 1997. Total land area sampled varied slightly from year to year, depending on air-photo coverage, but averaged about 1,700 square kilometres. Results are presented in Table 5 and Figure 2.

Table 5: Land Cover Change

Year	Cultivation	Grassland	Bushland	Woodland & River Forest	Settlement, Bare Ground & Water	Sample Points	Air Photos
	%	%	%	%	%	%	N
1961	13.66	19.83	46.76	10.80	8.95	1296	36
1967	21.15	24.15	39.46	9.69	5.56	1404	39
1985	30.49	52.49	10.28	0.47	6.26	5700	57
1997	43.84	42.31	9.19	1.64	3.02	12900	129

Figure 3: Land Cover Change



Cultivation in Busia District has increased from 14% of the land area in 1961, to 44% in 1997. This represents a compound rate of increase of 3.2% per annum, slightly less than the 3.5-4.0% rate of human population growth between 1969 and 1989 censuses. Grassland has increased by a similar amount from 20 to 42%, reflecting an expansion of short-term fallow.

Woody vegetation cover, in the form of bushland, woodland and riverine forest, has declined from 58% in 1961, to 11% since 1997. As woody vegetation is the primary haunt of tsetse, it is evident that there has been a substantial reduction of natural tsetse habitat in Busia District over the past 30-40 years. Riparian forest and dense woodland, the preferred habitat of *G. fuscipes fuscipes,* which in

2.6 Tsetse and Trypanosomosis

2.6.1 Tsetse Species Present and Distribution

Information presented here has been extracted from Veterinary Department files; KETRI reports; and Angus (1996). Two species of tsetse are found in Busia District:

Glossina fuscipes fuscipes is essentially a riverine and lacustrine species. It is found around the lake shore and along the Malaba-Malakisi and Sio river systems, and extends to the heads of tributaries, both within Kenya and Bugoma District in Uganda. The linear extent of potential riverine infestation is put at 545 kilometres, variously equated to be between 109-272 square kilometres of infestation.

G. pallidipes, typically a species of drier woodland savannah areas, is reputed to have invaded from Uganda during the last few years, extending as far as Hakati in southern Division and into Boro Division in Siaya District. More recent surveys have found *G. pallidipes* further north in Nambale Division of central Busia. Catches are generally low; distribution is patchy, and is associated with woody hillside vegetation.

2.6.2 Trypanosomosis

2.6.2.1 Sleeping Sickness Outbreak: 1977-1992

Until the break up of the East African Community in the mid 1970s, Kenya, Uganda and Tanzania participated in the joint East African Trypanosomiasis Research Organisation (EATRO), based near Tororo in Uganda on the border with Kenya. Since 1977, all sleeping sickness cases in Busia District have been admitted to the KETRI Sleeping Sickness Referral Hospital at Alupe, 5 kilometres north of Busia town. Between 1977 and 1992, the number of reported sleeping sickness cases ranged from zero to 88 a year. Over 75% of cases occurred during 1989 and 1990, with only sporadic cases in other years. Most cases came from Amogoro, Amukura, Nambala and Funyula divisions, with few from Butula in the east and Budalangi on the lake shore. There was no significant difference in the incidence of sleeping sickness between males and females, but there was a significantly higher incidence in the 30-60 year age range, almost certainly reflecting a closer contact with the vector amongst this group. For an historical perspective of reported sleeping sickness cases in Busia and Siaya (formerly Central Nyanza), see Map 4 and Figure 4.

Maudlin (1993) provides a useful account of the most recent outbreak of human sleeping sickness in Kenya caused by *Trypanosoma brucei rhodesiense*, which began in Busia District in 1987. The origins of the Kenya outbreak, however, may be traced to an epidemic which started over the border in Busoga, south-eastern Uganda, which "resulted largely from a breakdown in the control structures as a consequence of the unstable political situation in Uganda during the 1970's. Large-scale ground spraying operations against tsetse were interrupted; agricultural practices altered e.g. cotton growing (demanding heavy insecticide usage and bush clearance) was replaced by subsistence farming, allowing the spread of favourable tsetse habitat. Population movement from the north was accompanied by an increase in small-scale cattle rearing. The increase and spread of the tsetse vector (exclusively *Glossina fuscipes fuscipes*), together with an increase in cattle numbers (cattle are recognised reservoirs of SS [Onyango et al., 1966; and Wellde et al., 1989]), led to an outbreak of sleeping sickness. Medical authorities became aware of the outbreak in 1976 and by 1980 more than 8,000 cases were reported in Busoga. Following aerial spraying operations in 1980,the epidemic was temporally halted but by 1987 >6,000 cases were diagnosed in Busoga.

Map 4: Location of All Known Cases of Sleeping Sickness in Western Kenya: 1978-97

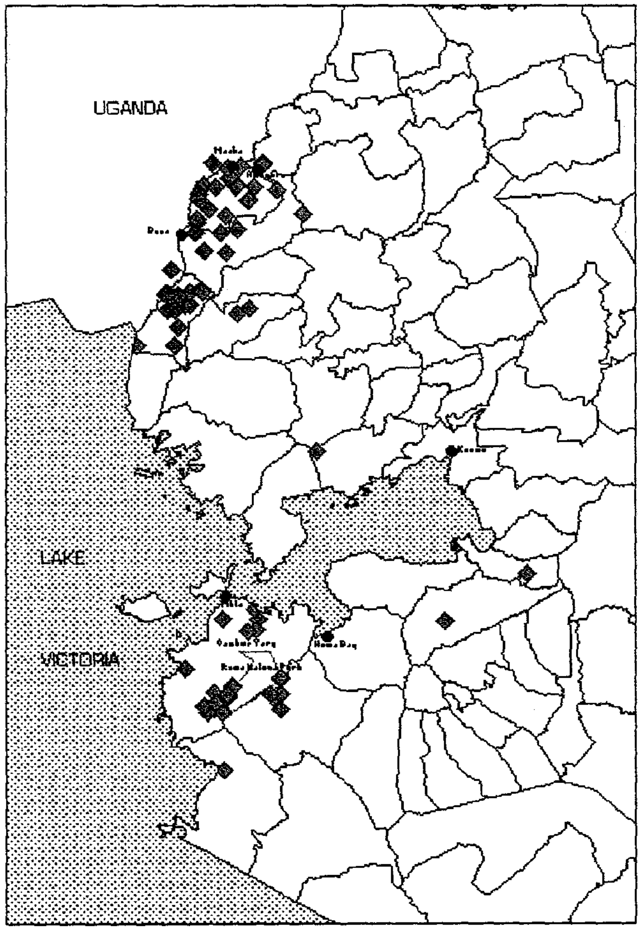
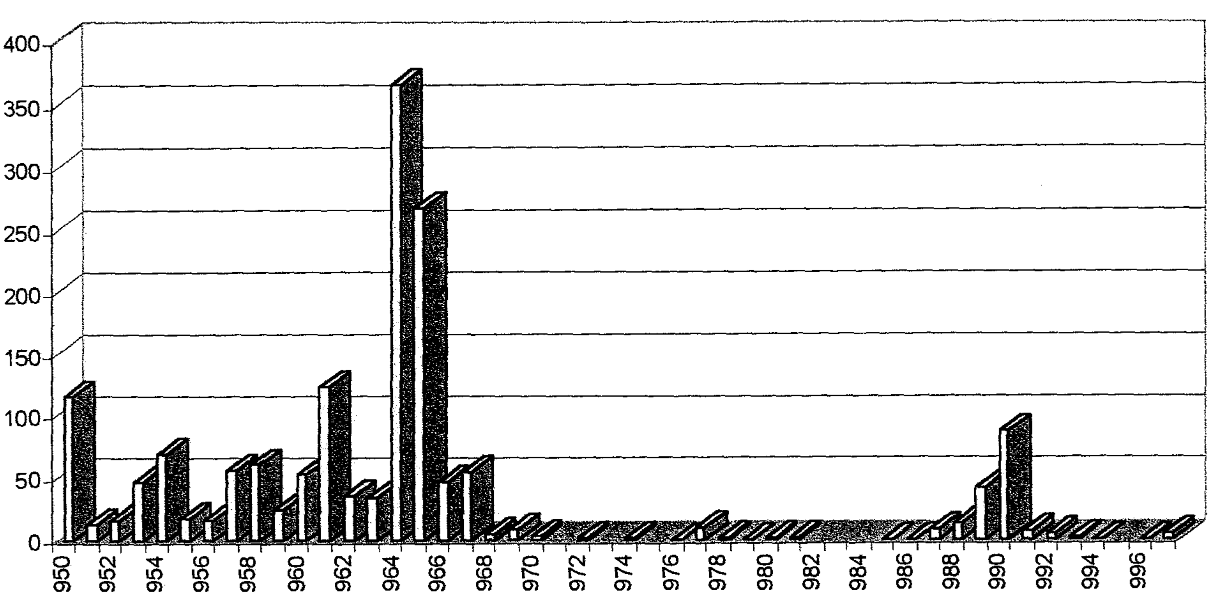


Figure 4: Human Sleeping Sickness Cases in Busia and Siaya Districts 1950-97



Meanwhile the disease spread eastwards from Busoga with a localised outbreak in Tororo District in 1988; over 300 cases were treated in Tororo District in 1990. Inevitably, infected flies gradually moved through the river systems of Tororo District and then, via the River Malaba, across the border into the Busia District of Kenya. The outbreak on the Kenya side of the border reached a beak in 1990, when 90 cases were treated at the KETRI Alupe Sleeping Sickness Referral Hospital.

To control the outbreak in Kenya, ground spraying operations instituted by the Tsetse Control Section of the Veterinary Department and tsetse traps were deployed throughout the area."

2.6.2.2 Vector Control Measures: 1977-1994

Prior to 1990, when regular systematic fly trapping was introduced, tsetse control was carried out largely on an *ad hoc* basis by bush clearance and ground spraying of insecticide in and around villages where sleeping sickness had occurred. Initially, DDT (25%) and Dieldrin (1.8%) were used, but when these were banned by Act of Parliament in 1983 they were replaced by cypermethrin (0.3%). The policy of bush clearance and insecticide application in and around any village with sleeping sickness continues, but, with so few cases being reported, field activities have been minimal during the nineties. (Angus, 1996; quoting Tsetse Control Section sources.)

In the past, the standard method of tsetse survey and population sampling was by means of tsetse patrol with hand nets using a moving black target between two men wearing blue overalls as an attractant. With the introduction of biconical traps in the early eighties, trapping has replaced foot patrols as the standard method of tsetse surveillance.

Following the 1989-90 outbreak of sleeping sickness, centred on Apatit and Katelenyang villages, systematic tsetse trapping has been carried out in many areas of the District using Lancien traps (Gouteux and Lancien, 1986) impregnated with 0.1% deltamethrin (Glossinex). Traps are generally sited along river courses and relocated every few weeks. Every three months, or so, the traps are re-impregnated with insecticide. Major reductions in tsetse catches of up to 99% were reported for some areas, but elimination was not achieved - see Table 6- and are unlikely to be permanent.

Table 6: Tsetse Traps and Targets and Catch Reductions in Busia District: 1990-1994

Division	Number of Sites	Number of Traps	Number of Targets	Flies/trap/day 1990	Flies/trap/day 1994	Percentage Reduction
Amogoro	3	710	0	1.9	0.5	74
Amukura	4	1,240	0	13.5	0.1	99
Nambale	3	570	0	13.5	0.1	99
Funyula	4	750	350	6.0	0.3	95
Budalangi	3	425	0	10.5	1.4	87
Total	17	3,695	350	8.0	0.3	71

Source: Tsetse Control Section, Veterinary Department (Busia)

2.6.2.3 Animal Trypansomosis

A year long epidemiological study of trypanosomosis in indigenous livestock of four villages in Busia District was carried out in 1993-94 (Angus, 1996). The four villages: Katelenyang; Apatit; Rukada; and Ngelechom; were specifically selected for the high prevalence of *Trypanosoma brucei* spp. in their livestock, for investigation of their role as reservoirs for human sleeping sickness.

The prevalence of trypanosomosis varied seasonally and from village to village, tending to be higher after the long rains from March to June, and lower in the drier months from November to December. *T. vivax* infections predominated, followed by *T. brucei* and *T. congolense*. Monthly total trypanosome prevalence rates for indigenous village cattle varied from 3-37%, i.e. from three in a hundred, to one in three cattle infected at any moment in time.

2.6.3 Changing Nature of the Problem

With an estimated 40% of the land area under cultivation and 45% grassland, it is clear that little, if any, natural tsetse habitats remain in Busia District. A few riparian forest patches survive and harbour limited populations of *G. fuscipes fuscipes,* but this habitat and species of tsetse appears to have been greatly reduced over the years

In upland areas, scrub and woodland have been turned to farmland and fallow, with varying degrees of bush regrowth. This would appear to have created conditions suitable for the expansion of *G. pallidipes.*

Recent studies have confirmed that cattle, and to a lesser extent pigs, are the most important potential reservoir of Rhodesian sleeping sickness in Busia District (Angus, 1996; and Masiga et al. 1995). It has also been demonstrated that chemoprophylaxis is capable of virtual elimination of that reservoir.

Whilst, tsetse persist in any given area, they remain potential vectors of trypanosomosis. In Busia, available information suggests that the natural habitats and hosts of tsetse have declined substantially over the years, and that tsetse distribution and abundance has been greatly reduced. Where tsetse persist, they remain a threat as a potential vector of human and/or animal trypanosomosis. In Busia, that threat has been reduced by expansion of arable agriculture and the elimination of the wildlife reservoir of trypanosomosis.

2.7 Environmental Concerns and Lessons for the Future

2.7.1 Environmental Concerns

There are virtually no protected areas within the District. With a long history of settlement, high human population density and agricultural expansion, few areas of "natural" vegetation or wilderness remain. Most of the larger wildlife species have long since been eliminated, and there has been a general loss of biodiversity.

2.7.2 Lessons Learnt

- There has been a substantial reduction in the number of reported cases of human sleeping sickness in Busia District over the past forty-seven years. Occasional outbreaks have occurred, the most recent being in 1987-92, with a total of 164 reported cases. In the outbreak prior to that in 1963-67 a total of 768 cases were reported. Sleeping sickness can, therefore, no longer be regarded as a disease of major importance in the area, compared, for instance, with malaria, HIV/AIDS, or road traffic deaths.

- Human population increase and agricultural expansion have greatly reduced the extent of natural vegetation in Busia District. Woody vegetation cover, indicative of tsetse habitat has declined from 58% to 11% of the land area from 1961 to 1997. Riparian forest and dense woodland have virtually disappeared.

- The disappearance of forest and woodland habitat and transformation to a more open mosaic of cultivation and fallow land, has coincided with the decline in forest tsetse, *G. fuscipes fuscipes*, and an expansion of the savannah species, *G. pallidipes*.

- Nevertheless, it is evident that tsetse persist in areas of high human population density, where large wildlife hosts (except for Monitor lizards) have virtually been eliminated, and little natural habitat remains.

- Bush encroachment and the spread of *Lantana camera* on old fallow land have created new artificial habitats for tsetse in some areas of the District.

- Whilst tsetse are clearly able to survive under such circumstance, conditions are sub-optimal, their distribution is fragmented and numbers are low.

- Busia District has the highest human population density of any of the case studies examined, with a projected 325 people per square kilometre by 1999.

- The District also has the highest potential for agricultural production of any case study examined.

- Whilst increasing population density may be cause for concern to some, others, subscribing to the view that necessity is the "mother of invention" (and change), would see circumstances necessary for the intensification of agricultural production (Boserup, 1965 & 1981) and further development of mixed farming.

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APPENDIX I: PARTICIPATORY RURAL APPRAISAL

Purposive Sampling
Information about environmental change in case studies areas was collected from local community groups. Ten to twenty participants were selected to take part in each of the group discussions.

Data Collection at Community Level
Participatory Rural Appraisal (PRA) tools and methods were used to collect information on environmental changes associated with tsetse and trypanosomosis in the case study areas. PRA is a family of approaches and methods used to enable people to present, share and analyse their knowledge of life and conditions, to provide better understanding and more effective development. The main aspect of the PRA is learning from, with and by members of the community (Theis and Grady, 1991). Qualitative surveys were carried out for the purpose of (a) collecting information about local production systems; (b) highlighting major changes on the nature of tsetse and trypanosomosis problem; and (c) identifying environmental concerns. The methods used included; key informant interviews, semi-structured interviews, time lines, trend analysis and participant observation.

Participant Observation
Observation is clearly the most basic method for obtaining information on and about the world around us. Observation is the key method for collecting reliable and valid data over a range of human behaviour. In this investigation, observation of physical features, social differences, behaviour and symbols provided important information for posing central questions. Observational data are supplemented by data obtained by other means. Direct observation was used to gain insights that were later tested by other techniques.

Semi-Structured Interviews
Semi structured interviews were held with community groups. Group interviews provided access to a larger body of knowledge of general community information. Questions were posed in dholuo according to a flexible checklist. Only some of the questions and topics had been predetermined, many questions were formulated during as discussion progressed.

Semi-structured interviews were used to collect information about local production systems, socio-economic circumstances, perceptions of tsetse and trypanosomosis control, and environmental concerns associated with these control measures. Groups of men and women were convened in each of the four areas. For each group 10-20 people were selected from various villages, different social strata with a bias towards age. The longer the period of residence the better. This was important so that participants were able to give information on changes that have occurred over as long a period as possible.

Time Lines
Time lines are rough overviews of events of significance for the history of the group or the area in question (Britha Mikkelsen, 1995). Time lines were important in that, they were used to correlate the changes noted during the semi structured interviewing.

Trend Analysis

Trend analyses emphasise changes in local resource endowments, cropping patterns, ecology, physical and social structure, settlement, population distribution, migration wealth, etc.. During the trend analysis exercise data for about 40 years was obtained. Using flip charts and marker pens, members of each group were asked to draw their own trend analysis diagrams. Trends show qualitative changes over time. Counters were used to provide a measure of change and relative importance. Trend analysis was used to obtain information about the extent of land under cultivation, livestock abundance, human population size, forests, pastures, wildlife numbers, human diseases, livestock diseases, and household income, between 1950s and 1990s. Causes of change were registered for further inquiry.

Key Informant Interviews

A key informant is an individual who is accessible, willing to talk and has great depth of knowledge about the particular issues of concern, here, health, livestock, community structure (Rhoades, 1979). At the community level the list included people who had been born in the area or had been resident for many years. The purpose for the interviews was to collect background information on human occupancy and key historical events, including: introduction of new crops, epidemics, droughts, famines, changes in land tenure, immigration and emigration.

APPENDIX II: AIR-PHOTO INTERPRETATION AND LAND COVER ASSESSMENT

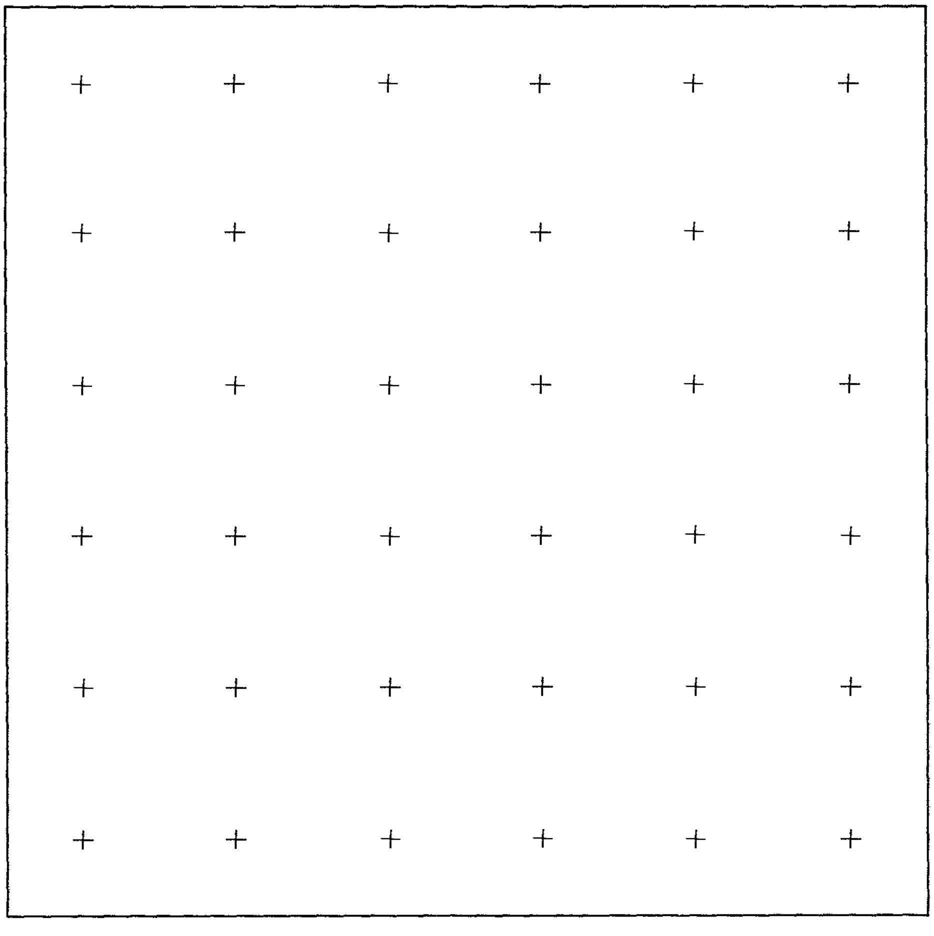
Land cover changes in case study areas were assessed by comparative air-photo interpretation.

Aerial photographic coverage specifications vary from survey to survey; e.g. height above ground (scale); extent of overlap between frames on same flight line; extent of overlap between adjacent flight lines; and film type (black and white, or colour). The method of air-photo interpretation outlined here is based on a technique of land use pattern analysis described by Brunt (1967) and demonstrated to KETRI Environment and Socio-Economic Unit staff using high resolution colour aerial photographs of Nguruman taken in 1991.

Because there is approximately 66% overlap between consecutive frames on each flight line and 33% overlap between adjacent flight lines, there is no need to examine all of every aerial photograph. In fact, if repetitive sampling of the same land area is to be avoided, which it should be, it is only necessary to sample the "unique" central part of every second frame. Given that each print is 9" x 9", the "unique" central part of every second frame is contained within a 6" x 6" portion, with a redundant peripheral 1.5" margin on all sides.

The "unique" central area of every second frame is sampled by means of transparent overlay with a 6 x 6 array of 36 sampling points (Figure 5).

Figure 5: 6 x 6 Array of Air-Photo Sample Points Used for Land Cover Assessment



Each sample point is examined closely and allocated to one of 10 possible vegetation and land use types (see Table 7). A tally is kept of the total number of sample points in each land cover category for each aerial photograph. Individual scores are then summed and converted to percentages for each survey area and period, from which it should be possible to demonstrate quantitative changes in the relative proportion of land cover types over time.

Table 7: Categories: of Vegetation and Land Use Types

Riparian Forest:
Along river coarse and drainages with dense trees (large/mature) and closed or nearly closed canopy.
Identification Characteristics: along drainage/tall-dense trees, dark colour, high texture

Dense Woodland:
Dense tree canopy but not closed, away from riparian zone (drainages).
Identification Characteristics: not along drainage, tall & medium trees, dark colour, high texture.

Open Woodland:
Scattered trees with either grass or shrubs as understory.
Identification Characteristics: fewer trees, scatter, medium colour, medium texture.

Shrubland:
No obvious trees (or very few), low height-shrub covering or scattered on ground.
Identification Characteristics: no trees, medium--light colour, medium texture.

Grassland:
No trees, few shrubs.
Identification Characteristics: no trees, light colour and texture.

Cultivation:
Includes active and fallow cultivation. Defined by a boundary, usually of geometric shape.
Identification Characteristics: pattern is geometric, light-dark in colour, texture varies.

Settlements/Tracks/Roads:
Usually dwellings can be seen, with bare ground and cultivation nearby. Tracks and roads are self evident and appear as white lines on photo.
Identification Characteristics: dwellings, lines.

Bare Ground/Rocks:
No vegetation.
Identification Characteristics: No vegetation, very light colour.

DFID TRYPANOSOMOSIS RESEARCH PROJECT

GALANA RANCH

COASTAL PROVINCE

DAVID BOURN

&

CATHLEEN J. WILSON

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Cover Photograph (Peter Stevenson): Orma Boran, Galana Ranch

3. GALANA RANCH

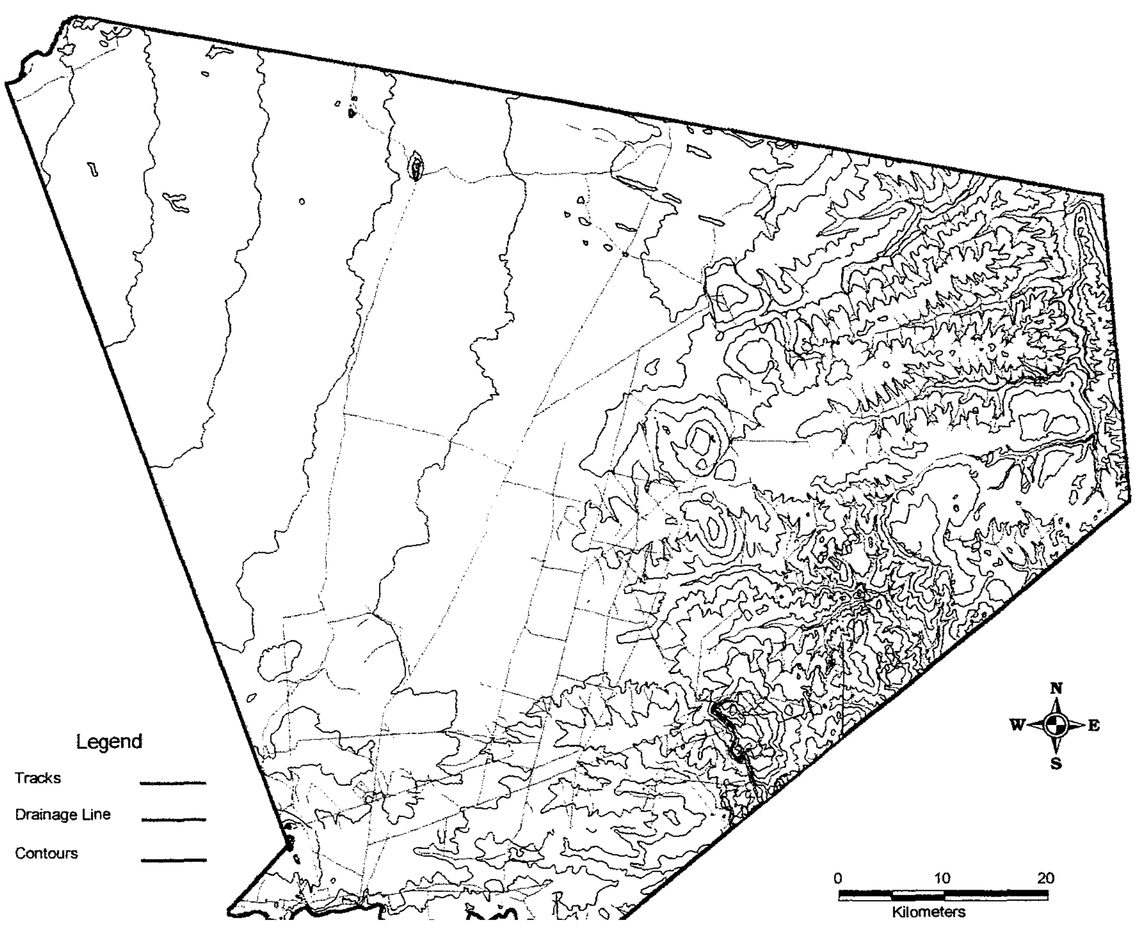
Much of the background information presented in this case study is derived from Alushula (1994), Heath (1996) and Parker (1996 a&b), and an associated archive of documents, listed in an appendix to this case study, and held by KETRI's Environment and Socio-economic Section.

3.1 Introduction

The region immediately to the north of the Galana, or Sabaki, river, in south-eastern Kenya, inland from the coast and east of what is now Tsavo National Park, has always been a remote and relatively inaccessible part of the country. Although historical records are sparse, Corfield (1974) has compiled a fascinating series of early accounts of the area. The deprivations of crossing the inhospitable and waterless "Taru desert" were often mentioned, and this was clearly one of the reasons why Lugard (1892, 1893 & 1959) was commissioned to survey the course of the Sabaki river inland from Malindi, as a possible route for the Uganda Railway in 1890.

Lugard commented on the density of vegetation, abundance of wildlife and the "entirely uninhabited" country through which he travelled, although he also referred to the many Maasai "war-paths" crossing the Sabaki river, and occasional meetings with the Galla. The disruptive and wide ranging impacts of Maasai raiding parties in search of cattle were mentioned by many early travellers in the region. Lugard also made passing reference to the loss of Maasai cattle due to plague (=rinderpest), which had deprived them of their means of subsistence and driven them to desperate measures.

Map 1: Galana Ranch Roads, Drainage and Topography



In his official history of the Kenya and Uganda Railway, Hill (1961) recounts how, in the late 1890s, "all the attempts made to introduce animal transport had failed. Three lots of camels brought from India ...... had quickly died. The horses of the 24th Balutchistan Regiment died within two months of arrival. Tsetse-fly and a lack of water precluded the use of bullocks between Mazeras and Kibwezi. But in Ukamba and beyond, where cattle thrived, there were brighter hopes for ox-drawn transport." "During 1897 and 1898 mortality amongst the railway's animal transport was enormous. Of 63 camels, all died; of 350 mules, 128 died; of 639 bullocks, 597 died; and of 800 donkeys, 774 died. In one caravan of 121 donkeys which left Mwachi (Mile 17) for Kibwesi (Mile 193) in December 1896, only 1 returned alive in the following April .... The belts of country infested with tsetse-fly as far as Mile 220 from the coast made it impracticable to maintain large gangs of labourers by animal transport save at prohibitive expense which the high rate of mortality entailed."

The first motorable track through the Galana case study area, running along the north bank of the river, was cut by the Game Department in the mid thirties, and named MacArthur's track after the Game Ranger responsible. A few years later, in 1939, just before the outbreak of the Second World War, a make-shift floating bridge was constructed across the Sabaki between Sala and Lali hills, and a second track was forced through to Lali hill, and northwards a further 110 kilometres to Dakadima and Dakadakacha hill. The prime movers for this initial opening up of the region to motor vehicles and the clearance of air strips on the south bank of the Sabaki and at Dakadima, were two white hunters: Baron Bror von Blixen and J.A. Hunter, who had a hunting concession for the area.

In the early fifties, the Shell Exploration Company cut a series of east-west seismic traces through dense vegetation to the north-east. Although many of these early tracks were rapidly overgrown and became impassable, some have been re-established and now form part of a network of motorable tracks and landing strips cleared initially by the Galana Game Management Scheme (1960-67) and subsequently extended by the Galana Game and Ranching Limited (1967-89).

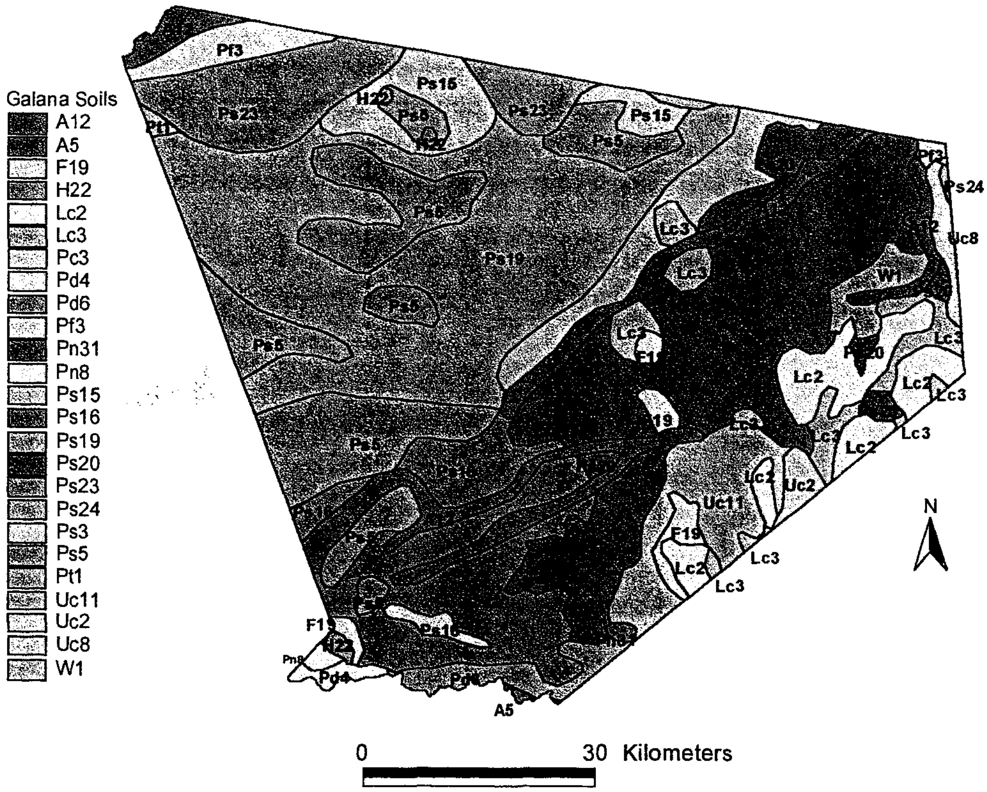
3.1.1 Geographical Setting

Galana Ranch covers an area of approximately 6,000 square kilometres in southern-eastern Kenya between 2^{0}15'S and 3^{0}06'S and 39^{0}00'E and 40^{0}10'E. (See Map 1 and Map 2.) For the most part the terrain is very flat, rising gradually from 130m above sea level in the east, to some 300m above sea level in the west, where it adjoins Tsavo East National Park. To the south-west the ranch is bounded by the Galana, or Sabaki river, an exceedingly important perennial water course emanating from the Athi and Tsavo rivers.

3.1.2 Geology and Soils

In geological terms, a few rocky outcrops of up-faulted Tertiary-Triassic Duruma sandstone, principally the Lali hills in the south-west, Dakadima in the north-west, Dakawachu in the north-east and Dakabuku in the east, rise above the surrounding flat lands of the Tertiary East African peneplain. Two types of soil predominate on Galana: grumsol and latisol. Grumsol is a grey margalitic soil. Latisol is a ferrugenous soil with a lower pH, cation capacity and saturation percentage than grumsol, but has a better soil structure and infiltration capacity and is thus capable of supporting greater botanical diversity and higher levels of a productivity.

Map 2: Galana Ranch Soils

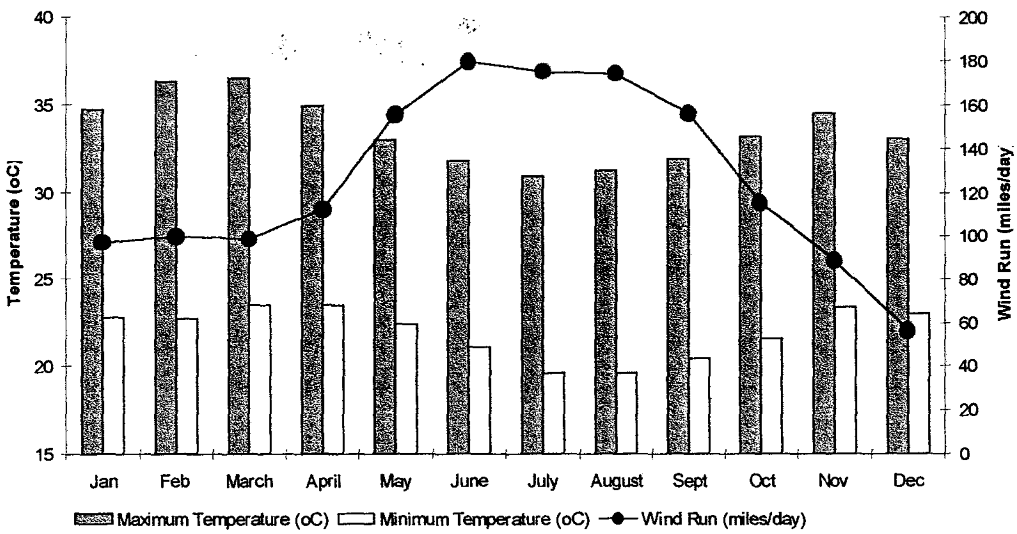


Symbol	Soil Name
A12	Chromic **Vertisols**,saline-sodic phase
A5	Eutric **Fluvisols**
F19	Luvic **Arenosols**; with ferralic and albic **Arenosols**
H22	Eutric **Regosols**, lithic phase
Lc2	Acric to rhodic **Ferralsols**
Lc3	Ferralic **Arenosols**; with albic **Arenosols**
Pc3	Lutho-orthic **Solonetz**, saline phase and vertic **Luvisols**, saline- sodic phase
Pd4	Calcic **Cambisols**, lithic or petrocalcic phase; with chromic **Luvisols**
Pd6	Chromic **Cambisols**, lithic or petrocalcic phase; with chromic **Luvisols**
Pf3	Luvo-orthic **Solonetz**, saline phase; with solodic **Planosols**, saline phase, chromic **Vertisols**, saline-sodic phase and cambic **Arenosols**
Pn31	Orthic **Luvisols**, sodic phase
Pn8	Rhodic **Ferralsols**
Ps15	Luvo-orthic **Solonetz**
Ps16	Gleyic **Solonetz**, saline phase
Ps19	Gleyic **Solonetz**, saline phase
Ps20	Solodic **Planosols**
Ps23	Luvo-orthic **Solonetz**, saline phase
Ps24	Orthic **Solonetz**, saline phase
Ps3	Ferralo-chromic **Acrisols**; with ferralic **Arenolsols** and ferric **Luvisols**
Ps5	Solodic **Planosols** and luvo-orthic **Solonetz,** saline phase
Pt1	Calcic **Luvisols**, pisocalcic phase; with chromic **Luvisols**, and pellic to chromic **Vertisols**, saline-sodic phase
Uc11	Undifferentiated **Luvisols**; with verto-luvic **Phaeozems**
Uc2	Eutric **Cambisols**, partly lithic phase associated with verto-luvic **Phaeozems**, sodic phase; with vertic **Cambisols**, sodic phase
Uc8	Rhodic and orthic **Ferralsols**
W1	Undifferentiated **Solonetz**

3.1.3 Climate and Rainfall

Seasonal variation in temperature, wind run and rainfall are shown in Figure 1 and Figure 2. February and March are the hottest months of the year, with mean maximum temperatures reaching 36.5^{0}C. July and August are the coolest, with mean maximum temperatures of around 30.9^{0}C. Mean monthly minima are 19.6^{0}C in July and 23.5^{0}C in March, April and November. Daily wind runs range from 90 kilometres per day in December to 280 kilometres per day in June, July and August.

Figure 1: Maximum and Minimum Temperatures and Wind Run at Oryx Paddocks



Rainfall is highly variable from year to year and from locality to locality, but usually has a bimodal pattern of distribution, with two wet seasons from March to May and October to December, as shown in Figure 2. For three years, between 1974 and 1976, monthly rainfall records were collected from six different points across the Ranch. Rainfall was highest in the east, with Dakabuko averaging over 510mm and Lali hills averaging 235mm. Figure 3 shows annual rainfall at the KETRI field station at Tank E for the period 1989-97.

Figure 2: Mean Monthly Rainfall at Ranch Headquarters

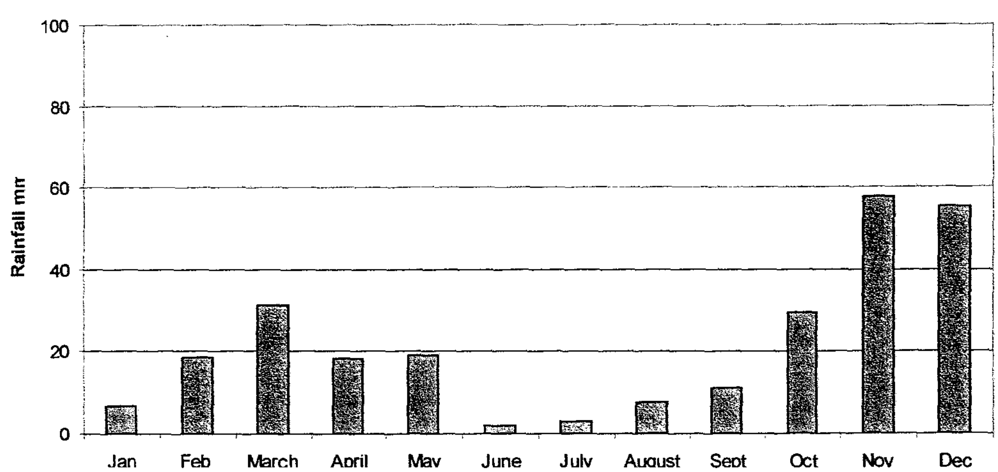
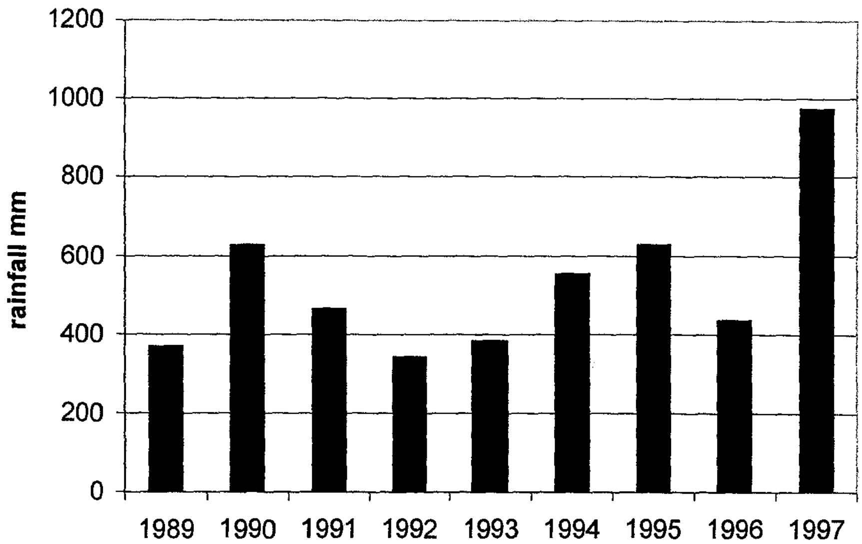


Figure 3: Rainfall at Tank E 1989-97



The mean annual rainfall at Tank E for the 8 years from 1989 to 1996 was 475.4mm. The rainfall total for the 10 months from January to October 1997 was 973mm. October was an exceptionally wet month with 455 mm of rain being recorded. The total rainfall for this *El Niño* year will be substantially higher than shown Figure 3, as heavy rains fell through November and December and continued on until May 1998.

3.1.4 Agro-climatic Zone and Vegetation

Galana Ranch spans three ecological zones (Pratt and Gwynne, 1977), from sub-humid and semi-arid in the east to arid in the west, which coincide very approximately with three broad categories of vegetation. The eastern third of the ranch is covered with **Thick Coastal Bush,** comprised mainly of *Combretum, Euclea, Grewia and Strychnos* species. The dominant grasses in this area are *Panicum sp., Setaria sp.* and *Schoenfeldia transiens.*

Further to the west the coastal vegetation gives way to more open ***Combretum*** **Wooded Grassland.** *Combretum aculatum* is the most common woody shrub. *Schoenfeldia transiens* and *Bracheria sp.* are the most common grasses. Common trees include *Dobera glabra* and *Terminalia parvula.*

The western third of the ranch is predominantly ***Acacia/Commiphera*** **Woodland.** Other common trees include *Euphorbia robechii* and *Delonyx elata.* Dominant grasses are *Aristida sp.* and *Erogrostis sp.*. Much of the eastern portion of these woodlands was destroyed by a major fire in 1962, covering an area of some 2,500 square kilometres and led to the formation extensive tracts of lightly wooded grassland in which *Chloris roxburgiana* became the dominant grass. Shrubs in this are include *Cordia gharaf* and various *Grewia spp.*. Large concentrations of elephants maintained this open grassland until poaching during the late seventies and early eighties eliminated the herds. Considerable regeneration of *Acacia senegal* and *Commiphora sp.* was apparent in this region by 1989.

The devastating floods of 1961, which widened the river by up to 100 meters, destroyed much of the

3.2 Historical Perspective

For a time line of events and activities in the Galana region over the past century, see Table 1.

3.2.1 Administrative Jurisdiction

Galana Ranch straddles the boundary between Tana River and Kilifi Districts of Coastal Province. The boundary, which runs diagonally through the ranch north-eastwards from the Lali hills, was established in around 1912 to demarcate the territorial interests of the Orma to the north-west, and the Giriama to the south-east.

3.2.2 Tsavo National Park

Tsavo National Park was established in 1948 and is the largest national park in Kenya, covering a total area of just over 20,000 square kilometres. For administrative and logistical reason, the park is divided in two: the area to the north and east of the Mombasa-Nairobi road and railway is known as Tsavo Park East, and that to the south and west as Tsavo Park West.

For a personal account of how the park was established and developed, see Sheldrake (1973); and for a detailed review of the historical record and annotated bibliography of the Tsavo region, see Corfield (1974). For assessments of wildlife ecology and conservation issues, including accounts of "the elephant problem" and the role of fire in vegetation dynamics, see Delany and Happold (1979); Eltringham (1979); and van Wijngaarden (1985).

3.2.3 Galana Game Management Scheme

In the late fifties concern was expressed over the loss of livelihood suffered by the Wata, a traditional elephant hunting community, who had been driven out of the Tsavo National Park. Most of the Wata men had been jailed for "poaching", and they had no other skills except hunting. In February 1960 the British Nuffield Foundation provided a grant of £10,000 to the Kenya Government to establish the Galana Game Management Scheme on land adjoining Tsavo East National Park and utilise the hunting skills of the Wata. The area covered by the scheme was 7,680 km^2, of which 960 km^2 was south of the Galana river.

Ian Parker was the first Warden of the Galana Game Management Scheme from 1960 to 1963. Background details to the establishment of the Scheme and the problems of keeping it running are contained in volumes 1 and 3 of the Galana Archive (Parker, 1996 a&b). Ian Parker was subsequently replaced by Gilfrid Powys, who went on to became a shareholder in Galana Game and Ranching Limited, which eventually took over from the Scheme on 1 July 1967.

Table 1: Time Line

	1912	/>>/	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	6
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	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
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of cattle on Galana Ranch						2755	4048	6028	6694	8621	11112	13200	14226	16800	16522	17497	18998	18931	20603	20685	21014	20931	21674	21845	22470			22732	22221	17464	13032	12432	11182	9523
%)						6	4.8	5.1	4.7	3.6	2.6	3.2	2.8	4.2	5.8	4.1	3.2	4.4	3.2	2.5	2	3.4	4.1	3.5	3.9									
(lions and hyena) (%)						1	0.3	0.5	0.5	0.2	0.4	0.9	0.5	0.8	1.1	1.1	1.1	1.4	1.5	1.1	1	1.4	1.4	1.3	1.2									

3.2.4 Galana Game and Ranching Limited

The following highlights, summarising the development of Galana Ranch from 1967 to 1989, have been extracted from Heath (1996) and the annual reports of Galana Game and Ranching Limited (GGRL, 1996).

July 1967 - June 1971

Galana Game and Ranching Limited formally took over from the Galana Game Management Scheme on 1 July 1967. The company started with a paid-up capital of KSh2 million, and was jointly owned by: Messrs Martin Anderson (38%), Gilfrid Powys (10%), and Alexander Atherton (2%); Sangare Ranch (26%); and the Kenya Government (24%).

During the early years, attention focused on infrastructural development and the establishment of water supply and road networks. Dams, storage tanks, roads, bridge, airstrips, offices and accommodation were constructed and bore holes were sunk. Construction of a causeway across the Galana river was started in 1967, but initial attempts were washed away, and a permanent crossing was not completed until 1972.

The first 321 cattle arrived on Galana on 5 November 1967 from Luoniek Ranch in Laikipia District, and a further 641 arriving by the end of the year. First spray race completed in 1968. Cattle yards constructed at Mile 10 and at Dakabuku in 1969. Research into the domestication of eland, oryx and buffallo began in 1970.

July 1971 - June 1972

232 men employed. Orma settled within northern ranch boundary. Evicted by Police from Hola. Lali pipeline completed. Three boreholes sunk to the west of Dakabuko hill. Water saline. 8,000 head of cattle on ranch. Planning to stock up to 18,000 within next five years. Noticeable difference in numbers and distribution, compared with open areas across boundaries.

Cattle diseases mentioned: bovine pleuro-pneumonia. Trypanosomosis incidence exaggerated because only very small number tested. Another dry year has proved that trypanosomosis is not a problem. Mild case of foot and mouth recorded, but with apparently no ill effects. Considerable losses through haemorrhagic septicaemia. Mysterious paralysis of hindquarters in steers.

Game utilisation has played an important part in building up the ranch. Species present include: cheetah, buffalo, bushbuck, caracal, civet, Coke's hartebeeste, crocodile, dikdik, eland, elephant, genet, gerenuk, hippopotamus, hyena, impala, leopard, lesser kudu, lion, oribi, oryx, Peter's gazelle, rhino, serval, topi, warthog, waterbuck, wild dog and zebra.

Elephant down in numbers, but all other species well on the increase. Elephants affected more than any other species by the drought, and many small ones were found dead, or abandoned. 16 "visiting sportsmen". Total game taken: 28 elephant; 6 rhino; 5 lion; 5 leopard; 11 buffalo; 6 crocodile; 11 lesser kudu; 6 impala; 14 gerenuk; 5 dikdik; 25 Grant's gazelle; 8 eland 3 ostrich; 19 oryx; 26 zebra; 6 waterbuck; 8 warthog. Gross return on game enterprise: Ksh588,598. Game domestication project continued.

July 1972 - June 1973

Over 300 men employed. Cattle diseases mentioned: two outbreaks of foot and mouth; incidence of

July 1973 - June 1974
Trypanosomosis has not caused any problems - able to maintain adequate protection from biannual Samorin. One major concern has been calf scours. 116 lion kills compared with 47 in 1972/73. Water development continues.

July 1974 - June 1975
Cattle diseases mentioned; trypanosomosis no longer a problem - excellent cover from biannual Samorin; salmonella infections in calves diagnosed and successfully treated; heavy loss of weaners due to haemorrhagic septicaemia; minor outbreak of rinderpest; heavy losses due to 3-day sickness in combination with plant poisoning; undiagnosed calf mortality after becoming wild and having uncontrolled fit. Water development continues.

Most spectacular and singularly significant observation is the occurrence of unusually large concentrations of elephant These elephant have been resident on property during the past two years and continue to increase alarmingly. Bulk thought to come from Tsavo East because of drought and destruction of vegetation. Other contributory factors: poaching and human population expansion in neighbouring areas.

Recent aerial counts made by National Park authorities indicate that resident elephant populations on Galana average between four and five thousand animals. As a result of this build up in elephant numbers, irreparable damage is being caused to Galana environment, particularly to trees and shrubs.

Wildlife observations: Oribi being sighted more regularly; bushbuck more numerous; topi population continues to swell; Coke's hartebeest also increasingly slowly; lesser kudu suffered severe reduction in numbers resulting from suspected rinderpest.

July 1975 - June 1976
Cattle mortality increased. Largely due to haemorrhagic septicaemia. Trypanosomosis also caused heavy losses due to Samorin cover tailing off. Undiagnosed calf mortality, after wild behaviour and uncontrolled fits persists. Water development continues, but elephant causing considerable damage to plumbing on tanks and troughs.

With continued decline in rainfall, management having doubts about carry capacity of ranch. Currently running 16,800 on 640,00 acres. This considered to be maximum for prevailing conditions.

Very severe habitat damage continues, caused almost entirely by a surfeit of vast concentrations of elephants. In the past, these elephant herds were continually on the move, covering much larger land area, thus allowing recovery periods for habitat renewal. From local observations, it would appear that the bulk of the elephants found on Galana are resident, moving off for very short periods only. Whole situation aggravated by below average rainfall over past four years. Nevertheless, it is apparent that the overall game population on Galana is increasing most satisfactorily.

During the year catered for 40 overseas visitors, including 22 hunting clients: 605 safari days, of which 316 were full hunting days. Safari days have doubled over the past four years, compared with previous four year average. Bag for the year: 8 rhino; 14 elephants; 4 lions; 15 buffalo; 9 gerenuk; 20 lesser kudu; 20 oryx; 7 eland; 36 zebra; 6 waterbuck; I impala; 23 Peters gazelle 16 warthog; 7 dikdik; 8 ostrich; 17 crocodile and 1 giraffe. NB elephant hunting banned during the year.

July 1976 - June 1977

Severe outbreak of foot and mouth, accounting for many deaths in calves and weaners. Purchase of a Boran herd from Kisima Farm Malindi proved a great mistake. Critical fact that the herd had been dipped every three days at Malindi was overlooked. The 7-14 day regime on Galana resulted in these cattle succumbing to heartwater, anaplasmosis, redwater and in many cases ECF. Previously undiagnosed high calf mortality now considered to be acute heartwater.

Once again trypanosomosis is a problem. Samorin withdrawn by Veterinary Department. Anthrocide Prosalt only available prophylactic. But subsequently discovered that ICI had discontinued its manufacture (!) and had to revert to Samorin. Microscope purchased and staff member trained in its use. Many cattle now saved by prompt diagnosis. Water development continues. Ox carting introduced.

July 1977 - June 1978

Colossal increase in three-day sickness and heavy losses due to haemorrhagic septicaemia. In spite of wet year trypanosomosis was not a problem. Embarked on sheep and goat production on pilot basis. Camels, now under prophylactic regime, have improved dramatically. Introduced as milk supply for herders. Major expenditure on fire control. Many fires started deliberately. Ranch General Manager, Mr. Paterson, leaves to take on the development of the new ADC ranch of the south bank. Galana owes a great deal to Mr Paterson for his competent management over the past six years. Mr. Howard takes over as general Manager.

July 1978 - June 1979

Only financial accounts available.

July 1979 - June 1980

In spite of being generally dry, proved to be one the most difficult years in combating various disease outbreaks. Mild outbreak of foot and mouth. Severe losses due to three-day-sickness. Major losses from *Trypanosoma vivax* causing a severe haemorrhagic syndrome. KETRI commenced work monitoring incidence of trypanosomosis in a herd of steers, initially at Tank E. Later moved to Kapengani to ensure higher trypanosomosis challenge. In spite of delayed start KETRI has in a short space of time come up with some valuable results with obvious benefit to the Ranch, primarily in reducing the cost of prophylactic treatment of the herd.

Camels completely settled down and breeding well. KETRI's regular monitoring has helped to improve health of the herd. A few milk camels attached to sheep and goat herds to provide milk to herders.

High cattle mortality due to predation by lions.

Government policy concerning game utilisation remains unclear.

July 1980 - June 1981

Foot and mouth affected young stock badly. Haemorrhagic septicaemia outbreak controlled by prompt inoculation. Trypanosomosis seems to be well under control. Trypanosome resistance to Samorin and Berenil demonstrated. Cause for concern. Recommended that use of Berenil be discontinued for three years and large doses of Samorin used as curative. Sheep, goats and camels doing well. Further development of water resources.

Continuing uncertainty about Government game utilisation policy. At end of June 1981 informed by Department of Wildlife Conservation and Management that game "utilisation scheme has been stood-over indefinitely until such time as the present policy on utilisation gets reviewed nationally."

July 1981 - June 1982

Haemorrhagic septicaemia, heartwater and trypanosomosis are the chief problems. Bovine contagious abortion has been confirmed. Sheep doing OK, but goats presenting a challenge to management. Further development of water resources, opening up ranch to more extensive grazing by cattle.

July 1982 - June 1983

Anaplasmosis and heartwater still account for the majority of cattle deaths. High incidence of trypanosomosis towards end of year. *T. vivax* occurring in areas not normally associated with high challenge. Nematode ear infection caused concern, but now under control. Rinderpest suspected but not diagnosed. Sheep still doing OK, but high mortality amongst goats. Cause unknown. Continued development of water resources

Government policy on game utilisation and multiple land use still uncertain.

July 1983 - June 1984

Rinderpest "type" disease lingered on and eventually brought under control when all cattle were vaccinated. Lumpy skin disease positively identified in trading stock. Three day sickness again. Trypanosomosis an ever present problem. All goats to be sold. If heartwater problem in sheep is not solved, sheep production will also be closed down. Kenya suffering one of worst droughts in history. Encroachment of northern areas of Tsavo National Park and Galana Ranch by Orma pastoralists.

July 1984 - June 1985

Trypanosomosis still a major problem. Foot and mouth introduced, but severe. All trading steers vaccinated against CBPP. Attempt to breed a half-bred Friesland/Boran for extra milk yields was disastrous: all 4 Friesland bulls purchased died within four months, in spit of every precaution. Trypanosomosis challenge at Tank E was particularly high at the time.

KETRI continue to be of great assistance, exploring new methods of tsetse control and general monitoring throughout the year. Considerable work has been done on fly repellents, and currently work on reducing fly populations is to be carried out using a screen covered with both an attractant and an insecticide. Ranch management feels that the real answer to trypanosomosis control is not to deal with the parasites within cattle but rather to reduce the tsetse fly populations, a goal that KETRI is vigorously pursuing.

Consideration and research into control of *Combretum* bush is becoming a high priority. This shrub is gradually taking over large areas of grazing in the centre of the ranch around Tank E.

July 1985 - June 1986

A mysterious disease causing massive liver damage in trading steers watering off the Korobo water hole is strongly suspected to have been plant poisoning. Trypanosomosis is again a major problem. Anaplasmosis and heartwater also took an unusually high toll. Heavy internal parasite burdens also present.

A possible major breakthrough in tsetse control, mention in last years report, has proved most encouraging. Emphasis is now on tsetse control, rather than the use or development of trypanocidal drugs.

Future of sheep operation in doubt. Further water resource development.

Poaching and armed Somalis becoming a major problem. Forces of law and order have completely broken down.

July 1986 - June 1987

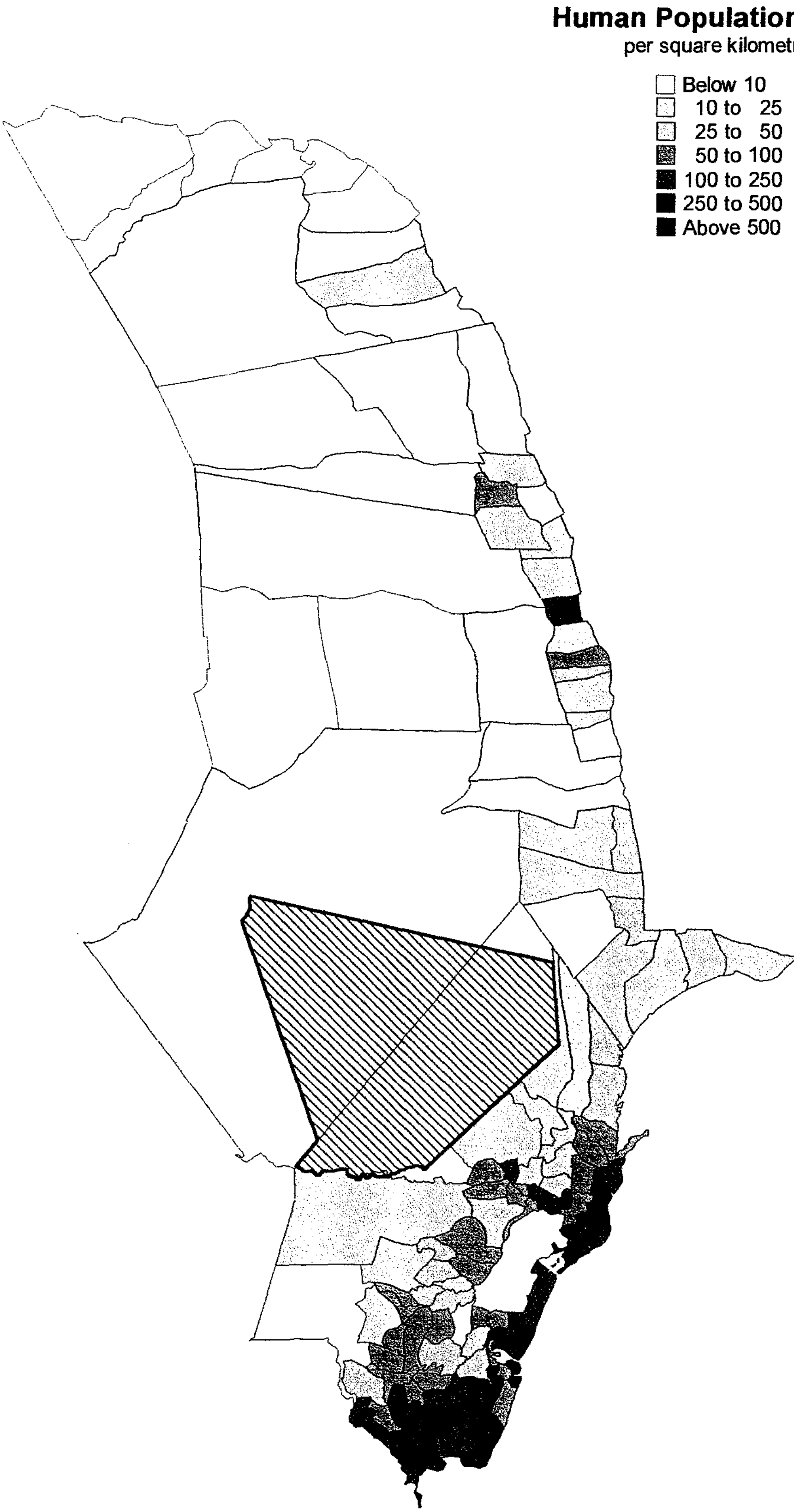
Anaplasmosis and heartwater are the main cause of death in young stock. All breeding cows contacted foot and mouth. The first time in many years. Acute infection of bovine farcy. Veterinary opinion is that all infected animals should be sold. CBPP broke out in all animals purchased in March. All had to be disposed of at a loss. Korobo disease broke out again in trading steers. No reason yet established for the condition, but suspect that it might be trypanosomosis related. Goats yet again proved a disaster and have been discontinued. Sheep have made a trading loss. Camels are OK.

Ranch radio licences withdrawn. Poaching and armed Somalis a continuing problem.

October 1989

Management of Galana Ranch taken over by the Agricultural Development Corporation (ADC), a Government parastatal. At handover, there were some 22,000 head of cattle; 200 kilometres of water pipeline; and 2,000 kilometres of roads and tracks.

Map 3: Human Population Density - Tana River and Kilifi Districts



3.3 Human Population

Settlement and grazing within Galana Ranch by Orma pastoralists is legally prohibited, but has been difficult to prevent and has been on the increase in recent years. Nevertheless, the ranch and its environs to the north and west remain sparsely populated, with a mean density of less than 10 people per square kilometre, as shown in Map 3. Population density increases to the east and south.

All major ethnic groups of Coastal Province south of the Tana River (Orma, Mijikenda, Swahili, Taita and Taveta) acknowledge in their folklore that when their forebears first settled in the region it was peopled by hunters (Parker,1996 a&b). One such group of hunters still occupying the region in the twentieth century are the elephant-hunting specialists, known to themselves and the Orma Galla as Wata (Watta or Waata), but to others, variously as Arianulo, Waliangulo, Wasania, or Sanye. Questioned as to their origins some Wata say that they came with the Orma; others that they have always been in the region, and came from nowhere else. Today, however, both Wata and Orma speak Oromo, and share so many cultural affinities with the Galla generally that, whatever their disparate origins, they must have been closely associated for a very long time.

It would appear that the Orma arrived in the coastal hinterlands south of the Tana from the north about the same time as the Mijikenda Bantu, four or five centuries ago. During the nineteenth century Orma power waned, and their own folklore tells of reverses in the south and west of their range at the hands of the Maasai. Simultaneously, they also suffered defeat by the Somalis to the north and east, being confined to south of the Juba river by 1800 and then driven back to the Tana river by 1865. By the time of colonial occupation of what is now Kenya in 1888, the southern boundary of Orma distribution was the Sabaki river.

North of the Sabaki, the Orma had used most, if not all, of what is today the Galana Ranch west of Dakabuko Hill, and from Dakabuko north-east to the Tana river. In the vicinity of the Dakabuko and south of the Sabaki, the country was largely open grassland and, *inter alia* supported a substantial population of topi, typical residents of grasslands and open woodlands. There was considerable intercourse between the Orma on the Sabaki and Malindi on the coast, and there was continuous internecine friction between the Orma and the Giriama, who were moving across the Sabaki towards Marafa and Baricho.

Eventually in around 1912, in an attempt to resolve these frequent disputes, the British Administration drew a line on a map running north-east from Lali hills to a point north of Jara water hole to demarcate Orma and Giriama spheres of interest. This line was later incorporated as part of the boundary between Tana River and Malindi (Kilifi) Districts. From then onwards the Orma were to stay to the west of the line and the Giriama to the east. This had a significant ecological consequence, in that as soon as the Orma ceased using the land to the east of the line, woody vegetation rapidly began to encroach on the former grasslands, topi habitat began to decline and tsetse habitat expanded.

Hobley (1929) has offered an alternative explanation for the decline of the Orma Galla in the coastal region of Kenya. He has suggested that as pastoral people, originating from the healthy Boran highlands in Ethiopia, they and their cattle were ill-adapted to the diseases encountered as they moved southward down the Tana river valley. Whilst there might be some truth in this, it hardly explains the much more extensive former distribution of the Orma people in the 15-17th centuries. The outbreak of a smallpox epidemic in the latter part of the 19th century is thought to have been a

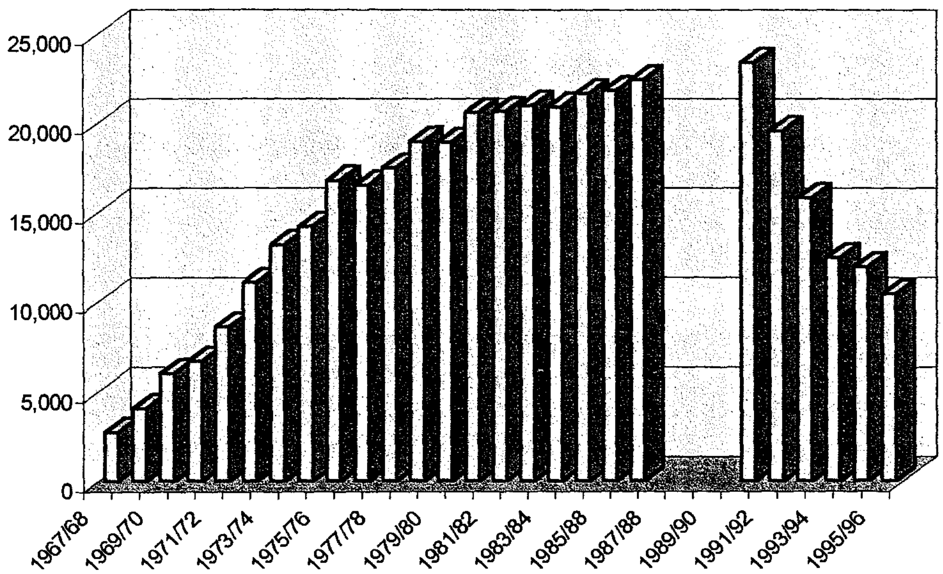
3.4 Livestock

Over the years Galana Ranch has maintained a variety of livestock, including camels, cattle, goats and sheep, and experimented with the domestication of buffalo, eland and oryx. Except in the early years, when licensed hunting of wildlife was permitted and generated substantial returns, the primary activity and source of ranch income has been the rearing of cattle for beef production.

3.4.1 Cattle Holdings

The first 321 cattle brought to Galana Ranch arrived on 5 November 1967 from Luoniek Ranch in Laikipia District, with a further 641 arriving by the end of the year. Numbers increased progressively over the next 20 years to exceed 22,000 head in1986/87. See Figure 4.

Figure 4: Mean Cattle Holdings on Galana Ranch: 1967/68 - 1995/96



Unfortunately there are no records available for the troubled period 1988-1990. For most of 1988 cattle numbers hovered around 27,000 and for a short period in early 1989 the herd exceeded 28,000 head, but by the time the ranch was taken over by the Agricultural Development Corporation the herd numbered around 22,000 animals. This figure was maintained for the next two years, until a progressive destocking commenced in 1991/92, and by early October 1996 there were only 8,832 cattle left on the ranch. During that month 1,760 trading steers were purchased to give a closing balance of 10,060 head.

3.4.2 Cattle Management

Cattle on Galana Ranch were maintained under one of two management regimes:

- As balanced herds, of breeding animals and their offspring; or as
- Trading herds, made up of cattle purchased from elsewhere, normally Tana River and Garissa Districts to the north, and brought onto the ranch for fattening.

The balanced herds of breeding animals were made up of "improved" Boran cows that came from ranches in Laikipia, and bulls purchased from top Boran breeders in Laikipia. In 1977 the ranch to increase meat and milk yields using exotic (*Bos taurus*), including Charolais and Friesan stock, but these all failed. Some success, however, was achieved with Sahiwal, and bulls were used on one herd in order to improve milk yields.

Breeding herds were divided into five camps, or "bomas", with four herds in each boma. Animals were taken out by 7 am each morning, and returned to their respective bomas at dusk. Two herders were allocated to each herd, with one person herding for four days, whilst the other "rested", and then changing over.

Initially, strong thorn enclosures were constructed to hold cattle at night, until Orma herdsmen persuaded ranch management that losses from predation would be lower if the cattle were not restricted at night. The traditional Orma system of allowing cattle to sleep around fires, with no restraining fence became standard practice. Lion predation continued, but losses from stampeding were greatly reduced.

Breeding herds were allocated to their respective bomas according to coat colour, and the ranch practised year round breeding. One bull ran with a herd at a time, and bulls were changed over every two months. Calves were counted and ear notched, to denote their age, at the end of every month. All calves were vaccinated against calf scour and the males were castrated at one month of age. They were weaned at eight months, and kept in small weaner groups for several months before they were separated into male and female herds.

At weaning, calves were vaccinated with *Brucella abortus* vaccine for the heifers and haemorrhagic septicaemia with blackquarter and anthrax for all. They were also branded with the registered ranch brand (K4R). Males were also branded with a lot number indicating their herd of origin. Heifers would only received a ranch brand at weaning, and then wait until they were selected for breeding at 27 months of age. Selection was originally done by "eye", but later all heifers were weighed, and only those above average weight were considered eligible for selection.

Once steers left the weaner boma, they remained in their allotted herd of approximately 250 animals until they were ready for sale at approximately three years of age. They were then transferred into the 'KMC' boma, where they were selected and weighed for sale.

Management of the trading steers was essentially the same as for Galana steers. Most animals were purchased on the Tana River, and then walked down to the ranch quarantine area. Immediately on arrival the animals were dipped and then branded with a number indicating the lot number. Large groups of cattle were then graded according to size, with the larger animals placed into the number one herd and the remainder into the other herds. The ranch preferred buying in lots of between 1,000 and 1,500 animals, and these would then be separated into herds of approximately 250. After branding all animals were inoculated against trypanosomosis, and in later years they were also de-wormed before all entire males were castrated. The average size of trading steers was 200 kg and these remained on the ranch for up to two years before they were large enough to sell.

3.4.3 Predation

With approximately 1% of the cattle herd being taken each year by lion, predation was a major economic loss and cause of concern to ranch management. Confirmed cattle killing lions were shot, and over the years approximately one lion was shot for every 10 to 15 cattle killed (Table 2). The ranch was not allowed to shoot predators from mid 1987 until July 1988, which led to a dramatic

Table 2: Lion Predation and Control

	Cattle > 1 month	Calves < 1 month	Lions Shot
1983	178	57	24
1984	193	58	23
1986	300	95	27
1987	226	104	21
1988	400	255	9
Total	**1298**	**570**	**104**

3.4.4 Diseases Other than Trypanosomosis

Contagious Bovine Pleuro-Pneumonia (CBPP) was first introduced onto the ranch by trading cattle in the late 1960s and caused heavy losses. In July 1972 a number of positive reactors were identified during routine screening. Thereafter, Galana opted to be in a CBPP quarantine area and part of the ranch (Kapengani) was set aside as a quarantine area. Animals were not released into the rest of the ranch without first undergoing three clear tests for CBPP and all other cattle were vaccinated annually. However, by 1982 testing had become very irregular and in September 1982 there were 5,000 cattle in the quarantine area, awaiting testing. By 1984 it was agreed that cattle would be vaccinated against CBPP as soon as they arrived on the ranch and that all cattle on the ranch would be vaccinated twice yearly.

By 1986, it was felt that the Kapengani quarantine area was not sufficiently isolated, and plans were made to create another quarantine area at Alango Shira. The infrastructure for this new area was completed in early 1987 and the first cattle were quarantined there in April of the same year. In June 1987 there was a severe outbreak of CBPP in cattle that had recently arrived from Tana River, 43 animals died as a result of the outbreak and a further 25 had to be slaughtered on the ranch. The whole herd, comprising over 400 cattle, was trucked to the Kenya Meat Commission in order to control the disease. The Veterinary Department CBPP testing team tested all quarantine cattle and it was found that the outbreak had been contained to one herd, and all other quarantine cattle were vaccinated. Further outbreaks of CBPP occurred in late 1991 and 1997, with many animals dying, including many of the Orma Boran breeding stock in the most recent outbreak.

Tick borne diseases, included heartwater (*Crowdria ruminatum*), anaplasmosis (*Anaplasma marginale* and *centrale*) and redwater (*Babesia),* were particularly prevalent to the east and south east of the ranch, where rainfall was greater. They became less of a problem in the drier western and northern parts of the ranch. Dipping was strategic and used more to control ticks than tick borne disease, this was done in the hope that calves would gain an immunity to the diseases at an early age. The ranch constantly suffered from anaplasmosis and heartwater, but it was felt that losses were acceptable and that a natural immunity was preferable to constant dipping. In wet years, such as 1985 and 1986, anaplasmosis was the main disease problem in calves and often accounted for the majority of deaths recorded in the cattle. The severity of tick borne diseases was highlighted whenever cattle were introduced from areas without prior exposure. Animals from Laikipia or Taita were very susceptible, and unless carefully monitored would all succumb to either anaplasmosis, or redwater, within a matter of weeks. In February 1986 the ranch recorded resistance to the organophosphorous accaricides, and changed to a new generation accaricide, Amitraz (Triatix, Helminths were not considered a significant problem in the early years of Galana, but by 1979 the importance of helminths in young stock had been appreciated, and all weaners were de-wormed as a matter of routine. Calves were sampled every month and treated once the worm burden was seen to increase; 500 eggs/gram was considered to be a high infestation. One lot of Orma cattle purchased in mid-1984 was very heavily infested with worms and after that all trading animals were treated as soon as they arrived on the ranch.

Foot and mouth disease (FMD) was frequently recorded on the ranch, with outbreaks in 1972, 73, 76, 78, 79, 80, 81, 82, 84, 85, 86, 87 and 88. The disease is endemic in Tana River District, and was never considered to be a serious veterinary health problem on the ranch. The policy was to expose as many cattle to the disease as possible once it was identified so that it would clear quickly. The greatest problem with foot and mouth was the imposition of a quarantine on the ranch, which affected livestock sales.

Rinderpest was recorded in trading steers from Tana River District in December 1974. This outbreak not only affected some cattle, but devastated the lesser kudu population on the ranch. There was a suspected outbreak in trading cattle in 1983, but this was never confirmed by the Veterinary Department.

Two wet years in 1977 and 1978 introduced a number of diseases that had not previously been recorded on the ranch. The first was ephemeral fever (three day sickness), which was first recorded in 1977. After that there were frequent outbreaks, and in many cases up to five percent of the affected cattle died. The worst outbreak occurred in November/December 1979 and resulted in many deaths.

At about this time it was realised that the breeding cattle were infected with *Brucella abortus,* a bacterial organism causing the disease commonly known as contagious abortion. It was uneconomical to clear this low level infection, as it meant culling all possible carriers, and the matter was complicated by the fact that most breeding cattle had been vaccinated with Strain 19 vaccine at weaning. It was decided that very low dosages of the vaccine on breeding cows would provide adequate protection, and after that cows were vaccinated approximately every two years with one twentieth of the normal dose. This proved to be very effective.

In 1978 a new acute disease affected the cattle. This was originally thought to be bovine petechial fever (onderiatis), but was later found to be haemorrhagic septicaemia (*Pasturella multocida*). After this outbreak the ranch vaccinated all weaners against the disease and managed to control it at low levels, with a few cases being brought on by dramatic changes in the weather, especially at the end of the dry season. At the same time as introducing vaccination against haemorrhagic septicaemia, the ranch started vaccinating (Bovivac, Hoechst) all young calves against calf scours (*Escheria coli*). This greatly reduced the incidence of white scour in small calves and led to decreased mortality.

By November 1978 another 'new' disease was seen for the first time on the ranch. This was a parasite called *Rhabditis bovis* and caused a purulent ear infection that was treatable with Negesunt (Bayer), mixed with water and injected into the infected ear, untreated animals occasionally died. This disease was never cleared from the ranch, although it was controlled at low levels.

Small biting flies (*Lispocephala mikii*) were a problem during the rains, in that they caused intense irritation, to the extent that cattle would stop feeding. In 1985 the ranch sprayed on a synthetic

The first cases of bovine farcy (*Bovine nocardiosis*) were brought onto the ranch in April 1980 from Wenje in Tana River. This disease gradually spread throughout the ranch and became a major problem in the breeding cattle. The disease appeared to be incurable and the only method of dealing with it was to isolate and slaughter infected animals. By 1986, breeding cattle were being isolated into farcy herds to the detriment of the ranch breeding policy. By mid-1987, there were 900 cows isolated into farcy herds and, by the end of the year, an estimated one third of the breeding herd was infected with the disease.

3.4.5 Costs of Veterinary Supplies

The costs of veterinary inputs on Galana Ranch in the early nineties are summarised in Table 3. Over a two year period from April 1992 to March 1994, a total of KSh7.8 million was spent on veterinary drugs and vaccines, equivalent to KSh277 (=US$5.5) per animal per annum The largest single item of expenditure was on Acaricides, accounting for almost a third of the total, closely followed by trypanocides at 29%., with vaccines 18%, and antibiotics 16%.

Table 3: Cost of Veterinary Inputs: April 1992 to March 1994

	Acaricides	Trypanocides	Vaccines	Antibiotics	Drenches	Total
Total Cost (KSh)	2,533,613	2,310,205	1,438,274	1,253,393	327,457	7,862,942
Percentage	32.2	29.4	18.3	15.9	4.2	100.0
Cost/head/year	89.2	81.3	50.6	44.1	11.5	276.8

Source: ADC Galana Ranch records; base on a mean holding of 14,204 cattle during that period.

3.5 Wildlife

When Galana Game and Ranching Limited was first established in 1967, the letter of allotment specifically stated that the grantee "shall be permitted to carry out professional hunting in accordance with the provisions of the Wild Animals Protection Act (Cap 376)". The letter also allowed for trapping and export of wild animals, game cropping and the undertaking of wildlife and range research projects, including those that necessitated the killing of game. The ranch employed its own hunter, and for 10 years professional hunting safaris were a very lucrative sideline to the ranch's activities. Indeed, hunting supported the cattle operation for the first few years.

The main attraction to hunting clients was elephants, and up to 25 animals a year were taken in the early seventies. The trophies were exceptional and Galana offered some of the best elephant hunting in the world. Other animals hunted for their trophies included rhino, lion, leopard, buffalo, crocodile, lesser kudu, impala, gerenuk, dikdik, Peter's gazelle, eland, ostrich, fringe eared oryx, Burchell's zebra, common waterbuck and warthog. Hunting quotas and actual off-takes are shown in Table 4.

In 1970 the ranch constructed two permanent hunting camps, one on the river and the other at Dakadima, to accommodate visiting hunters, and on occasion accommodated two hunting parties at a time. In 1972 the ranch hosted 16 visiting hunters, and in 1976 hunting safaris were conducted on 316 days by 22 clients. After the hunting ban was imposed in May 1977, the ranch used the river camp for photographic safaris, until Government closed the camp in December 1987.

Table 4: Wildlife Hunting Quotas and Off-take from Professional Hunting Safaris on Galana Ranch

Species	Quota	1971/2	1974/75	1975/6
Elephant	75	25	13	14
Rhino	9	6	6	8
Lion	12	5	10	4
Leopard	12	5	1	
Buffalo	50	11	9	15
Crocodile	50	6	9	17
Lesser Kudu	25	11	22	20
Impala	8	6	6	1
Gerenuk	30	14	15	9
Dik Dik	40	5	6	7
Peter's Gazelle	30	25	28	23
Eland	20	8	10	7
Ostrich	12	3	5	8
Oryx	50	19	19	28
Zebra	50	26	37	36
Waterbuck	12	6	11	6
Warthog	20	8	15	16

The drought in 1971/72 led to very high elephant mortality, with an estimated 6,000-8,000 out of 36,000 dying in the Tsavo East/Galana ecosystem alone. This was reflected in the amount of found ivory recovered by staff members. In the nine month period from September 1971 to June 1972, 898 pieces of ivory weighing 10,757 pounds and 20 rhino horns were recovered. However, this mortality had largely affected females and had no effect on the quality of trophies.

The first aerial count was conducted by ranch management in 1972, and further counts were made in 1976 and 1980. See Table 5. These figures clearly indicate that, although elephant numbers declined during the seventies and rhinos appear to have been eliminated, most other wildlife populations were either stable or had increased.

Table 1 shows that elephant were being illegally hunted as early as 1976, and on 22 March 1976 Galana received a letter withdrawing their elephant quota. This was followed a year later by a comprehensive hunting ban. Rhino were also be illegally hunted and within two years very few remained. In August 1978, the ranch wildlife manager-cum-professional hunter was killed during a gun battle with Somali poachers, when they were found removing horns from three rhino they had just shot.

Table 5: Wildlife Population Estimates

Species	1972	1976	1980	1988	1989	1991	1994
Oryx	5,279	9,676	11,895				
Elephant (live)	2,166	6,293	1,810	90	94	50	46
Elephant (carcasses)	0	131	0				
Elephant (skeletons)	0	1,214	0				
Eland	1,300	1,570	945				
Giraffe	855	1,586	1,450				
Peter's Gazelle	2,608	2,511	13,215				
Zebra	1,603	3,338	3,760				
Warthog	0	836	2,415				
Lesser Kudu	497	351	690				
Gerenuk	790	411	3,860				
Buffalo	3,444	3,754	3,790	667	389	842	3
Ostrich	743	448	1,790				
Rhino	134	60	0				
Waterbuck	321	119	460				

Sources: Heath (1996); and Douglas-Hamilton *et al.* (1994).

By 1985, ranch management resolved to publicise the level of poaching, and this resulted in a number of abortive anti-poaching exercises undertaken by the Tana River District authorities. Each unsuccessful anti-poaching attempt led to increased criticism of the ranch management and personnel, and they were increasingly accused of colluding with the predominantly Somali bandits. By August 1987, management estimated that over 40 elephant were being killed each month. The situation came to a head in early October, when the Government mounted a major anti-bandit campaign and targeted senior ranch staff for being behind the poaching. This mistaken perception was transmitted to the highest levels of Government, and ultimately led to the revocation of the lease and the ranch's sale to the Agricultural Development Corporation in October 1989.

Subsequent low level aerial surveys of the greater Tsavo region in 1988, 1989, 1991 and 1994 have confirmed the catastrophic decline in the numbers of elephant and buffalo on Galana Ranch (see Table 5), but indicated that populations within Tsavo National Park, itself, were recovering. Elephant numbers in Tsavo increased from 4,327 in 1988, to 6,264 in 1994, and buffalo increased from 3,891 to 10,842. (Olindo *et al.*, 1988; and Douglas-Hamilton *et al.*, 1994).

In 1990 and 1991 a concerted effort by the Kenya Wildlife Service to control poaching began to pay dividends and elephant poaching was virtually eliminated. However, the decrease in armed Somali bandit activity coincided with an increase in meat hunting by Giriama and Wata hunters. Although there are no recent figures available for Galana, it is estimated that meat hunters have reduced the populations of oryx, buffalo, eland, giraffe, zebra and Peter's gazelle by up to 80% in the southern and eastern parts of the ranch. The small herds of topi appear to have been wiped out. In August 1996 there were signs of extensive meat hunting in the Kapengani and Dakabuko areas of the ranch. Interviews with staff confirmed the scale of illegal hunting and indicated that giraffe and buffalo were

3.5.1 Game Domestication

The Kenya Game Department was invited to conduct a study of game domestication on Galana Ranch and their Capture Unit caught the first oryx, eland and buffalo in February 1970. A research area was set aside for the domestication programme 12 kilometres north of the main ranch headquarters, and four 100 acre "game proof" paddocks were erected. The Galana game domestication research programme was managed and financed by the African Wildlife Leadership Foundation (now African Wildlife Foundation) (King, 1975 a&b; 1977; and 1978; Lewis, 1974, 1975, 1977 and 1978; Stanley-Price, 1976

By the end of 1972, there were 7 buffalo, 16 eland and 17 oryx in the domestication programme. Initial research indicated that although eland were temperamentally suitable for domestication, they were not physiologically suited, as they required great mobility, and domestication constrained them to the extent that they did not grow as well as expected. Buffalo were found not to be suitable for domestication because of temperament and slow growth rates. Oryx, however, were found to be very promising, and the project began to focus on them, increasing the herd up to 139 by 1977.

Unfortunately the domestication project suffered a setback in 1977, when Government banned all forms of wildlife utilisation (Kenya Gazette Supplement No 30 of 20 May 1977). This effectively prohibited all forms of wildlife utilisation, including the slaughter and sale of domestic oryx. Despite the ban the ranch retained support for the domestication programme and encouraged research, but gradually management lost interest and the herds began to decline through death and attrition to the wild herds. Some oryx were given to Game Ranching at Athi River and others, together with the eland herd, to the Baobab Farm at the coast. Both herds continue to thrive. By 1989, only 15 domestic oryx remained on Galana Ranch and they were given to the Tsavo River camp.

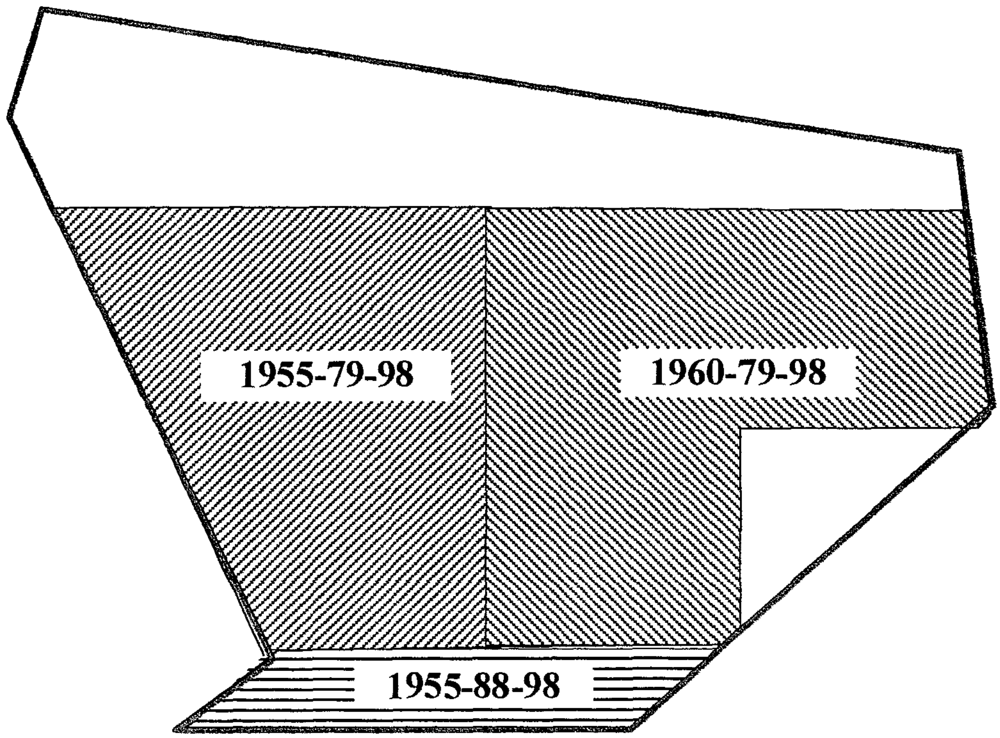
3.6 Land Cover Change

Galana Ranch extends over some 6,000 square kilometres and spans a range of environmental conditions from sub-humid to semi-arid. Vegetation and land cover changes were assessed by comparative air-photo interpretation and point sampling. For details of the method and categories used, see Appendix II.

Partial aerial photographic coverage of various parts of the ranch was available from Kenya Surveys for 1955, 1960, 1977, 1979 and 1988. Much of the earlier photography was at a scale of 1:70,000 and was of generally poor quality. Nevertheless, major land cover types could be distinguished by their characteristic tone, texture and pattern.

Additional photographic coverage at a scale of 1:25,000 on 35mm colour slide film was obtained in February 1998 by systematic aerial point sampling (SAPS). Eight latitudinal flight lines, 10 kilometres apart, were flown across the ranch at a nominal height of 2,000 feet above ground level (Lamprey and Michelmore, 1998) to provide a total of 628 high resolution colour photographs.

Figure 5: Air Photo Coverage of Galana Ranch



The extent and dates of aerial photography are indicted in Figure 5. For the purposes of photo-interpretation, the ranch was divided into three zones: southern, western and eastern, reflecting the dates of photographic coverage. Land area sampled varied from year to year, depending on air-photo coverage, but averaged about 4,000 square kilometres, or two-thirds of the total ranch area.

3.6.1 Southern

The southern zone covers a relatively narrow strip along the Galana river, where ranch headquarters, staff accommodation, pumping station, tourist camp, airstrip and main access road are located. For a summary of land cover changes in the southern zone over the 43 years from 1955 to 1998, see Figure 6 and Table 6.

The most obvious change in the southern zone has been an opening up and thinning of woody vegetation cover from 1955 to 1988, with a major increase in grassland from 12% to 50%, and a corresponding reduction in shrubland from 60% to 23%. This period coincides with a major fire in 1962, progressive increase in ranch activities from 1967 to 1989, and a substantial increase in elephants during the seventies, prior to their virtual elimination in the eighties. Since 1988 shrubland has increased and grassland has decreased to their former levels.

Over the entire period from 1955 to 1998 open woodland appears to has doubled from 12% to 24%, whilst dense woodland has declined. Much of the dense forest along the Galana river was destroyed during the floods of 1961. A degree of caution is necessary with this interpretation, however, because of the limited photographic coverage available for 1988, and because the 1998 SAPS photography did not include the Galana river.

Figure 6: Land Cover Change Southern Galana Ranch: 1955-88-98

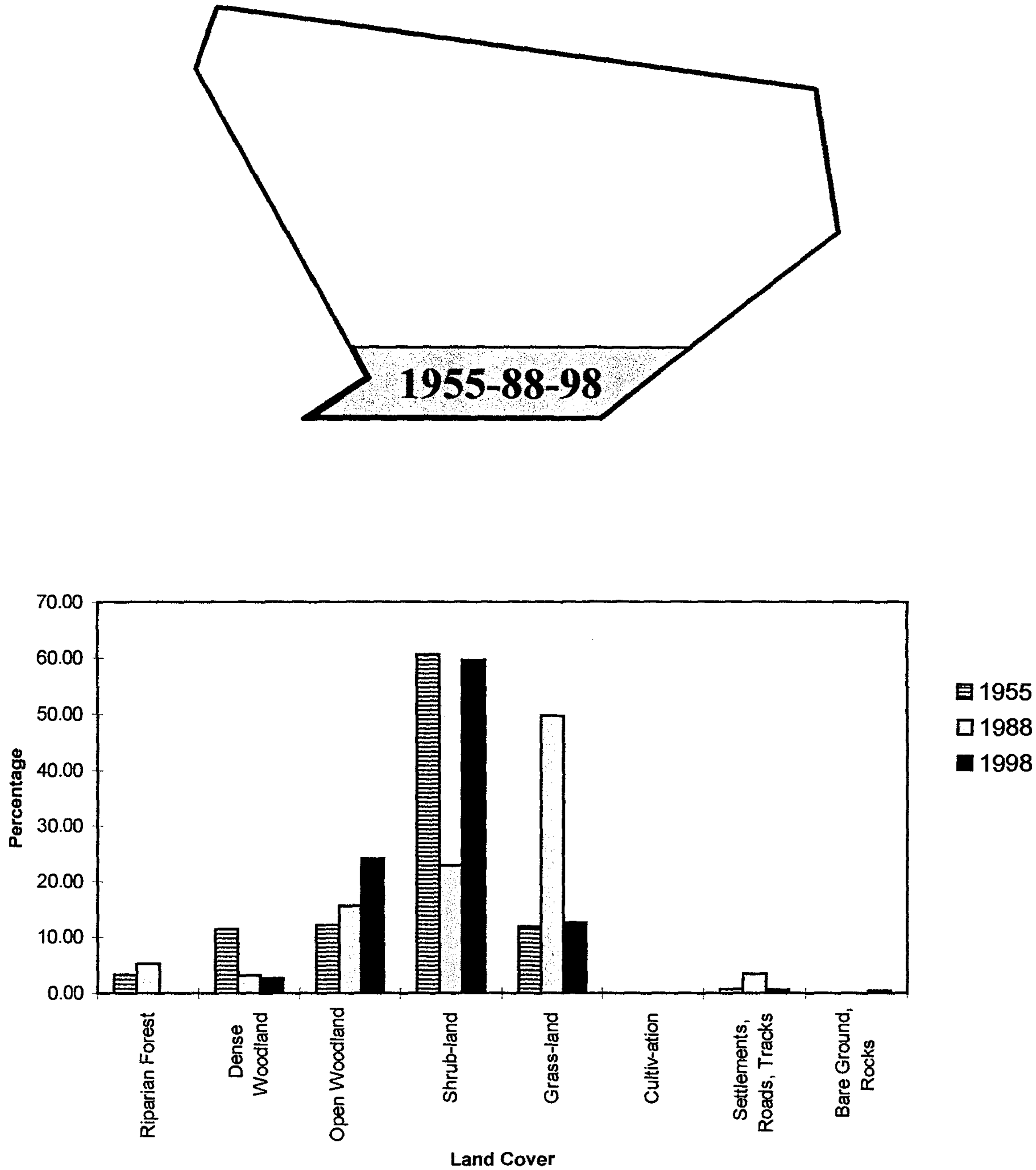


Table 6: Land Cover Change Southern Galana Ranch: 1955-88-98

Year	Riverine Forest %	Dense Wood-land %	Open Wood-land %	Shrub-land %	Grass-land %	Cultiv-ation %	Settlement, Roads, Tracks %	Bare Ground, Rocks %	Total Points	N Frames
1955	3.27	11.41	12.2	60.62	11.81	0	0.69	0	1008	28
1988	5.21	3.13	15.63	22.92	49.65	0	3.47	0	288	8
1998	0	2.66	24.1	59.56	12.62	0	0.66	0.4	1596	42

3.6.2 Western

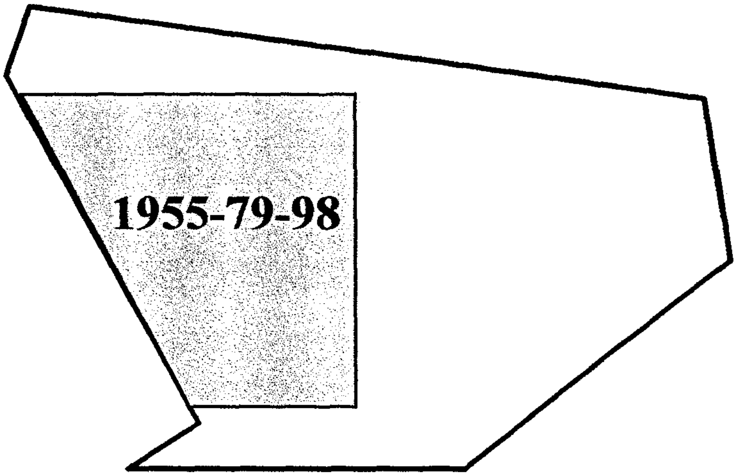
The division between western and eastern zones of the ranch lies within a transition from thick coastal bush in the east, to more open wooded grassland and Tsavo National Park in the west. For a summary of land cover changes in the western zone over the 43 years from 1955 to 1998, see Figure 7 and Table 7.

From 1955 to 1979, woodlands declined from 49% to 29% and grassland increased from 7% to 26% in the western zone of the ranch. Shrubland cover hardly changed from 43% to 45%. Roads and tracks were few and far between, and cultivation was virtually absent. Subsequently, from 1979 to 1998, the extent of open woodland and shrubland has increased by 15%, whilst grassland has declined by a similar amount.

In the mid seventies the ranch had an estimated population of 4,000-5,000 elephants, and very severe damage to habitat was reported in Annual Reports for 1974/75 and 1975/76. (See Section 3.2.4). It seems likely, therefore, that the observed reduction in woodland and expansion of grassland between 1955-1979 was due, at least in part, to the impact of large concentrations of elephant, as was the case in Tsavo National Park (Eltringham, 1979; Delany and Haphold, 1979; and van Wijngaarden, 1985).

Fire has also been an important factor affecting Galana's vegetation (Heath, 1996). Very hot, destructive fires ensue after the build up of woody biomass during a series of wet years, or after prolonged wet seasons, as in 1961/62, and again in 1997/98. According to Heath, the presence of elephants never really controlled *Combretum* on Galana, but the combination of fire and elephant impact was responsible for maintaining the more open areas of central and western Galana during the sixties and seventies. Since then, however, elephant numbers have been greatly reduced, and are now rarely seen on the ranch. As a consequence, woody vegetation has recovered and encroached upon grassland.

Figure 7: Land Cover Change Western Galana Ranch: 1955-79-98



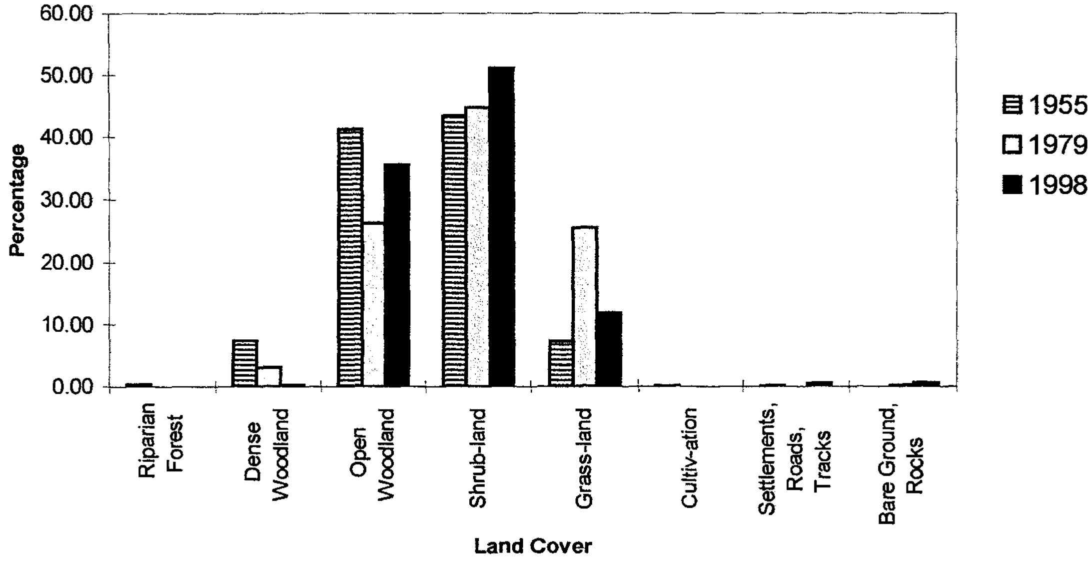


Table 7: Land Cover Change Western Galana Ranch: 1955-79-98

Year	Riparian Forest %	Dense Woodland %	Open Woodland %	Shrub-land %	Grass-land %	Cultiv-ation %	Settlement, Roads, Tracks %	Bare Ground, Rocks %	Total Points	N Frames
1955	0.28	7.43	41.33	43.48	7.31	0.06	0.11	0	1764	49
1979	0	3.15	26.3	44.81	25.56	0	0	0.19	540	15
1998	0	0.19	35.62	51.07	11.93	0	0.56	0.63	3186	177

3.6.3 Eastern

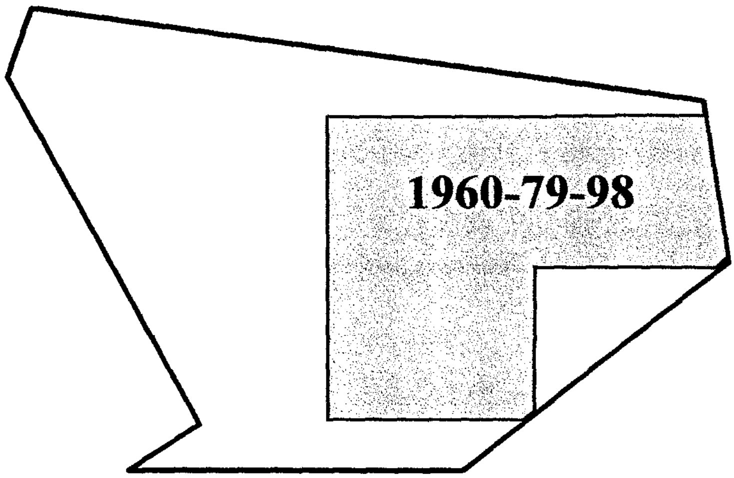
The eastern zone is generally wetter and more densely vegetated than other parts of the ranch. For a summary of land cover changes in the eastern zone over the 28 years from 1960 to 1998, see Figure 8 and Table 8.

In contrast to western and southern zones, there appears to have been a marked increase in woodland cover in the eastern zone during the sixties and seventies, from 11% in 1960 to 64% in 1979. Shrubland and grassland declined from 48% to 21%, and from 32% to 10%, respectively. Since 1979, open woodland and grassland have declined and shrubland has increased. A small amount of cultivation was present in 1960, but none was evident in 1979 and 1998. A slight increase in settlement, roads and tracks was also evident, but represented less than 1% of the land area.

The vegetation of the eastern zone is transitional between thick coastal bush to the east, and more open grassland and *Acacia/Commiphora* woodland to the west. The central portion of the ranch is predominantly *Combretum* wooded grassland, and because of higher rainfall has greater potential for livestock production. Much of the ranch infrastructure of pipelines, water tanks, spray races was, therefore, developed in this area.

From various accounts, it would appear that the vegetation of the central ranch was much more open in the past, than it is today. The great fires of 1962 had a devastating impact on woody vegetation over a wide area. Subsequently, more open woodland with reduced shrubland, was maintained by fire and elephants until the late seventies. Over the past twenty years, with the virtual disappearance of elephants and progressively fewer cattle on the ranch since 1991, there has been a major resurgence of woody vegetation cover, and decline in grassland. For further discussion of the roles of elephants and fire in vegetation dynamics, see: Delany and Happold (1979); Eltringham (1979); and van Wijngaarden (1985).

Figure 8: Land Cover Change Eastern Galana Ranch: 1960-79-98



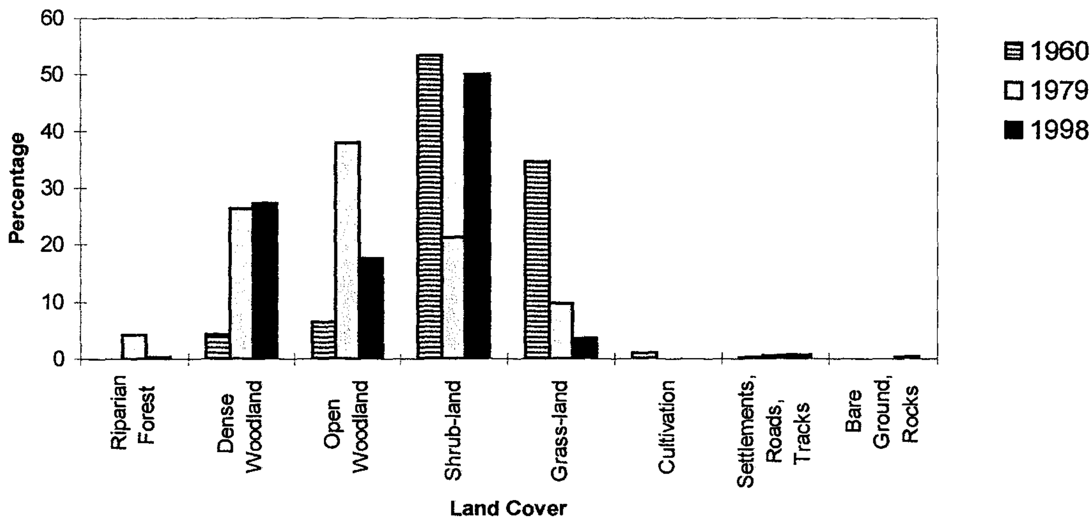


Table 8: Land Cover Change Eastern Galana Ranch: 1960-79-98

Year	Riverine Forest %	Dense Wood-land %	Open Wood-land %	Shrub-land %	Grass-land %	Cultiv-ation %	Settlement, Roads, Tracks %	Bare Ground, Rocks %	Total Points	N Frames
1960	0	4.27	6.41	53.42	34.62	1.07	0.21	0	468	13
1979	4.17	26.39	37.9	21.23	9.72	0	0.6	0	504	14
1998	0.37	27.32	17.61	50.06	3.64	0	0.69	0.32	3492	194

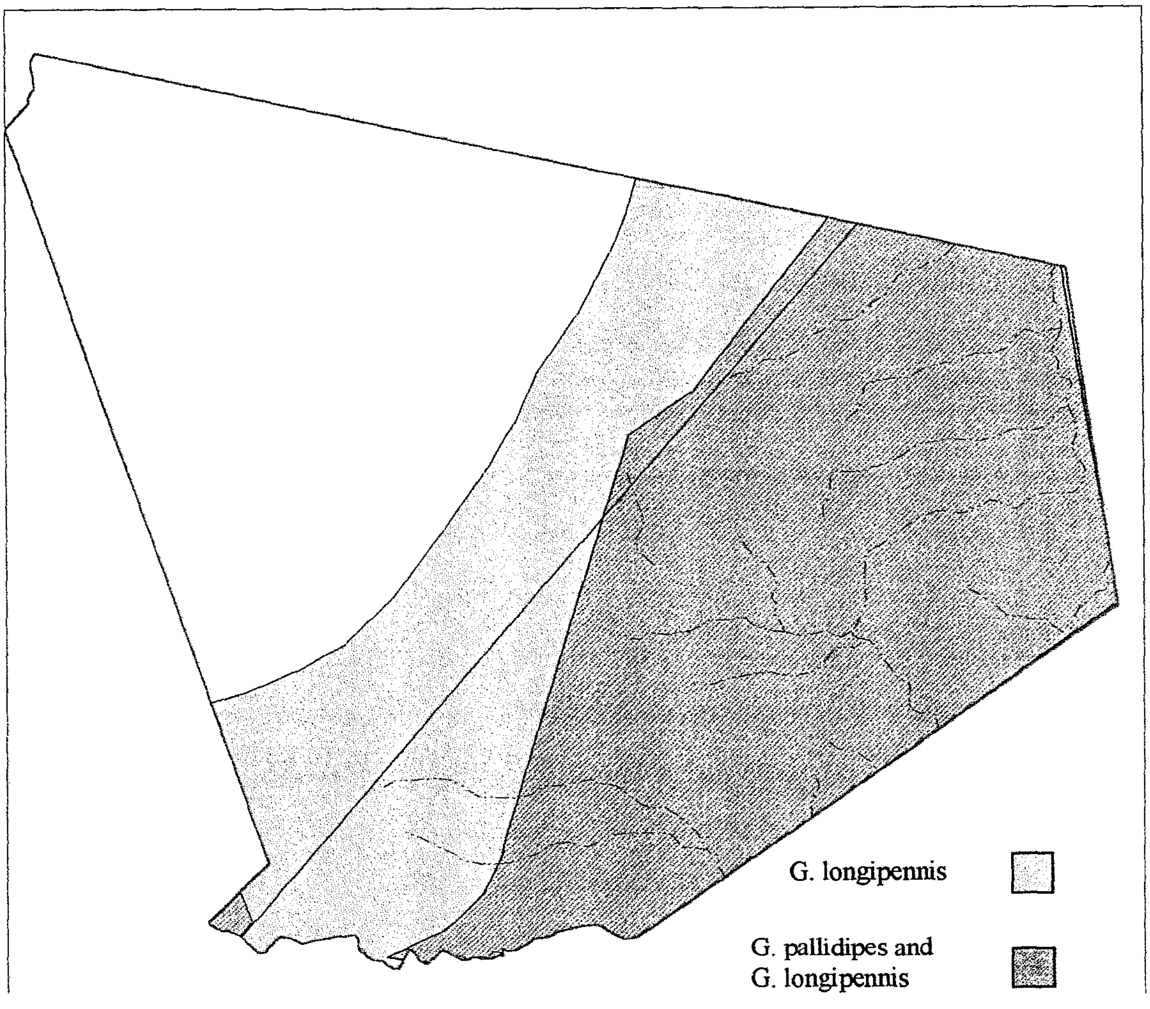
3.7 Tsetse, Trypanosomosis and Trypanotolerance

3.7.1 Tsetse

Four species of tsetse are found on Galana Ranch, infesting up to half the land area at maximum dispersal during the wet season (Map 4). *Glossina pallidipes* favours the eastern dense coastal bush, moving out into the more open *Diospiros* parkland in the rains. *G. austeni* and *G. pallidipes* frequent the denser vegetation of the Galana river, whilst *G. longipennis*, "the example *par excellence* of arid, almost desert, conditions" (Ford, 1971), tends to be found in open, drier sections of riverine vegetation and more densely wooded upland areas. Occasional catches of *G. brevipalpis* have also been recorded around Dakabuko hill.

The earliest known tsetse survey of the area was undertaken by the Department of Veterinary Services in April/May 1963 (Parker, 1996a&b). Its findings are reflected in the 1967 Tsetse Distribution Map in the National Atlas of Kenya and the OAU/STRC *Glossina* Distribution Maps of Africa (Ford and Katando, 1977). Further surveys were undertaken by KETRI during the eighties and the findings of most recent surveys, carried out in the early nineties, have been summarised by Makumi (1994).

Map 4: Tsetse Distribution on Galana Ranch



Whilst far from conclusive, available information indicates a broadly similar pattern of tsetse distribution in the early sixties and the early nineties, with tsetse being confined to the eastern half of the ranch, and along the Galana River. In the sixties, the north-western region adjacent to Tsavo National Park, was also thought to be infested, but had not been formally surveyed. Recent investigations, however, have failed to detect the presence of tsetse in this more arid north-western zone, but they do indicate a westward expansion of the coastal *G. pallidipes* belt into areas formerly considered to be the preserve of *G. longipennis*.

In the seventies and eighties, the central and southern parts of the ranch were thought to be virtually fly free, but more recent surveys indicate an extensive infestation of *G. longipennis,* stretching from Lali hills in the south-west through to the *G. pallidipes* in the east (see Map 4). Local infestations of *G. pallidipes* have also been identified in pockets of denser vegetation around Minjilla dam and Didima hill.

Various authors (Makumi, 1994; Heath 1996; and Parker 1996 a&b) have commented on the increasing density of woody vegetation in central and southern areas of the ranch, which has followed the decline the region's elephant population, and a reduction in the frequency and extent of bush fires. The number of elephant on the ranch, as determined by low level aerial survey, appears to have peaked at around 6,000 in the mid-seventies. By 1988, as a result of extensive poaching, there were less than 100 (Olindo *et al.*, 1988). The region is also prone to periods of drought, the most severe of which occurred in the early seventies, early eighties and early nineties.

Whilst it may be difficult, if not impossible, to distinguish the relative importance of elephants, fire, drought and climatic variation on the complex process of vegetation succession, it is, nevertheless, important to establish what changes in woody vegetation cover have actually taken place, because this provides an indication of the extent of potentially suitable tsetse habitat and risk of trypanosomosis transmission. (See previous Section 3.6.)

3.7.2 Trypanosomosis

In the first few years of cattle management on Galana, the ranch controlled trypanosomosis by using Antricyde Pro-salt (Quinapyramine sulphate), but by mid-1970 the Provincial Veterinary Officer recommended the use of Samorin (Isometamidium chloride, May and Baker) in preference to Antrycide Pro-salt.

In June 1972, management reported that they were able to treat cattle with Samorin every six months. The ranch continued with three or four yearly treatments of Samorin for all cattle until 1977. It was then suggested by the PVO's office that the ranch should give sanitive treatments with Berenil (Diminizene aceturate, Hoechst) two weeks before every third Samorin treatment, and this practice was instituted.

By May 1978, the first hint of possible resistance to Samorin was recorded in the Kapengani area. In this instance a very acute "Haemorrhagic" form of *T. vivax* was confirmed, in animals that had been given Samorin 40 days previously, by veterinarians from KETRI. This was the first time that this form had been recorded on the ranch, although it was first identified in Machakos and had been known from the coast as the 'Likoni' strain of *T. vivax*. This haemorrhagic strain continued to appear periodically, and when it next appeared in January 1980 killed 50 cattle in three bomas at Kapengani. This, despite the routine Berenil followed by Samorin regime that had been practised for

In August 1979, KETRI established a research field station on Galana and were able to provide much valuable advice on the management and control of trypanosomosis. They recommended the strategic use of Samorin, and increasing the dosage from 0.5 to 1mg/kg. They also suggested that Berenil should only be used as a curative. By early 1981, there were concerns about resistance to Berenil, and Samorin only appeared to give 25 days prophylaxis. The ranch employed their own microscopist, and started keeping records on animals sampled and the quantity of trypanocidal drugs used (See Table 9).

Table 9: Usage of Trypanocides

	1981/2	1982/3	1983/4	1984/5	1985/6	1986/7
Results from Random Sampling of Herds						
No of cattle tested	6,440	5,075	5,759	3,786	3,996	5,594
No of cattle treatments	29,743	17,547	33,519	36,791	68,461	23,652
Gms of Samorin used	8,382	4,870	7,138	7,810	9,756	4,961
Tablets of Novidium used				37,140	55,654	11,282
Sachets of Berenil used					5,640	9,780
Cost of Trypanocides (KSh)	209,550	145,320	186,090	331,260	589,640	336,571
Cost per Ranch Unit (KSh)	10	7	9	14	29	15
Sick Animals Sampled						
T. congolense		29	38	161	189	150
T. vivax		32	101	471	546	297
T. brucei				29	10	
Anaplasmosis		23	31	126	143	259
Babesia		2	4	55	3	5
Negative		64	220	1,410	2,274	1,573

By 1984, trypanosomosis appeared to be more prevalent than ever and one group of 1,306 cattle from Garsen had an infection rate of 30%, the worst ever encountered until then. This group of cattle was possibly the first to show signs of what was to become known on the ranch as *"Korobo"* disease, a gradual wasting accompanied by jaundice and a distinctive smell.

By early 1985, there were grave concerns about resistance to Samorin, and one group of cattle from Tana River were given Samorin twice in two weeks in an attempt to clear up trypanosomosis. Resistance to trypanocides was confirmed in trials held in February 1985, and it was decided to use Novidium (*Homidium chloride*) in preference to Samorin. 1985 was the worst year on record for trypanosomosis and the number of treatments increased threefold from 1983. In this same year there were records of trypanosomosis at Tank E, the first cases in this area for many years.

In August 1985 the first definite cases of *"Korobo"* disease were seen in the Alango Shira/Korobo area of the ranch. Severe liver damage was the single most important post mortem lesion, and at that time Leptospirosis was suspected. Algae on the water holes and plant poisoning were also considered as possible causes, and there were suspicions that the disease could possibly be related to frequently treated with Samorin. A further outbreak of *"Korobo"* in April 1987 reinforced the feeling that increased trypanosomosis infections and frequent Samorin usage were somehow linked to the disease. There was a further outbreak of *"Korobo"* in July and August 1987. A ranch experiment on the disease pointed strongly to drug toxicity, with the combination of Berenil and Samorin in quick succession being the most probable cause of the syndrome. However, this realisation came too late to prevent a major disaster in November and December of the same year in which over 1,200 cattle died.

By December 1987, there was still no officially recognised cause of *"Korobo"* although ranch management was convinced that it was associated with trypanosomosis and the administration of Berenil and Samorin. A meeting was held at Kabete with top veterinarians in the country, but there were no new leads on the possible cause. At this stage the ranch was recording breakthroughs to Samorin after two weeks, and KETRI reported breakthroughs after 11 days for Samorin and 18 with Ethidium (Homidium bromide). By April 1988, breakthroughs to Samorin were recorded in as little as 8 days by KETRI, and in May a representative from May & Baker, the manufacturers of Samorin, advocated increasing the dosage rate for Samorin to 1.5 mg/kg. He denied any possible Samorin toxicity, although conceded that Berenil in conjunction with Samorin could possible cause liver damage. This was later confirmed as the cause of *"Korobo"* in a trial performed at the KETRI Nguruman Field Station.

Following the disaster in November, it was decided to adopt a new approach to the problem through tsetse control and the use of insecticide impregnated targets, a technique originally developed in Zimbabwe. In December 1987, 10 traps were in place to monitor tsetse numbers in the Alango Shira quarantine area, and by February 1988 there were 240 targets in place. In March 1988 a further 200 targets were installed and there were indications of reduced tsetse numbers in the traps. In April tsetse numbers in the traps continued to decline, although tabanids were caught in large numbers, with up to 1,200 flies caught in a trap in one day.

By August 1988, no tsetse were being caught in the traps, and only 6 cases of trypanosomosis were recorded in 2,000 cattle over a period of three months in the Alango Shira quarantine area. There were no cases of *"Korobo"* and the animals had only been treated with Novidium prior to leaving the Tana River. The greatest problem with the targets was not in administering them but with theft; 150 cloths were stolen by Somali or Wata hunters in the first six months.

After ADC took over the ranch they continued to maintain the targets, but, with the reduction in purchases and overall cattle numbers, the targets were allowed to deteriorate and, by 1996, they were no longer being maintained. Trypanosomosis continued to be a major disease problem, accounting for at least 44 deaths in 1994/5 and 57 deaths in 1995/6. (See Table 10.) A further 30 and 88 cattle were lost due to "debility," many of which were almost certainly undiagnosed cases of trypanosomosis.

Table 10: Summary of Cattle Deaths: July 1994 to June 1996

Year	Vermin	Anaplasmosis	Debility	Tryps	Heart-water	Farcy	CBPP	Other	Total
1994/5	160	73	30	44	24	7	4	111	453
1995/6	192	97	88	57	45			194	673

3.7.3 Trypanotolerance

In addition to epidemiological field research and advising on vector control and the use of trypanocidal drugs, KETRI has also collaborated closely with ranch management on a long term cattle breeding programme, selecting for improved weight gain and enhanced trypanotolerance in Orma Boran. The programme is of considerable strategic importance to livestock production and sustainable utilisation of marginal tsetse infested land in East Africa.

The Boran cattle, owned by the Orma people of Tana River District, sometimes known as the Tanaland Boran, are thought to have originated from the Borana region of southern Ethiopia and to have arrived in the semi-arid rangelands of eastern Kenya 400-500 years ago. Tsetse infestation in that region is confined largely to riverine habitats and land adjacent to the Tana river. The Orma people practice a seasonal transhumance into the rangelands away from the river during the wet season, but return to riverine areas of tsetse infestation during the dry season. Their cattle have, therefore, survived the challenge by tsetse and trypanosomes for many generations, and have developed a tolerance to trypanosomosis through natural selection.

Galana Ranch operates two regimes of livestock management (see Section 3.4.2), one for fattening traded Orma cattle purchased from Tana River District; and the other of keeping balanced breeding herds of improved Kenya Boran, originating from tsetse free highlands of Laikipia District. Differences between these two types of Boran cattle, maintained under tsetse challenge, were first recognised in the early eighties (Dolan *et al.*, 1985; Njogu *et al.*, 1985), and since then various studies have been carried out comparing the performance of both steers and breeding animals (Dolan, 1993, 1996 & 1997).

In all cases it has been found that the Orma cattle do better than the improved Boran under tsetse challenge. They become infected less often, and once infected succumb less easily to the disease. Infection and mortality rates in the Orma are approximately half those observed in Kenya Boran. Under both prophylactic and curative treatment regimes the Orma cattle require fewer drugs. Kenya Boran, however, are a better beef animal. They generally grow faster and reach a heavier mature body size than the Orma Boran, and this trend is only reversed in years of very high tsetse challenge.

A selective breeding programme for Orma cattle was initiated in 1983 with the aim of improving the beef production characteristics, whilst at the same time maintaining their disease resistant qualities. Galana Ranch purchased the foundation stock of cows, heifers and five bulls from the Orma people between 1983 and 1987. These animals, some with calves at foot, were trekked on to the ranch and held initially in the ranch quarantine area for a three to four month period. They were then handed over to KETRI for ear-tagging, and recording commenced on the first group of 83 cows in October/November 1983. Subsequently, the breeding herd of cows has expanded through recruitment of Orma females born from original stock. After weaning, male calves are maintained in a separate herd on the same regime as cows and calves. Breeding bulls are selected from these weaners on the basis of their post weaning growth rates.

The Orma cattle provide the only well documented case of east African cattle with a degree of resistance to trypanosomosis. Evidence for trypanotolerance has also been found in Maasai cattle, and it is likely to occur in any breed with a long history of exposure to the disease. The Orma have an advantage over many of the other indigenous breeds in aast Africa, however, in that they are faster growing animals, with a larger mature body size.

3.8 Environmental Concerns and Lessons for the Future

3.8.1 Environmental Concerns

Galana Ranch was established in 1967 and occupies an extensive area of sub-humid to semi-arid rangeland, previously inhabited by Orma pastoralists and Wata hunters. For the past thirty years the ranch has remained largely uninhabited, except for ranch staff, transient pastoralists, illegal hunters and military personnel.

3.8.1.1 Occupancy of Ranch Land

Recently, however, with general insecurity in the region and reduced patrolling by ranch staff, there appears to have been an increase in pastoral transhumance across the northern boundary and settlement within the ranch has been reported. Whilst, this development in itself may not be of immediate environmental concern, it does have serious implications for the future management and integrity of the ranch environment.

3.8.1.2 Tsavo East Buffer Zone at Risk

Galana Ranch and its forerunner, the Galana Game Management Scheme, were established, at least in part, to provide a buffer zone for Tsavo East National Park. Loss of that buffer zone, or changes of land use with it, should be of concern to park authorities.

3.8.1.3 Loss of Biodiversity

There has been a catastrophic decline in the number of elephant, rhino and buffalo on the ranch, and oryx, eland, giraffe, Peter's gazelle and topi have been greatly reduced due to excessive, uncontrolled hunting.

3.8.1.4 Land Cover Change and Expansion of Tsetse Habitat

Comparative air-photo interpretation indicates that there have been major changes in vegetation and land cover within the ranch between 1955-98. Woody vegetation has increased at the expense of grassland, particularly in the central portion of the ranch. As a result, there has been a substantial expansion of potential tsetse habitat, and the risk of trypanosomosis transmission has almost certainly increased.

3.8.2 Lessons Learnt

3.8.2.1 Co-existence of Livestock and Wildlife

Large numbers of cattle can be successfully ranched in close proximity to wildlife and tsetse. Even at its maximum holding, with 28,000 head of cattle on Galana in early 1989, the overall ranch stocking rate was very low at 21 hectares per head, or approximately 5 animals per square kilometre. However, it should be remembered that the ranch, at least in the past, has also supported substantial wildlife populations. Indeed, until the banning of hunting in 1977, Galana Ranch obtained much of its income from hunting safaris.

3.8.2.2 Avoidance of Tsetse: A Key Disease Control Strategy

Just as with more traditional pastoral systems, avoidance, or reduction, of tsetse challenge and disease transmission risk remains a key component of any cost-effective cattle and disease control strategy. This is particularly true in areas such as Galana, located on the margins of tsetse

3.8.2.3 Drug Toxicity Problems

Prophylactic and therapeutic drug treatments against trypanosomosis have been extensively used on Galana, and have generally given good protection. However, toxicity problems may arise when trypanocidal drugs are administered too frequently, or in combination, as the ranch found to its cost when thousands of ranch cattle died through excessive usage of Berenil and Samorin.

3.8.2.4 Trypanotolerance of Orma Boran

Orma Boran cattle are trypanotolerant and do better than improved Boran under tsetse challenge. They become infected less often, and once infected succumb less easily to the disease. Infection and mortality rates in the Orma are approximately half those observed in Kenya Boran. Under both prophylactic and curative treatment regimes the Orma cattle require fewer drugs.

Given their differential susceptibility to trypanosomosis, the ranch has adopted a general strategy of maintaining the Kenya Boran breeding herds in the south and west of the ranch, and keeping the trypanotolerant Orma fattening stock in the eastern zone. With the seasonal retreat of tsetse and the availability of fodder, however, this strategy is not followed throughout the year, and Kenya Boran herds are moved eastwards into more central areas of the ranch during the dry season.

During the course of preparing this case study it was reported that many of the Orma Boran breeding stock had been infected with CBPP and died. This is a major loss to Kenya, and every effort is required to conserve what remains of this important genetic resource.

3.8.2.5 Environmental Change Tips Epidemiological Balance

A tentative scenario for the impact of environmental change on vector distribution and the epizootiology of trypanosomosis on Galana Ranch is outlined below:

- The cumulative impact of a substantial elephant population, frequent fires and intermittent drought during the sixties and seventies, reduced woody vegetation cover and opened up central and southern areas of the ranch.
- Former tsetse habitats were, thereby, transformed into more open grassland and wooded grassland, no longer suitable for the tsetse.
- By the early eighties tsetse had retreated from extensive areas, and much of the south-central part of the ranch was considered to be fly free.
- With the decline in elephant numbers, fewer bush fires and less severe drought conditions during the eighties and nineties, there has been a regeneration of woody vegetation and an expansion of tsetse habitat.
- During the late eighties and early nineties, *G. pallidipes* has extended its range to occupy the eastern third of the ranch, with outlier populations at Minjilla dam and Didima hill, and *G. longipennis* has reinfested central southern areas from Lali hill to Kapengani.
- With expansion of tsetse habitat into areas of the ranch frequented by cattle, and with increasing numbers of cattle maintained under low to moderate challenge for at least part of the year, trypanosomosis has become an increasingly worrisome problem during the eighties and nineties.

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APPENDIX I: THE GALANA ARCHIVE

A collection of documents relating to the establishment of the Galana Game Management Scheme and Galana Game and Ranching Limited is held in the library of KETRI's Environment and Socio-economic Section, Muguga. The 19 volume Galana Archive contains a wide range of reports, publications and personal papers, brought together by Brian Heath, former Manager of Galana Ranch, Ian Parker, former Officer in Charge of the Galana Game Management Scheme, and Keith Sones of StockWatch Limited. The collection constitutes an invaluable source of reference material, summarised below:

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APPENDIX II: AIR-PHOTO INTERPRETATION AND LAND COVER ASSESSMENT

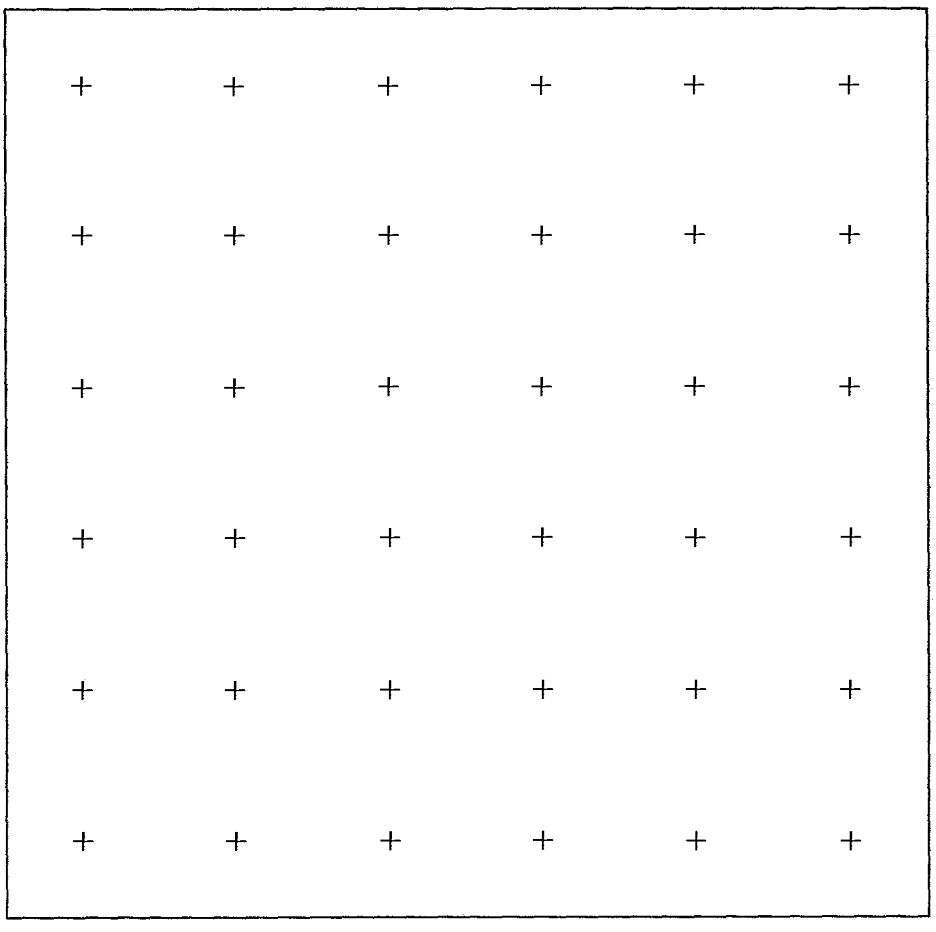
Land cover changes in case study areas were assessed by comparative air-photo interpretation.

Aerial photographic coverage specifications vary from survey to survey; e.g. height above ground (scale); extent of overlap between frames on same flight line; extent of overlap between adjacent flight lines; and film type (black and white, or colour). The method of air-photo interpretation outlined here is based on a technique of land use pattern analysis described by Brunt (1967) and demonstrated to KETRI Environment and Socio-Economic Unit staff using high resolution colour aerial photographs of Nguruman taken in 1991.

Because there is approximately 66% overlap between consecutive frames on each flight line and 33% overlap between adjacent flight lines, there is no need to examine all of every aerial photograph. In fact, if repetitive sampling of the same land area is to be avoided, which it should be, it is only necessary to sample the "unique" central part of every second frame. Given that each print is 9" x 9", the "unique" central part of every second frame is contained within a 6" x 6" portion, with a redundant peripheral 1.5" margin on all sides.

The "unique" central area of every second frame is sampled by means of transparent overlay with a 6 x 6 array of 36 sampling points (Figure 9).

Figure 9: 6 x 6 Array of Air-Photo Sample Points Used for Land Cover Assessment



Each sample point is examined closely and allocated to one of 10 possible vegetation and land use types (see Table 11). A tally is kept of the total number of sample points in each land cover category for each aerial photograph. Individual scores are then summed and converted to percentages for each survey area and period, from which it should be possible to demonstrate quantitative changes in the relative proportion of land cover types over time.

Table 11: Vegetation and Land Cover Types

Riparian Forest:
Along river coarse and drainages with dense trees (large/mature) and closed or nearly closed canopy.
Identification Characteristics: along drainage/tall-dense trees, dark colour, high texture

Dense Woodland:
Dense tree canopy but not closed, away from riparian zone (drainages).
Identification Characteristics: not along drainage, tall & medium trees, dark colour, high texture.

Open Woodland:
Scattered trees with either grass or shrubs as understory.
Identification Characteristics: fewer trees, scatter, medium colour, medium texture.

Shrubland:
No obvious trees (or very few), low height-shrub covering or scattered on ground.
Identification Characteristics: no trees, medium--light colour, medium texture.

Grassland:
No trees, few shrubs.
Identification Characteristics: no trees, light colour and texture.

Cultivation:
Includes active and fallow cultivation. Defined by a boundary, usually of geometric shape.
Identification Characteristics: pattern is geometric, light-dark in colour, texture varies.

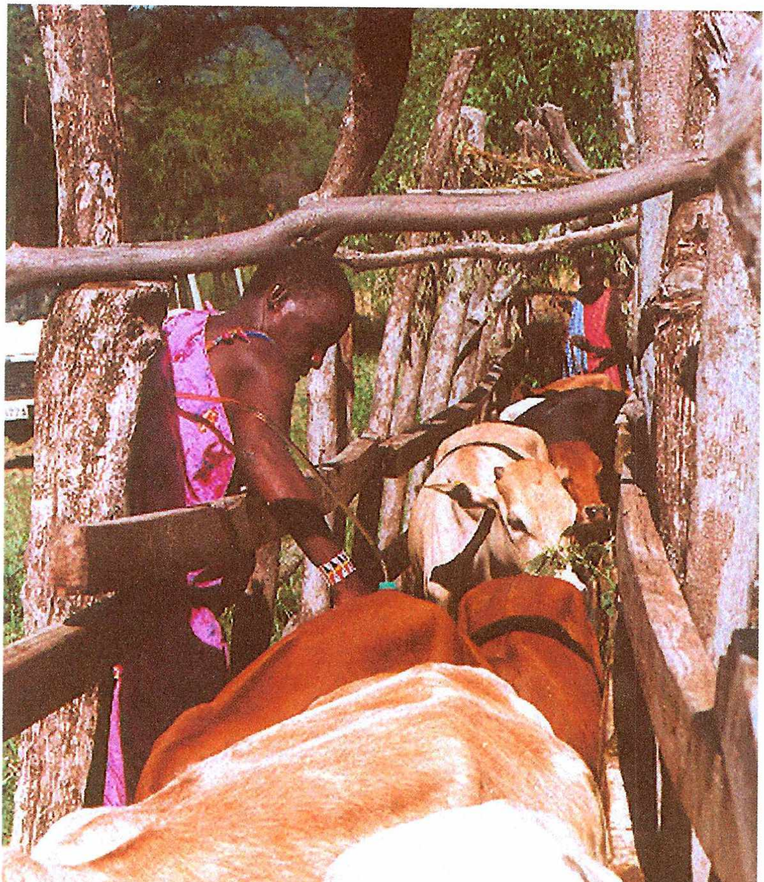
Settlements/Tracks/Roads:
Usually dwellings can be seen, with bare ground and cultivation nearby. Tracks and roads are self evident and appear as white lines on photo.
Identification Characteristics: dwellings, lines.

Bare Ground/Rocks:
No vegetation.
Identification Characteristics: No vegetation, very light colour.

DFID TRYPANOSOMOSIS RESEARCH PROJECT

NGURUMAN

SOUTHERN RIFT VALLEY



GEORGE ODOUR OLOO
&
DAVID BOURN

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Cover Photograph (David Bourn): Application of pour-on at Kamango's Crush, Nguruman.

4. NGURUMAN

4.1 Introduction

In the language of the Maasai ethnic majority, the term "Nkuruman" or "Ngurumani" is used to identify any area of cultivation, or place where crops are grown; and is an important distinguishing feature to pastoralists in the semi-arid rangelands of the southern rift valley. More than a century ago G.A. Fischer visited Ngurumani on the Bagasi river on his journey through Maasailand in 1883 (Spink and Stevens, 1946). The Bagasi is almost certainly the same river as that now known as the Pakaase, flowing off the Nguruman escarpment just north of Lake Natron. Fischer travelled two days march further north to another Ngurumani, also called Kalemma, on the Entasopia, which is the location of modern day Nguruman.

The Nguruman case study area lies between the western escarpment of the rift valley and Lake Magadi in southern Kenya, extending southwards to Lake Natron on the border with Tanzania, and includes both Ol Kiriamatian and Shompole Group Ranches. (See Map 1.)

This case study examines the historical background and environmental context of trypanosomosis control in the southern rift valley of Kenya, and provides an objective assessment of long term land cover change.

4.1.1 Geographical Setting

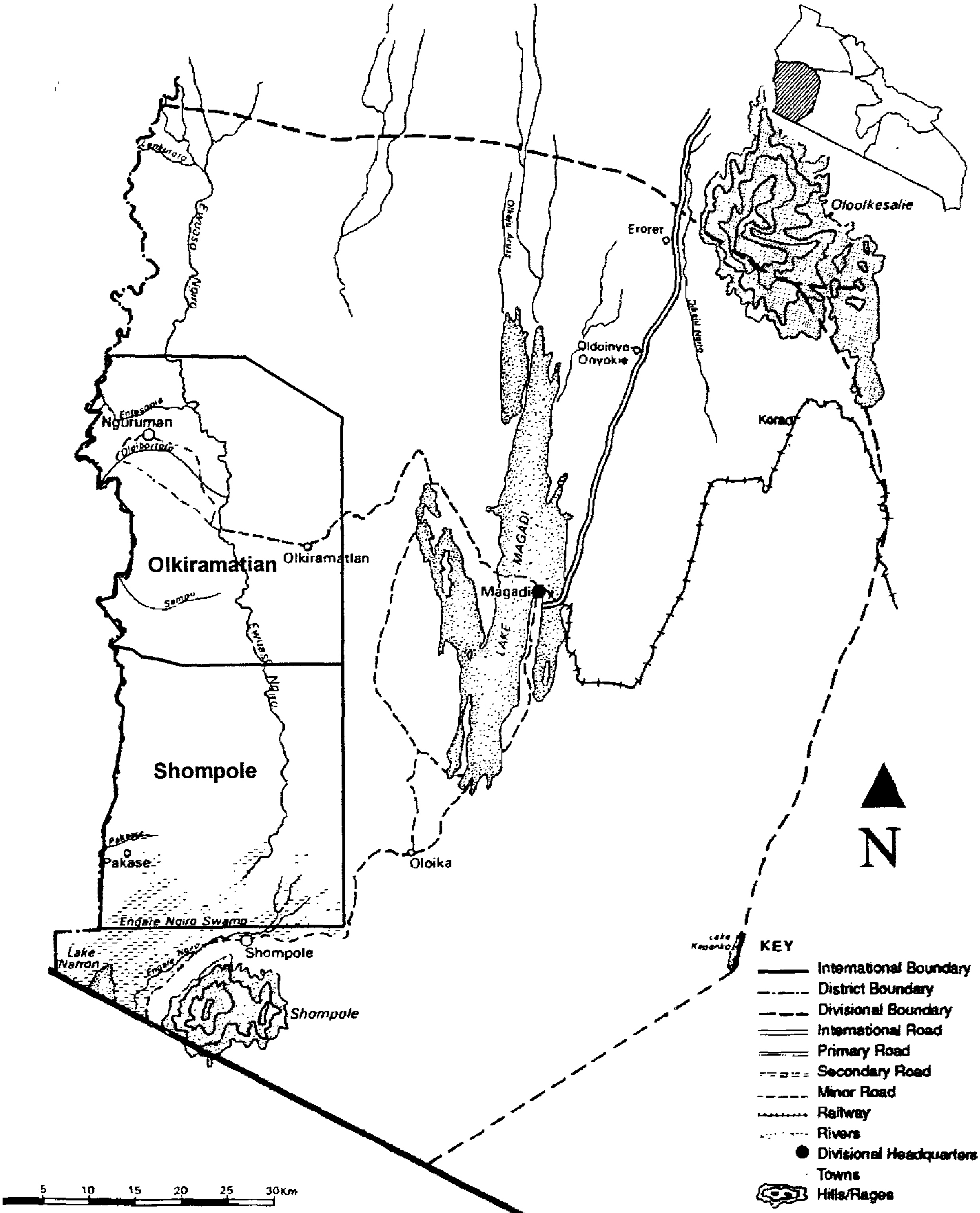
The study area lies on the floor of the rift valley in southern Kenya, at a general altitude of 800m in the north, declining gradually to 600m in the south. The Nguruman escarpment, which forms the western wall of the valley descends to the east by a moderately steep escarpment to a platform at an altitude of about 1,500m, after which it drops spectacularly to the floor of the valley.

Alluvial material brought down by perennial rivers that descend from the escarpment forms fans and piedmont plains. Those of the Oloibortoto, Entasopia and Pakaase rivers are particularly extensive, spreading out over several kilometres from the base of the escarpment on the valley floor.

Landforms in the northern and eastern part of the area are determined by minor parallel running faults, all trending a little east of north, resulting in a broken topography of narrow table and step-like strips, or plateaux, alternated by depressions, or "troughs". The plateaux are composed of lightly eroded Pleistocene lavas and their surfaces are generally featureless. The depressions have been filled with fine textured sediments, in particular lake beds, or colluvial material washed in from surrounding areas. Several of these "troughs" are without any external surface drainage system, and may become swampy during the rains.

The Ewaso Ngiro river, with headwaters in the Mau range, traverses the areas from north to south and drains into lake Natron. In its northern reaches, the river forms a narrow valley, which gradually widens and spreads out into several branches in the swampy area just to the north of Lake Natron. Mount Shompole, a steep sided and heavily eroded dormant volcano, rises to an altitude of 1,565m at the southern extremity of the study on the Tanzanian border overlooking Lake Natron. (Okoth and van Engelen, 1984)

Map 1: Magadi District, with Location of Olkiramatian and Shompole Group Ranches



Source: Kajiado Atlas, 1990.

4.1.2 Geology and Soils

Most rocks in the area are of volcanic origin. The oldest being the Shompole volcanics, consisting mainly of brown tuffs with thin agglomerate horizons, probably dating from Miocene times. The Olivine basalts that make up the Nguruman escarpment are of similar age, and erupted during the initial period of rift faulting. A second movement along the fault in lower Pleistocene times was accompanied by eruption of an extensive and thick series of plateau trachytes on the valley floor.

Subsequent widespread grid faulting broke up the floor of the rift valley into a series of parallel raised and sunken blocks. The Lake Natron/Ewaso Ngiro depression was partly filled with lacustrine sediments, some of which can be found 15 kilometres north of the Ewaso Ngiro bridge. These sediments are progressively overlain by sediments of the Ewaso Ngiro river. Other smaller depressions are filled with deposits partly of lacustrine origin and partly from the out wash from the escarpment (Baker, 1958 & 1963; cited by Okoth and van Engelen, 1984).

Soil genesis at Nguruman is not well advanced. All soils have a low, to very low, organic matter content; free calcium carbonate occurs in many sub-soils, and pH is generally above 7 (Okoth and van Engelen, 1984).

The soils of the mountains, hills, scarps and plateaux are all characterised by their shallowness, sandy loam to sandy clay loam textures and rocky and stony aspects. Some parts of the foot slopes have identical soils, while other parts show deeper ones. Most are classified as Lithisols.

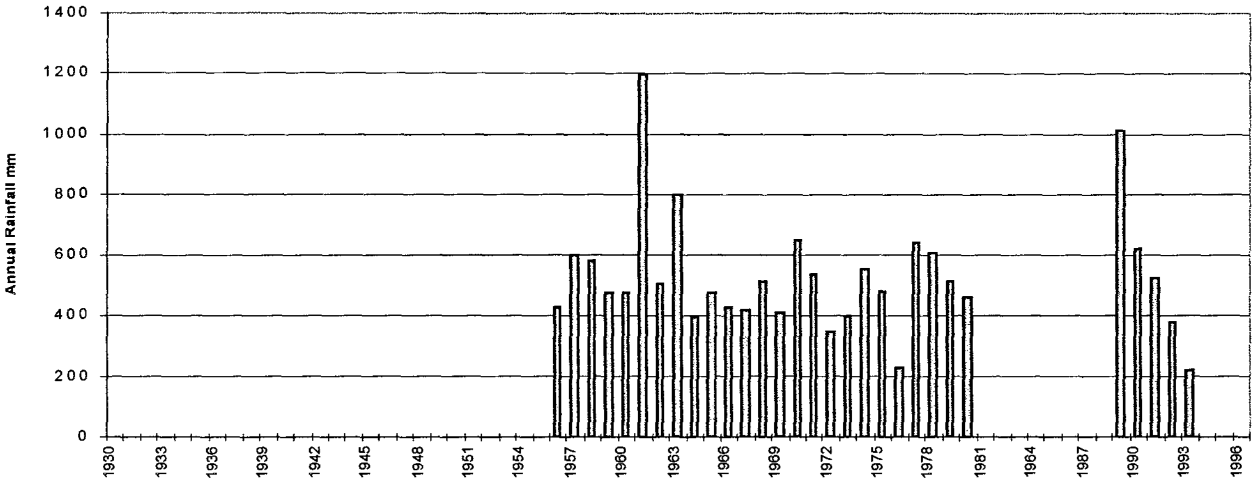
The soils of the piedmont plains associated with the stepped plateaux are deep, and have sandy loam to silty clay loam textures. Profile developments in these colluvial/alluvial materials is not well progressed, and the soil key out as Regosols and Cambisols. The piedmont plains at the foot Nguruman escarpment have more stony, rocky and shallower soils.

Most of the plains have deep soils, varying in texture from sandy clay loam to clay loam. The soils of the block faulted depressional plains are sodic, and in places saline. Poorer drainage conditions and sodic/salinity occur in varying degrees in the soils of the lacustrine plains. They have been classified as Solonchaks.

The soils of the alluvial valleys and floodplains are all deep and have a wide range in texture, which is related to their alluvial genesis. Levee-like deposits have rather sandy textures, while some small "backswamps" have more clayey soils with poorer drainage conditions. All alluvial soils are young and may conserve some stratification. They are classified as Fluvisols.

4.1.3 Rainfall and Climate

Figure 1: Magadi Long Term Annual Rainfall



Full data series with Kenya Meteorological Department. Mean annual rainfall for incomplete data series is 531mm.

Figure 2: Magadi Seasonal Rainfall Pattern

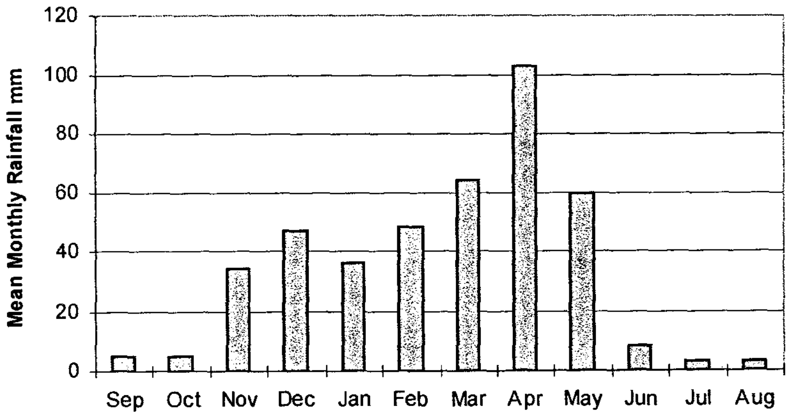
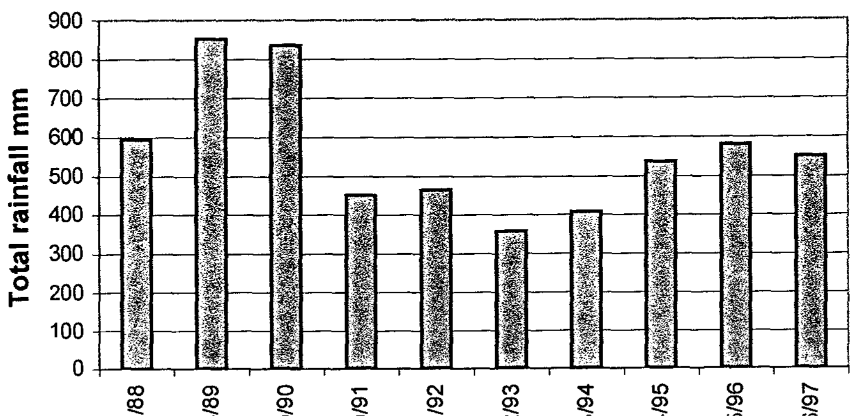


Figure 3: Nguruman Annual Rainfall: August - July



4.1.4 Agro-Climatic Zone and Vegetation

Nguruman's climate is classified as arid, and agricultural potential is generally low. Rainfall, however, is greater on the adjacent escarpment and highlands, and perennial rivers flowing from them support limited areas of forest, dense woodland and, increasingly, irrigated agriculture along the Oloibortoto. (See Map 4.) Otherwise, the vegetation of the southern rift valley is classified as wooded and bush grassland. *Acacia tortilis* (Ol Tepesi in Maa) is the most common and conspicuous tree, with *Cordia sinensis* (Ol Doroko in Maa) occurring only in areas of enhanced ground water. Annual grasses are more common and extensive than perennial grasses, and are by far the most important for cattle production, *Sporobolus cordofanus* on alluvium and *Aristida adoensis* and *A. mutabilis* on the stony plateaux (Agnew, pers comm.).

4.2 Historical Perspective

"At the advent of the colonial period the Maasai were expanding their control over the pastoral resources of the rift valley, interacting with and in some cases displacing or incorporating other farming and herding groups. What are now seen as different Maa-speaking peoples, and different sections of the pastoral Maasai, were emerging within a context of considerable movement between substance categories and between ethnic groups which have later come to be seen as discrete and distinct from the Maasai [see contributions to Spear and Waller (eds.), 1993]. This dynamic period of expanding territory and evolving ethnic identity, culminated in the *Iloikop* wars. By 1880, these had left powerful allied Maasai groups in control of the central rift valley grazing, but also set the scene for conflict among the victors........

"The turning-point for the Maasai expansion came at the end of the nineteenth century. Catastrophic epidemics of introduced disease swept through Maasailand. Intersectional raiding to rebuild herds helped the spread of livestock disease, and famine, and the movements that resulted, speeded the spread of smallpox and other human diseases. This period of disaster, remembered as *Emutai,* decimated herds and Maasai communities alike and drove Maasai survivors to take refuge as gatherer-hunters, as slaves, as dependants in farming groups, and as mercenaries with colonial forces [Waller, 1988]. In 1903, a new *Eunoto* age-set ceremony reconciled the survivors of warfare, disease and a shattered economy. Maasai society emerged, after 1900, in a new form. The period of expansion was over, spatial organisation had changed, the boundaries were closing and the colonial administrative structure of section and location assumed new importance. The internal balance of power between warrior and elder agesets shifted. A harder-edged definition of Maasai identity emerged as boundaries became fixed and the question of who was, or was not, Maasai became for the first time and important determinant of right of access to scarce resources [Waller, 1993]" (Homewood, 1996).

4.2.1 Administrative Jurisdiction

The administrative history of Maasailand begins in 1886, with the demarcation of the Kenya-Tanganyika boundary. Between 1986 and 1890 the British consolidated their sphere of influence to the north of the boundary and the Germans to the south. In 1902 the Maasai in Uganda were transferred to the East African Protectorate under Naiveté Province; and in 1904 two Maasai reserves were created: a Northern Reserve, centred on what is now Laikipia District; and a Southern Reserve, centred on what is now western Kajiado District.

By treaty of 1911, the Maasai of the Northern Reserve moved into an enlarged Southern Reserve. Two districts, Narok and Ngong were formed from that reserve in 1913, with Narok serving as

Kajiado. Maasai Province was reduced to an extra-territorial district in 1934, and was absorbed into Southern Province in 1953. (Sandford, 1918; Campbell, 1981; Ole Katampoi *et al.*, 1990; and Grandin, 1991).

Administrative boundaries in Kajiado District correspond closely with the territories occupied by the main Maasai sections (*iloshon*; singular: *oloshon*). The study area is located in the extreme west of Kajiado District on the boarder with Narok District in Magadi Division, the territory of the Iloodokilani.

Administratively, the area is located within Magadi Division of Kajiado District. Magadi Division, itself, is divided into Olkiramatian Location to the north and Magadi Location to the south. Olkiramatian Location is divided into four sub-locations: Nguruman, Olkiramatian, Oldoroko and Oldoinyo-Onyokie Sub-Locations. Magadi Location is divided into the Magadi and Shompole Sub-Locations.

4.2.2 Development Activities

4.2.2.1 Magadi Soda Company

With a current annual turnover of US$30 million (Naikuni, pers. comm.), the dominant economic force in the southern rift valley region is unquestionably the Magadi Soda Company. The company was first established in 1911, and its somewhat chequered history has been documented by Hill (1964).

4.2.2.1.1 Fuel Wood Collection

Rotating heated kilns, or ovens, are used to convert raw "trona" (sodium sesquicarbonate - $Na_2CO_3.NaHCO_3.2H_2O$) from Lake Magadi to sodium carbonate, or soda ash, in a process known as "calcining". In the early years of operation of the Magadi Soda Company, imported oil was used as the primary fuel source. To reduce costs during the world economic depression in the thirties, however, it was decided to replace oil by locally obtained wood. A producer gas plant was built in 1934, and in that year 6,228 tons of fuel wood were cut and 4,100 tons were carted to Magadi (Hill, 1964).

In the company's annual report for 1935, the General Manager, Major Pelling, stated that "with the unlimited supplies of wood available within economic reach of Magadi it seems safe to forecast our independence of imported fuels for calcining." A substantial labour force was mobilised to cut and gather firewood in the surrounding area, and a fleet of vehicles was maintained for transport to the factory. In the following year, 8,185 tons of fuel wood were consumed in the production of 42,733 tons of soda ash. The use of fuel wood increased with increasing production of soda ash during the war years.

By 1941, a total of 70,734 tons of firewood had been cut, and doubts were raised about Major Peeling's "unlimited supplies." To quote directly from Hill, *op. cit.:* "By the end of September nearly all the available timber in the Magadi concession and in the river concession east of the Ewaso Ngiro had been cut out. In October cutting started to the west of the river, which had to be bridged. This area was 25 miles from Magadi, and due to the bad roads, transport costs were high. .... In 1942 and 1943 a shortage of lorries limited the tonnage of wood fuel which it was possible to transport from the cutting areas to the factory. The cost of the fuel from the west bank of the Ewaso Ngiro rose in 1943 to Shs.19/- a ton at the factory. Arrangements were made to buy wood fuel up-country - 3,658 tons in 1942 and 5,596 in 1943."

190,799 tons of wood fuel were cut down in the Nguruman area and consumed in the production of soda ash during the fifteen year period 1935-1949; an average of 12,720 tons per annum.

Assuming an average fuel wood yield of 100 tons/ha, this would amount to the clearance of 1.27 square kilometres of woodland each year, or 19 square kilometres in total. In practice, there is likely to have been considerable wastage, and a much larger area of woodland was probably cleared. It is not very surprising, therefore, that photo-interpretation (Section 4.5) shows a progressive increase in woodland and decline in shrubland during the immediate post war, post deforestation, period: 1950-1991, when woody vegetation was recovering.

4.2.2.1.2 *Water Supply*

From the earliest years of its existence, Magadi Soda factory depended on water supplies delivered through a circuitous 150 kilometres long pipeline from permanent springs on the Ngong hills, which also provided water for steam locomotives on the Magadi branch line. In times of drought, however, supplies dwindled, and, with increasing demand, it was recognised that additional water supplies would be required.

In 1949, "preliminary investigations confirmed that Ewaso Ngiro was too turbid for a source of supply, and that the Masai were opposed to water being taken from the Endosopia river. In September the local Masai and the Kajiado local Native Authority Council approved extraction of up to 200,000 gallons a day from the Oloibortoto river and the grant of two-thirds of an acre for headworks, providing 10,000 gallons a day were made available for Masai cattle at selected points along the 21 miles of pipeline to Magadi .... £175,000 was voted for the new supply from the Oloibortoto. Orders for the plant, equipment and pipes were placed in December 1950" (Hill, *op. cit.*).

The Oloibortoto water supply to Magadi became available in April 1952 and eventually replaced the supply from Ngong. During the first four months in which the Oloibortoto scheme was in service a daily average of 154,222 gallons was received in Magadi, of which 137,143 gallons were from the new supply, compared with an average of 35,930 gallons in the previous year. The Ngong supply continued to be operated, almost entirely for the benefit of the railway and the Maasai, until a satisfactory arrangement was reached for its disposal (Hill, *op. cit.*). The Oloibortoto remains the primary source of fresh water to the Magadi Soda Company to the present day.

4.2.2.2 Infrastructure

Other than the Magadi Soda Company, there is very little infrastructure in the southern rift valley. The initial impetus to open up the area came with construction of an access road to collect firewood for the Magadi soda factory in the mid 1930s. This was followed by construction of water pipeline from the Oloibortoto river to Magadi in 1951/52. Under the terms of the agreement for provision of water to Magadi, the pipeline includes several cattle water points along its 30 kilometre length. A second water pipeline from the Sampu river to Olkiramatian and beyond (?) was constructed in 1980. Local government offices have been built at Olkiramatian, but remain largely unoccupied. The study area has a good selection of airstrips to choose from: one close by the AMREF clinic at Nguruman, which has been rehabilitated recently by a joint contingent from the Kenya and British armies; another near the Ewaso Ngiro bridge; and a third at Olkiramatian settlement, which is no longer functional.

4.2.2.3 Agricultural and Rural Community Projects

4.2.2.4 Group Ranches

The formation of group ranches in Kajiado District began in 1964, immediately after independence, with the establishment of a proto-type at Poka in the Kaputiei section of Central Division, under the first phase of the Kenya Livestock Development Programme. By the mid eighties, after two further phases of the programme, at least fifty group ranches and many more individual ranched had been registered in Kajiado District. Olkiramatian (21,612ha) and Shompole (62,689ha) Group Ranches were declared in 1970; adjudicated in 1972; and formerly incorporated in 1974.

Map 2: Kajiado District Group Ranches

Source: Kajiado Atlas, 1990.

Much has been written, both for and against, the adjudication of land, the establishment of group ranches, and the continuing process of their sub-division (e.g. Ole Katampoi, 1990; Grandin, 1991; Rutten, 1992; and Klinken, 1993).

Table 1: Nguruman Time Line

1883	G.A. Fischer travels through Maasailand visiting Ngurumani on the Bagasi (=Pagasi?) river and another Ngurumani, also called Kalemma (=Nguruman?), two days march further north on the Endasopia
1883	Outbreak of Contagious Bovine Pleuro-Pneumonia (CBPP) - *olkipieri*
1890-94	Rinderpest epidemic *Oladua*
1892	Smallpox epidemic
1904	First Maasai Agreement establishing Northern and Southern Reserves
1911	Second Maasai Agreement, moving Northern Reserve Maasai to enlarged Southern Reserve
1911	First Magadi Soda Company established
1911	Construction of Konza- Magadi railway begins
1915	Construction of Konza-Magadi railway completed
1924	First Magadi Soda Company goes into liquidation Second Magadi Soda Company established
1926	Drought and famine: *Olameyu loolonito* - drought of skins
1928	Magadi Soda Company signs new 99 year leases on the waters and land surrounding Lake Magadi covering (792 square kilometres) and northern part of Lake Natron (46 square kilometres) signed, backdated to 1924
1929	Wall Street Crash - effective start of world economic depression
1934	Drought and famine: *Olameyu looloyik* - drought of bones
1934	Period of fire wood collection to fuel Magadi Soda Company's calciners begins
1939	Second World War begins
1943	Drought and famine: *Eboot enkurma nanyokie* - great famine
1945	Second World War ends
1949	Period of fire wood collection to fuel Magadi Soda Company's calciners ends - total of 190,799 tons of firewood collected since 1934
1951	Heavy rains and flooding: *Olari loonkariak* - abundant grass and water
1951/2	Construction of water pipeline from Oliobortoto to Magadi
1960-61	Drought and famine: *Eboot enkurma sikitoi* - great famine of yellow flour
1963	Heavy rains and flooding: *Olari le nteke* - abundant grass and water - helicopters used for relief food supply
1963	Independence
1970	Declaration of Olkiramatian and Shompole Group Ranches
1972	Adjudication of Olkiramatian and Shompole Group Ranches
1974	Incorporation of Olkiramatian and Shompole Group Ranches
1980	Sampu water pipeline constructed
1983	ICIPE Field Station
1983-84	Drought
1987	KETRI Field Station
1991-93	Olkiramatian Shompole Community Development Programme (OSCDP), including use of odour baited traps for tsetse control, operational
1995	Deltamethrin pour-on introduced to Nguruman livestock owners on experimental basis for multipurpose disease and vector control
1997	Cumulative total of KShs.250,000 spent on pour-ons in Nguruman area

4.3 People and Agriculture

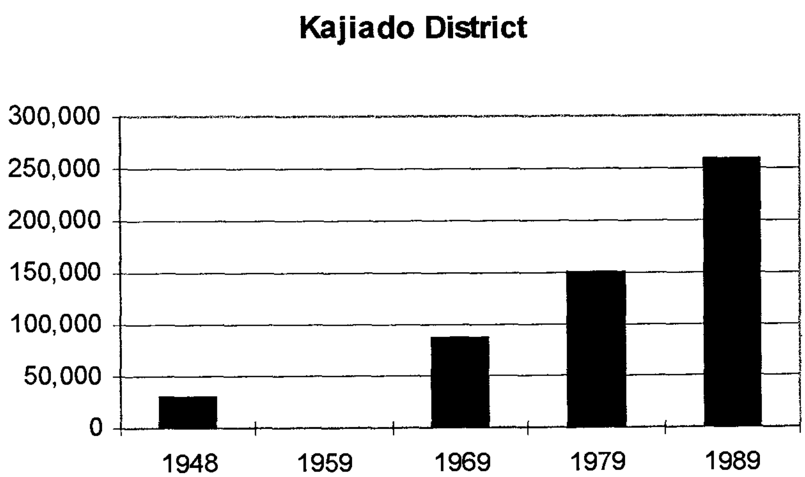
4.3.1 Population Size, Growth Rate and Density

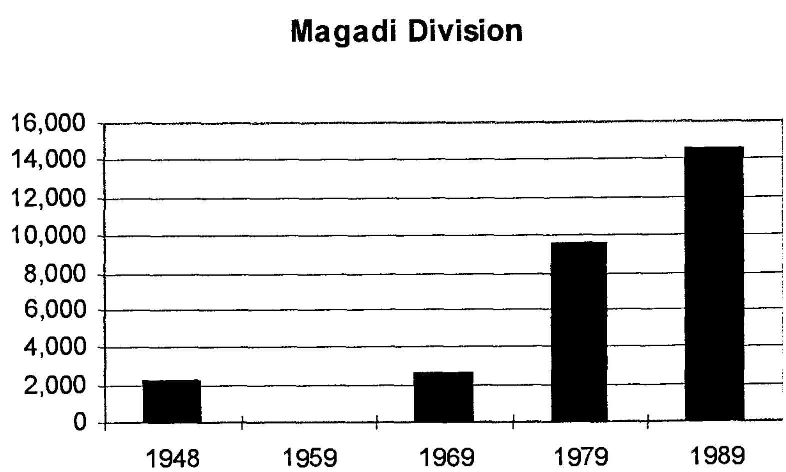
Table 2: Human Population Census Returns

Kajiado District					
Year	1948	1959	1969	1979	1989
Males	15,584		43,986	75,137	133,543
Females	13,403		41,917	73,868	125,116
Total	28,987		85,903	149,005	258,659
Households					
Sq. km			*22106 ?*	*19605 ?*	*21756 ?*

Magadi Division Population Growth, excluding Magadi town ?					
Year	1948	1959	1969	1979	1989
Males	1,113		1,433	5,031	7,747
Females	1,061		1,096	4,550	6,781
Total	2,174		2,529	9,581	14,528
Households				1,923	3,129
Sq. km	*853 ?*			*1921 ?*	*2689 ?*

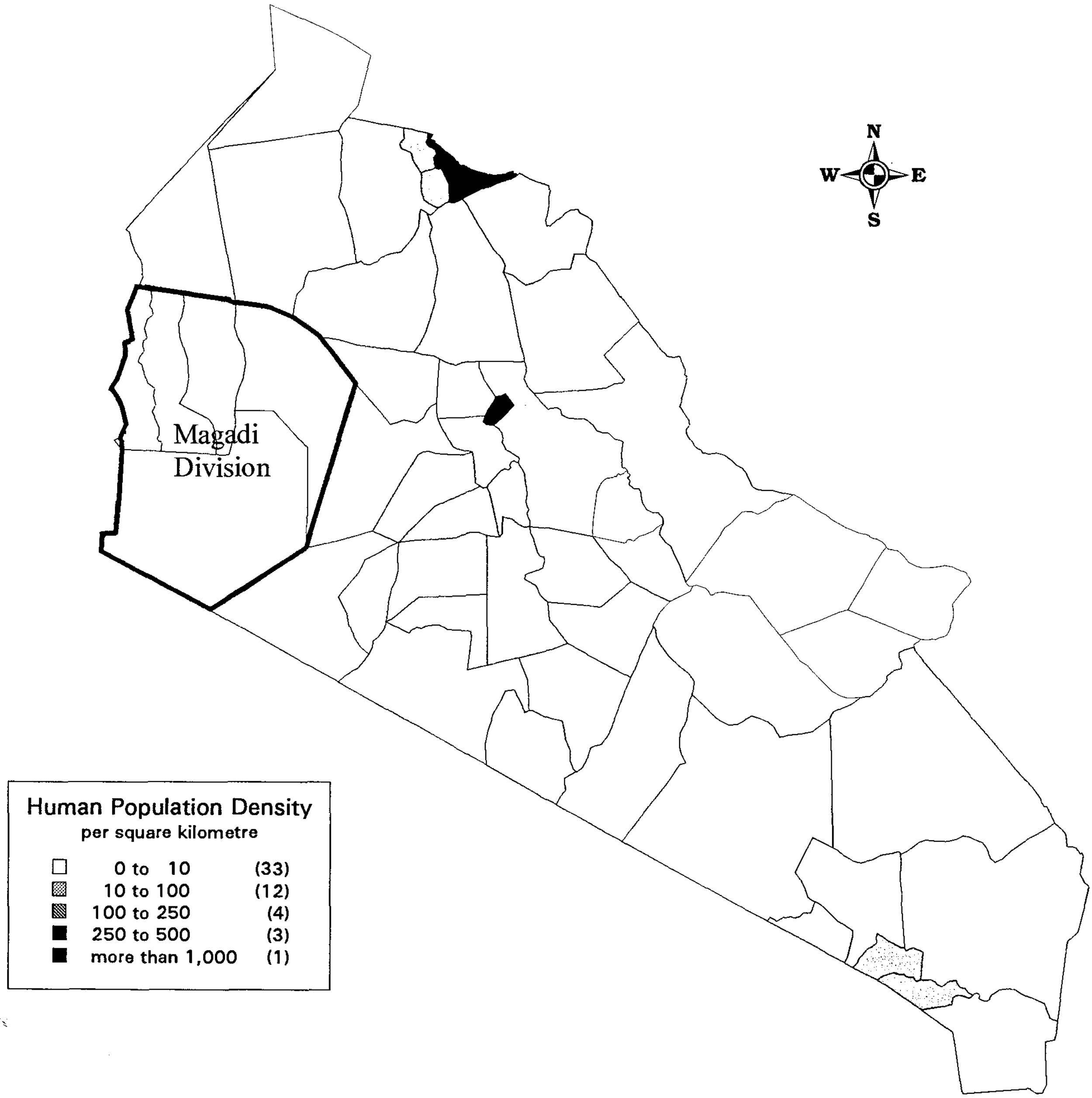
Figure 4: Human Population Growth





4.3.2 *Population Distribution*

Map 3: Human Population Density in Kajiado District 1989
Showing the Location of Magadi Division



4.3.3 *Ethnic Composition*

The great majority of inhabitants of the Nguruman area are Maasai.

4.3.4 *Farming Systems*

Predominantly transhumant pastoralism, with some agro-pastoralism and irrigated agriculture.

4.3.5 *Land Tenure*

Formerly communal land tenure through group ranch, but land with potential for irrigated

4.4 Livestock and Wildlife

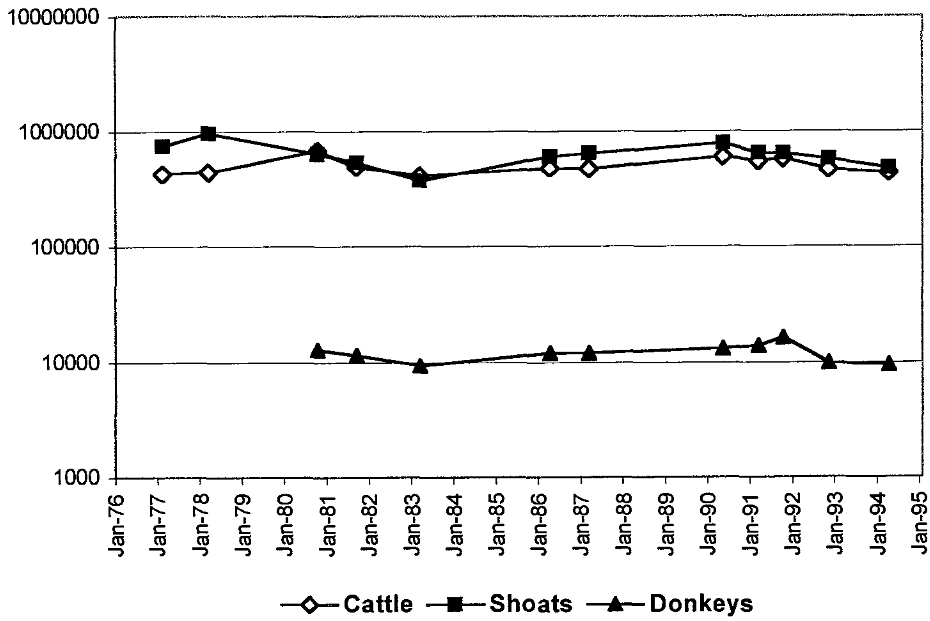
4.4.1 Livestock

Table 3: Kajiado District Livestock Populations: 1977-94

	Cattle	Shoats	Donkeys
Feb-77	428,123	749,059	
Mar-78	444,550	963,058	
Oct-80	670,972	630,442	12,767
Sep-81	488,362	538,778	11,433
Mar-83	409,105	369,235	9,339
Apr-86	479,984	605,677	11,926
Mar-87	470,079	641,978	11,987
May-90	604,929	786,300	13,002
Mar-91	551,759	639,274	13,759
Oct-91	576,535	641,671	16,204
Nov-92	466,583	569,686	9,791
Apr-94	437,623	479,848	9,511

Source: GoK, 1995; based on low level aerial surveys.

Figure 5: Kajiado District Livestock Population Estimates: 1977-94



Note: Logarithmic Scale

4.4.2 Wildlife

In the late fifties and early sixties, the commonest large herbivores in the Magadi area were wildebeest and the common zebra, found close by the Ewaso Ngiro swamp and in the surrounding grasslands. Buffalo were also abundant in the Ewaso Ngiro and in the foothills of the Loita hills. Impala and Grant's gazelle were both moderately common. Oryx could also be seen on the northern shore of Lake Natron, and giraffe occurred wherever there were acacias. Rhinoceroses were formerly abundant in the area, but had been greatly reduced in number. Elephants were rarely seen, but occasionally descended from the Loita hills to the Ewaso Ngiro Their absence from the strip between the river and the escarpment was considered curious, as in similar country elsewhere in Kenya they were often numerous. Hyena were numerous and lions were common. Leopards were to be found on the Nguruman escarpment and along the Ewaso Ngiro. Cheetahs were also present, but not common (Brown, 1964).

Spink and Stevens (1946) refer to the Nguruman escarpment as "a well watered country with long grass, large trees and numerous rivers, a Masai Reserve, but unfortunately tsetse-fly country. Game was plentiful, particularly buffalo and rhino, of whose presence there was much evidence."

No wildlife population estimates are available for the Nguruman case study area itself, but it seems reasonable to suggest that long term trends may be similar to those for Kajiado District as a whole, shown in Table 4. These figures are derived from repeated low level aerial surveys, and are the most objective and reliable assessments available. In marked contrast with most other areas in Kenya, wildlife populations in Kajiado have remained relatively stable, or increased, over the past two decades, the only exception being a significant decline in wilderbeest.

Table 4: Kajiado District Wildlife Population Trends: 1977-94

				Significant Difference		
	1970s	1980s	1990s	70s-80s	80s-90s	70s-90s
Baffalo	2,224	1,337	1,539			
Eland	2,421	6,107	5,262	+		+
Elephant	157	701	1,168			+
Gazelle - Grant's	26,509	23,124	26,482			
Gazelle - Thomson's	4,297	10,420	4,140	+		
Gerenuk	81	156	294		+	+
Giraffe	6,874	7,428	9,297		+	+
Impala	10,364	13,962	13,274			+
Kongoni	3,969	2,777	4,270		+	
Lesser Kudu	119	18	67	-		
Oryx	1,273	1,068	1,442			
Ostrich	2,289	4,913	8,917	+	+	+
Waterbuck	66	278	572	+		+
Wilderbeest	41,907	27,740	25,012	-		-
Zebra Burchell's	17,718	24,804	40,514		+	+

Source: Grunblatt et al. (1996)

4.5 Land Cover Change

Land cover change at Nguruman was assessed by comparative air-photo interpretation. For details of the method used see Appendix I. Aerial photographic coverage was available for 1950/52, 1961, 1970 and 1991. Total land area sampled varied slightly from year to year, depending on air-photo coverage, but approximated a total area of 660 square kilometres (22 by 30 kilometres). Results are presented in Table 5 and Figure 6.

Table 5: Land Cover Change in the Southern Rift Valley: 1950/52 - 1991

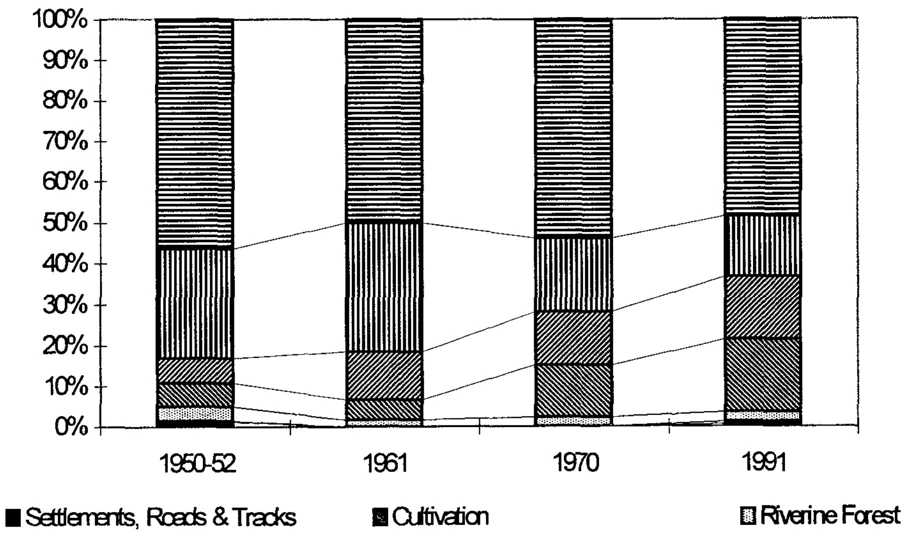
Year	Settlements, Roads & Tracks	Farm-land	Riverine Forest	Dense Woodland	Open Woodland	Shrub-land	Grassland, Swamp & Bare Grnd	Sample Points	Air Photos
	%	%	%	%	%	%	%	n	n
1950/52	1.23	0.10	3.70	5.76	6.07	26.65	56.48	972	27
1961	0.00	0.00	1.79	4.96	11.71	31.55	50.00	504	14
1970	0.00	0.00	2.38	12.70	13.10	17.86	53.97	252	7
1991	0.66	0.58	2.41	17.91	15.06	14.84	48.54	1368	38

Grassland, bare ground and swamp were recorded separately during photo-interpretation, but, because of seasonal and inter-annual variations in which grassland can change to bare ground or swamp, and back again, these three land cover types have been merged into a single class, which accounts for approximately half the total land area. The difference between 56% in 1950/52 and 49% is not statistically significant.

At the other end of the scale, cultivation, and settlement, roads and tracks, are at the limits of detection of the method used, and collectively accounting for less than 2% of the land area. Differences between years are not significant.

Riverine forest, which in reality is a very narrow band of more or less closed canopy vegetation fringing the banks of Ewaso Ngiro and Oloibortoto rivers, appears to have declined slightly from 3.7% in 1950/52 to 2.4% in 1991, but again this is not statistically significant.

Figure 6: Land Cover Change in the Southern Rift Valley 1950/52 - 1991



Things become more interesting when woodland-shrubland dynamics are considered. Dense woodland has increased three-fold, from 6% in 1950/52 to 18% in 1991. Open woodland has more than doubled from 6% in 1950/52 to 15% in 1991. This remarkable collective increase in woodland cover from 12% to 33%, appears to have taken place largely at the expense of shrubland, which has halved from around 30% in the fifties and sixties, to 15% in 1991.

As dense woodland is the primary habitat of *Glossina pallidipes,* the most abundant species of tsetse at Nguruman, it would appear that the potential extent of infestation may have increased over the past forty years from 1950/52 to 1991.

Three possible explanations are offered for these somewhat unexpected findings:

- Recovery of woodland vegetation, after extended period of firewood collection by Magadi Soda Company during the first half of the twentieth century (see Section 4.2.2.1.1).

- Recovery of woodland vegetation, in response to reduced destruction from declining in wildlife populations, especially elephant.

- Expansion of woodland resulting from climatic change, higher rainfall, increased escarpment runoff and/or raised water table.

Of the three, a combination of the first two is considered to be most likely, and are currently being investigated as a research study for a higher degree.

Although cultivation occupies only a very small percentage of the land area under study there are strong reasons to believe that the production of high value horticultural crops for the export market is becoming a major dynamo of the local economy. More detailed photo-interpretation and participatory rural appraisal are planned.

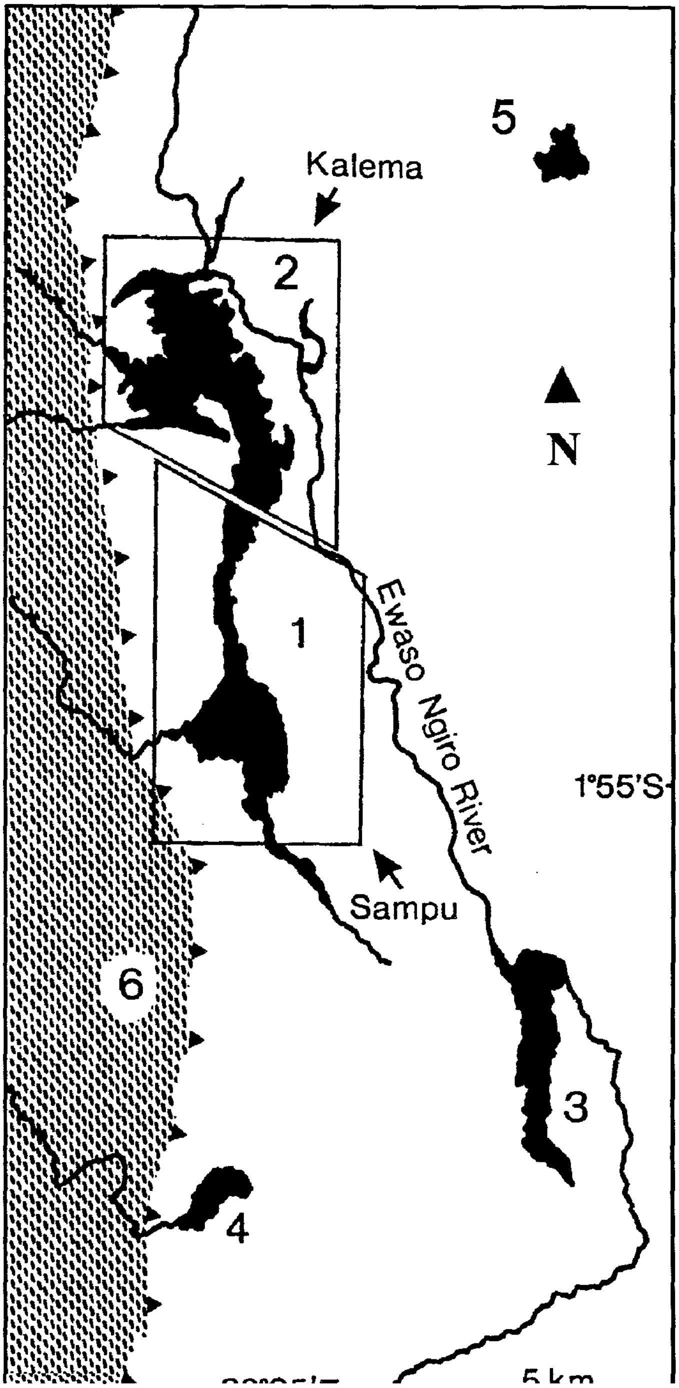
4.6 Tsetse and Trypanosomosis

Studies of tsetse and trypanosomosis at Nguruman began in the early eighties and have been the subject of some controversy and institutional rivalry over the years. The Nairobi based International Centre for Insect Physiology and Ecology (ICIPE) established its field station at Nguruman in 1983, and initiated a series of studies focusing on tsetse ecology, population dynamics and the development of trapping techniques for vector control. (Dransfield & Brightwell, 1989; Dransfield *et al.*, 1990; Williams *et al.*, 1990a, 1992; Brightwell *et al.*, 1992; and Brightwell *et al.*, 1997). KETRI set up its adjoining field station at Nguruman in 1987, to examine trypanosomosis and trypanotolerance in pastoral livestock, and the impact of the disease on livestock production (Mwangi, 1993; Roderick, 1995; Roderick et al., 1997; Stevenson, 1998; Mwangi *et al.*, in prep).

4.6.1 Tsetse Distribution

"The Nguruman area has a number of woodland patches infested with tsetse ([Map 4] see also Dransfield *et al.*, 1990), mainly *Glossina pallidipes* Austen with a lower number of *G. longipennis* Corti (Diptera: Glossinidae). The area most intensively monitored comprised two adjoining patches of woodland (the Sampu and Kalema woodlands) fed by streams from the Loita hills [west] of the Nguruman escarpment. A narrow strip of woodland along the Oloibortoto river joins these two patches. The lowland woodland patches are surrounded by mainly open savanna, which acts as a dispersal zone for both species of tsetse during the rains.

Both *G. pallidipes* and *G. longipennis* are also present on the top of the escarpment and for some distance into the hills. However, the highland *G. pallidipes* populations appear to be largely isolated from the lowland populations (at least in the dry season) by open scrub along the sides of the escarpment. The Ewaso Ngiro supports very few flies, other than where it broadens into the Ewaso Ngiro swamp (mostly *Cordia sinensis* thicket with scattered *Acacia tortilis* along season watercourses)." (Brightwell *et al.*, 1997).



Map 4: Dry Season Tsetse Habitat

Key: 1 Sampu Woodland; 2 Kalema Woodland; 3 Ewaso Ngiro Swamp; 4 Pakaase Woodland; 5 Oldoroko Woodland; 6 Escarpment plateau and foothills. Black triangles – escarpment top.

Box 1: Early Records of Tsetse in the Southern Rift Valley

Mr. E.D. Brown, an administrative officer stationed at Naivasha in 1911, reported that the country along the Uaso Nyiro (=Ewaso Ngiro), below its junction with Narosura river, "is never inhabited by the Masai, apparently because of tsetse-fly; excepting a strip some 10 miles long and varying from a mile or so, to 8 to 10 miles, the land is stony to a degree and full of thorn-scrub. But where the Ngurumani are, is a belt of fertile country traversed by many streams, which enter the Uaso Nyiro or lose themselves ere they reach the river."

Referring to the southern rift valley and Uaso Ngiro in 1913, the Government Entomologist Mr T.J Anderson, commented that "the valley, ten miles from the German border to the Nguruman colony is a fly-area. Two species were taken *Glossina pallidipes* and *G. longipennis*." The former was widely distributed and, contrary to expectations, *G. longipennis* was found to be common on the moist swampy flats and on the river bank.

In an unpublished report on the "Tsetse-fly of the Masai Reserve" written in 1914, Mr. R.W. Hemsted sated that the only region where fly prevailed to such an extent as to render it unfit for cattle was that lying near the lower reaches of the Uaso Nyiro. It was inhabited by the Ngurumani, apparently a branch of the agricultural Masai, who possessed fairly large flocks of sheep and goats, but who it was believed, never kept cattle.

A revised sketch map of the southern Masai Reserve, dated 1919, shows both banks of Uaso Nyiro from the Tanganyika border to a distance of about seven miles below the Naroura River, infested with tsetse-flies.

According to the Masai, tsetse-flies are present during and for some time after the long rains in the neighbourhood of Lorgasailik [Oloolkesalie], a prominent hill (5,000 feet high) north-east of lake Magadi. Near a swamp at the foot of this hill, there is thick bush favourable it would seem to *G. brevipalpis*. Specimens of *Glossina pallidipes* and *G. brevipalpis* were collected at 3,850 feet.

The Masai are a nomadic pastoral people and readily move their homes and stock when in need of water and grazing. During the rainy seasons surface water and green grass is available in the normally arid regions; and the people and their cattle, sheep and goats, are widely scattered over the reserve. The Nyiri desert, parts of the Athi and the Loita plains, many of the smaller plains and areas in the rift valley soon lose the surface water and the grazing is soon used up. In the drier seasons, the tribes concentrate in the richer areas of the reserve. Congestion becomes acute, and many are compelled to seek pasturage for their stock near and in districts, which they know to be infested with tsetse flies or some other pest. Rather than lose all stock by starvation, they venture into these districts with the hope, apparently, that at least a nucleus for future increase of stock may be saved. Long and bitter experience has taught these people the dangerous haunts of the tsetses. They seem to be familiar with the permanent belts of the fly, and the general extent of their spread during and after the rains. When possible, they avoid infested zones until the flies recede to their limited permanent habitations.

Extracts from: Lewis, A.E. (1934). *Tsetse-flies in the Masai Reserve, Kenya Colony.* Bulletin of Entomological Research, **25**, 439-455.

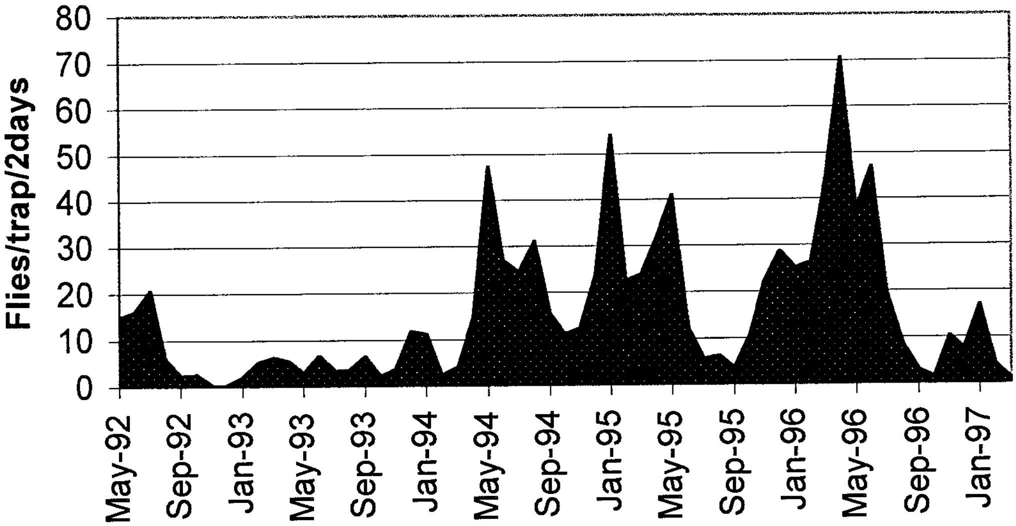
4.6.2 *Tsetse Trapping*

"Following the development of a low cost trapping technology (Brightwell *et al.*, 1987, 1991) in 1987, a pilot control project was started in about 100 km^2 of woodland and savanna. Initially 100 odour-baited NG2B traps were deployed concentrated in the 15-20km^2 Sampu woodland and along the Oloibortoto River up to the southern edge of the Kalema woodland; numbers in the area were greatly reduced (see Dransfield *et al.* 1990). The area was increased somewhat to about 150km^2 in 1988 with the addition of a further 110 traps near the escarpment and to the south of the Kalema woodland (see [Map 4]) mainly to act as barriers to re-invasion. Until 1990, the pilot control was maintained by ICIPE at the same intensity, but then maintenance declined and by 1991 traps in the Sampu woodland were falling into disrepair" (Brightwell *et al.*, 1997).

The Olkiramatian and Shompole Community Development Project (OSCDP) was started in May 1991. "This was a community-based integrated rural development project. Its objectives included tsetse control in the area, funded in part by the development of ecotourism (Dransfield *et al.*, 1991). Traps were constructed by the community and deployed over an area of about 100km^2 in the Kalema woodland (to the north of the original pilot control zone - see [Map 4] and later at Pakaase and the Ewaso Ngiro Swamp." (Brightwell *et al.*, 1997).

The tsetse control component of the community project was terminated in March 1993 (Williams *et al.*, 1995). Since then, intermittent trapping has taken place in the Sampu woodlands, and ICIPE attempted to revive community trapping, without success. Figure 7 shows the relative abundance of tsetse in north Kalema from 1992-1997, in terms of the mean number of tsetse caught in twenty biconical traps set for two days each month.

Figure 7: Mean Tsetse Catch in North Kalema



Source: Stevenson, 1998.

4.6.3 *Trypanosomosis*

4.6.3.1 Human Sleeping Sickness

No cases of human sleeping sickness have been reported from the Nguruman area, or the wider southern rift valley region. A few isolated cases have been reported in the past from the Maasai Mara region further to the west, but it is believed that these were contracted elsewhere in other more distant foci of infection (Wellde et al., 1989).

4.6.3.2 Animal Trypanosomosis

The incidence of trypanosomosis in cattle at Nguruman varies widely from zero to 50%, depending on the mode of herd management, breed, season and year. Sedentary livestock production is the exception rather the rule at Nguruman The great majority of Maasai practice seasonal transhumance to and from wet and dry season pastures, avoiding areas of tsetse infestation as best they can.

Transhumant herds, kept on the open rangelands away from tsetse habitats for most of the year, have much lower infection rates than sedentary herds, maintained in or near tsetse habitats throughout the year. Infections rates peak twice a year: once immediately after the long rains, when tsetse are most numerous and widely dispersed; and again during the late dry season, when tsetse abundance is relatively low, but cattle are forced to move into or through infested woodlands in search of fodder. The following sections have been extracted from Stevenson (1998).

4.6.3.2.1 Incidence of Trypanosomosis

From the regular monitoring of sentinel cattle, where treatment was only given if infection was confirmed, it has been possible to measure the number of times each year that cattle become infected with trypanosomes (Table 6). The traditionally managed cattle, that are moved as grazing is exhausted, seldom require more than one treatment per cow per year.

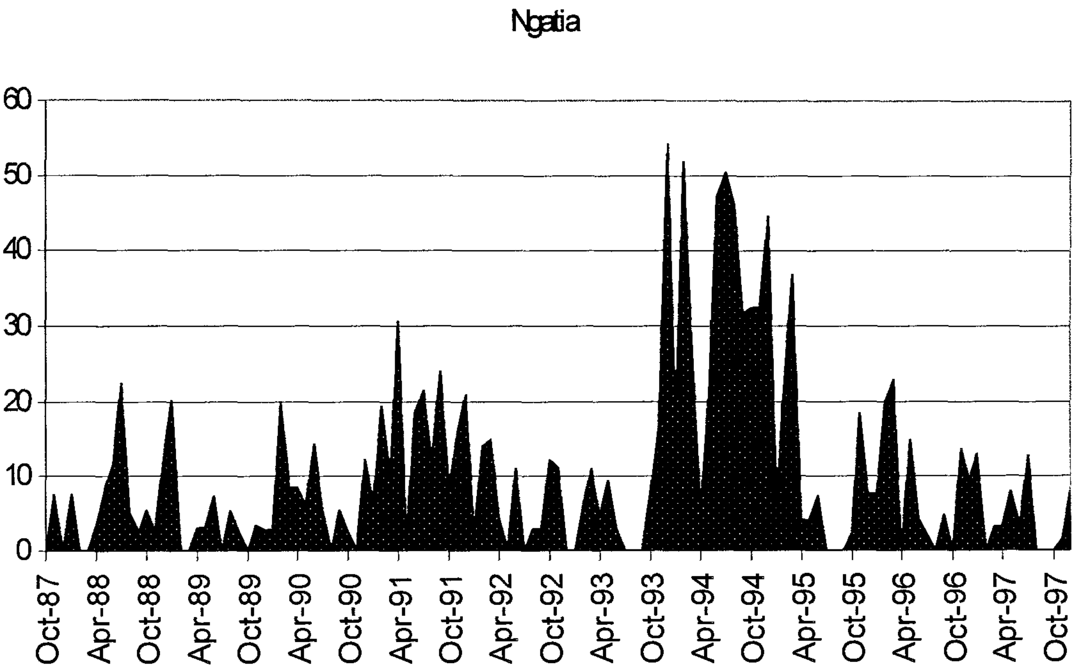
Table 6: Annual Trypanocidal Treatments Rates

Farmer	Herding	Tsetse Habitat*	1988	1989	1990	1991	1992	1993	1994	1995	1996
			Treatments per animal per year								
Ngatia	Transhumant	Sampu	0.8	0.5	0.9	1.9	0.8	1.1	4.1	1.0	0.9
Kinoya	Transhumant	Sampu		0.5							
Sarara	Transhumant	Kalema		0.7							
Kisiango	Transhumant	Kalema	1.2	1.1							
MRTC farm	Sedentary	River		0.6							
Kamango	Sedentary	North Kalema	4.6	3.7	4.4	3.0	1.1	1.1	3.0	1.9	1.5
Oloibortoto	Sedentary	South Kalema						3.1	6.6	4.3	3.9
Lasiti	Sedentary	Kalema		3.2							

* The main tsetse habitat that the herd may enter. Source: Stevenson, 1998.

There is annual variation in trypanosome infection rates and this is illustrated in Figure 8 that shows the incidence of infection in a transhumant herd that has been followed for 10 years. The one year when several treatments were required was 1994, when a severe drought forced the farmer to move his herd to the Sampu area and up the escarpment for much of the year. This was a year when the trapping scheme at Sampu was not functional.

Figure 8: Monthly Incidence of Trypanosomosis in a Transhumant Herd

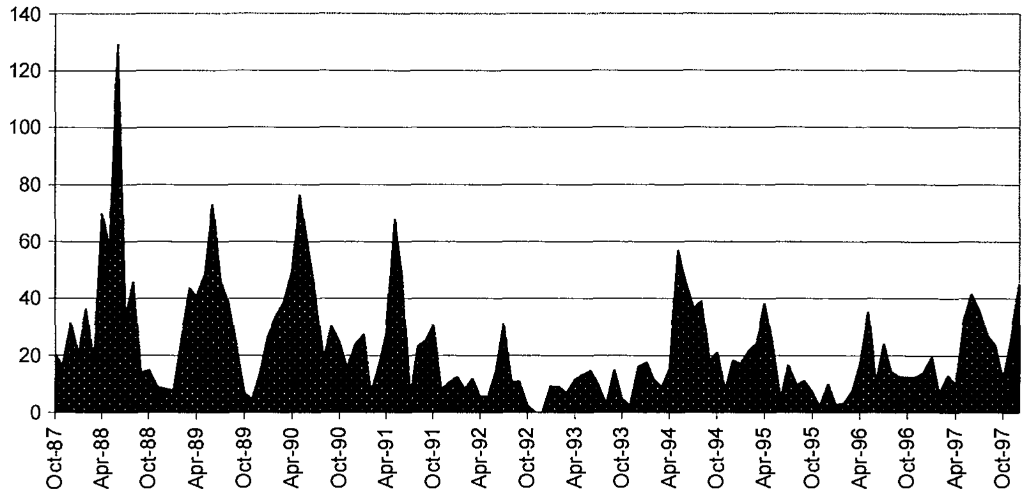


(Source: Stevenson, 1998)

This infrequent requirement for trypanocide treatment was supported by information on drug use obtained from farmers on the Group Ranch that were treating their own cattle, when they considered, from clinical signs, to be infected (Roderick et al.,1995: Roderick, 1997). Again, it was found that transhumant farmers were generally treating their cattle less than once a year.

A different picture is seen in the cattle resident in the Ngurumani village (Kalema) area. These cattle do not move away from the woodland during and after the rainy season, and the infection rate is therefore higher than that seen in the transhumant herds. Cattle belonging to one farmer (Kamango) in the north of Kalema have been followed for 10 years. These animals sometimes require treatment 3 – 5 times a year. The two years when treatment requirements were low (around one treatment per cow per year) were the years that the trapping scheme in the Kalema area was running efficiently and rainfall was low. The good correlation between fly numbers and infection rate in this herd has been described elsewhere (Brightwell et al., 1997). Since 1995, this farmer has been regularly using pour-on on his cattle and it is thought that this accounts for the reasonably low infection rates seen in the herd during 1995 and 1996 (Stevenson et al., 1998). As expected, there is a marked seasonal fluctuation in infection in this herd, with high infection rates being seen after the rains when fly numbers are high (Figure 9).

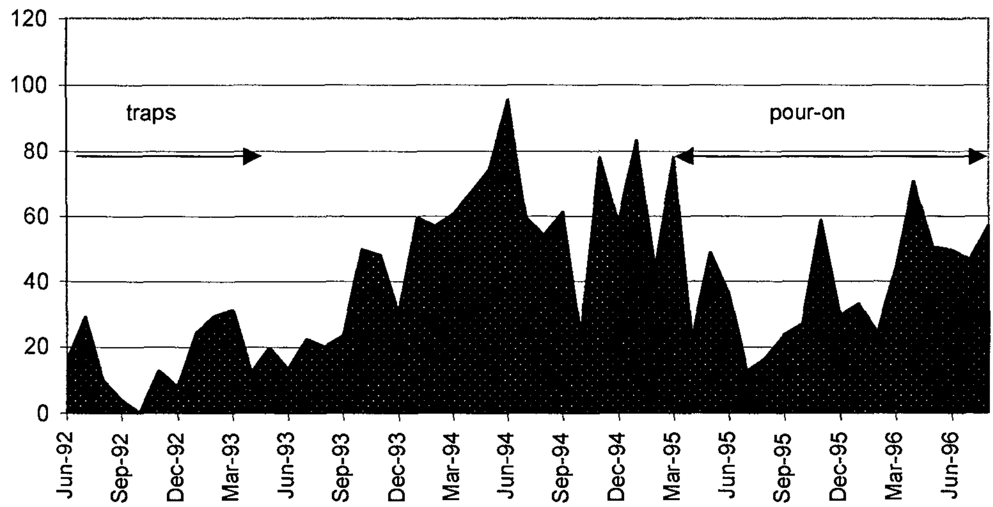
Figure 9: Incidence of Trypanosomosis in Herd Resident in the Kalema Area



Source: Stevenson, 1998.

A group of KETRI-owned steers (the Oloibortoto sentinels) has been kept close to the pipeline toad around the border of the Sampu and Kalema areas (Map 4). These steers graze along the base of the escarpment and towards the Kalema woodland. High infection rates can be recorded with the majority of the herd becoming infected in some months of the year. During the years of the trapping scheme at Kalema the infection rate was relatively low, but after the traps were abandoned the incidence of disease increased (Figure 10). Pour-on was applied to these steers from May 1995 at two-monthly intervals, which may account for the reduction in disease incidence after this time.

Figure 10: Incidence of Trypanosomosis in Steers at Oloibortoto, Near Pipeline Road



Source: Stevenson, 1998.

4.6.3.3 Disease Control Measures

The primary strategy adopted by the great majority of pastoralists at Nguruman for the control of trypanosomosis is to minimise the risk of disease transmission, by avoiding areas of tsetse infestation. Complete avoidance is rarely possible, so chemotherapy is also commonly practised. Chemoprophylactics are less frequently used, although some therapeutic drugs also have per animal, per year. Antibiotics are administered at a similar rate, and are frequently mixed with trypanocides as a broad-spectrum treatment. Studies by Mwangi, (1993) and Mwangi et al. (in prep.) also suggest that local Maasai zebu cattle exhibit a degree of trypanotolerance.

As Stevenson (1998) concludes, all the evidence collected to date supports the conclusion that the traditional Maasai pastoralists at Nguruman are able to avoid the main tsetse areas at Nguruman and keep the treatment rate in their cattle in most years to around one treatment per cow per annum. As one treatment for an adult cow costs the farmer around US$1 and suitable drugs are generally available on the Group Ranch, alternative methods of trypanosomosis control must be appreciably cheaper, and as simple to apply, if they are to be accepted by the farmers.

4.7 Environmental Concerns and Lessons for the Future

4.7.1 Environmental Concerns

4.7.1.1 Deforestation ?

Pastoralists are often accused of overstocking and habitat degradation. Contrary to this view, the air-photo based assessment of land cover change over the past fifty years in the Nguruman area indicates that woody vegetation cover has increased, following an earlier episode of deforestation by the Magadi Soda Company. More recently, the expansion of irrigated agriculture and horticultural production to supply Nairobi and more distant, but lucrative, markets of the European Union, has introduced a new factor into the equation and process of environmental change. Previously, the supply of soda ash; now the supply of "out of season" vegetables. Is pastoralism to be held accountable for both ?

4.7.1.2 Decline in Wildlife ?

Historical evidence indicates that there has been a widespread reduction in Kenya's wildlife populations since the beginning of the twentieth century. Systematic aerial surveys of rangeland areas confirm the continuation of this trend over the past two decades in all Districts, except Kajiado, Laikipia and Narok. Available information for Kajiado District, including the Nguruman case study area, suggests that, following earlier declines, wildlife populations have stabilised and that some species have increased since the late seventies.

4.7.2 Lessons Learnt

4.7.2.1 Limited Areas of Tsetse Infestation

The southern rift valley of Kenya is a hostile environment, with seasonal extremes of temperature and aridity beyond the limits of tsetse endurance, except where locally modified by vegetation. Only two areas of tsetse infestation in the southern rift valley are shown on Lewis's map of tsetse distribution in the Masai Reserve (=Narok and Kajiado Districts), published in 1934. The larger of the two, at the foot of the Nguruman escarpment and along the Ewaso Ngiro, remains. The other area, in the vicinity of Oloolkesalie, north-east of lake Magadi, where *Glossina pallidipes* and *G. brevipalpis* were recorded, seems to have disappeared (Stevenson, pers. comm., reporting the unpublished findings of Brightwell and Dransfield).

4.7.2.2 Effectiveness of Trapping for the Control of Tsetse

Traps are capable of controlling tsetse populations, but the local community trapping scheme was not sustainable, as implemented. When properly looked after, constellations of odour bated traps are a highly effective means of controlling tsetse populations, with population suppression levels in excessive of 99% being achieved over extended periods. Problems arose, however, in establishing a sustainable system of management and maintenance.

4.7.2.3 Reasons for Persistence of Tsetse

Although traps were highly effective at controlling local tsetse populations, eradication was not achieved, and fly numbers increased whenever trapping was reduced. This was because the two control areas were not isolated from each other, or from the adjacent escarpment, where uncontrolled tsetse populations remained as a source for re-invasion.

4.7.2.4 Indirect Control of Tsetse

Despite the failure to maintain an effective trapping programme at Nguruman, there is strong evidence to suggest that tsetse populations are being greatly influenced and controlled by the cumulative impact of human population growth and agricultural expansion. At Kalema, in particular, natural woodland is being transformed into farmland and wildlife has been virtually eliminated, although game is common in surrounding areas.

Brightwell et al. (1997) report that *"G. pallidipes* numbers have yet to return to pre-control levels. This could be partly because of the continuing drought with rainfall levels in 1994-1995 [and 1996] well below average, but in Kalema may also be due to clearing of the woodland for farms. Far from protecting forest, the community regards infested woodland as a threat to their livestock, and hence its destruction becomes inevitable.

4.7.2.5 Linkage Between Vector and Disease Control Demonstrated

Nguruman studies provide convincing evidence of a strong positive correlation between abundance of tsetse and incidence of trypanosomosis in cattle over a seven-year period. There are surprisingly few examples of the expected relationship in the scientific literature.

4.7.2.6 Successful Disease Control Strategy

The great majority of pastoralists at Nguruman minimise the risk of disease transmission by avoiding areas of tsetse infestation. Complete avoidance is rarely possible, and chemotherapy is common. Cattle are treated with trypanocidal drugs at an average rate of approximately one dose, per animal, per year. This very low average rate of treatment includes a range of husbandry practices, but is broadly indicative of the scale of the problem, and the success of the general strategy of disease avoidance.

4.7.2.7 Success of Pour-on Trials

A novel approach to trypanosomosis control has recently been introduced to livestock owners at Nguruman in trials involving the application of the synthetic pyrethroid, deltamethrin, as a pour-on. The product has been well received and accepted as a useful veterinary product by livestock owners, and one for which they are prepared to buy, alongside trypanocidal drugs, antibiotics, anthelmintics and acaricides that are already widely used. Pour-on appears to have a three fold attraction, for which livestock owners are prepared to pay good money: rapid and visible short term removal in ticks; general reduction in biting flies, not just tsetse; and improved looks of prestigious animals.

4.7.2.8 Future of Trypanosomosis Control at Nguruman

Given the failure of the community tsetse trapping programme, the continuing risk of trypanosomosis, and the apparent success of recent pour-on trials, it seems likely that the pour-on usage at Nguruman will increase in years to come, provided of course that products are available locally and are competitively priced. Pastoralist will also continue to use their age-old strategy of

NGUKUMAN

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APPENDIX I: AIR-PHOTO INTERPRETATION AND LAND COVER ASSESSMENT

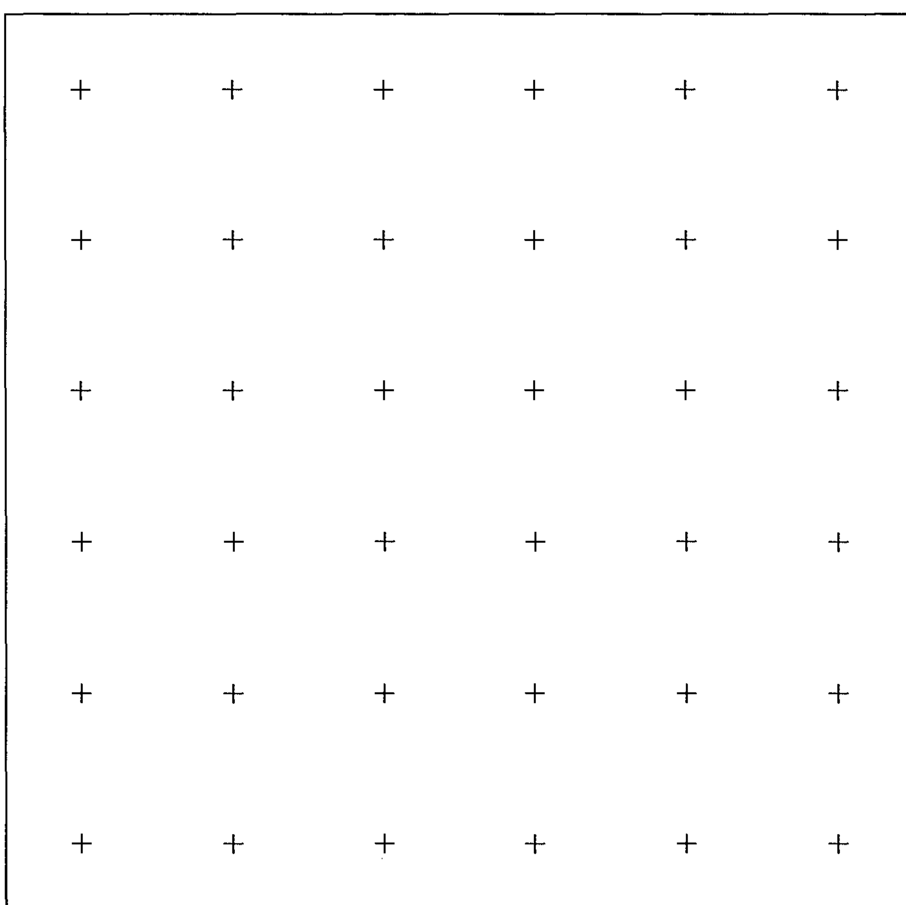
Land cover changes in case study areas were assessed by comparative air-photo interpretation.

Aerial photographic coverage specifications vary from survey to survey; e.g. height above ground (scale); extent of overlap between frames on same flight line; extent of overlap between adjacent flight lines; and film type (black and white, or colour). The method of air-photo interpretation outlined here is based on a technique of land use pattern analysis described by Brunt (1967) and demonstrated to KETRI Environment and Socio-Economic Unit staff using high resolution colour aerial photographs of Nguruman taken in 1991.

Because there is approximately 66% overlap between consecutive frames on each flight line and 33% overlap between adjacent flight lines, there is no need to examine all of every aerial photograph. In fact, if repetitive sampling of the same land area is to be avoided, which it should be, it is only necessary to sample the "unique" central part of every second frame. Given that each print is 9" x 9", the "unique" central part of every second frame is contained within a 6" x 6" portion, with a redundant peripheral 1.5" margin on all sides.

The "unique" central area of every second frame is sampled by means of transparent overlay with a 6 x 6 array of 36 sampling points (Figure 11).

Figure 11: 6 x 6 Array of Air-Photo Sample Points Used for Land Cover Assessment



Each sample point is examined closely and allocated to one of 10 possible vegetation and land use types (see Table 7). A tally is kept of the total number of sample points in each land cover category for each aerial photograph. Individual scores are then summed and converted to percentages for each survey area and period, from which it should be possible to demonstrate quantitative changes in the relative proportion of land cover types over time.

Table 7: Vegetation and Land Cover Types

Riparian Forest:
Along river coarse and drainages with dense trees (large/mature) and closed or nearly closed canopy.
Identification Characteristics: along drainage/tall-dense trees, dark colour, high texture

Dense Woodland:
Dense tree canopy but not closed, away from riparian zone (drainages).
Identification Characteristics: not along drainage, tall & medium trees, dark colour, high texture.

Open Woodland:
Scattered trees with either grass or shrubs as understory.
Identification Characteristics: fewer trees, scatter, medium colour, medium texture.

Shrubland:
No obvious trees (or very few), low height-shrub covering or scattered on ground.
Identification Characteristics: no trees, medium--light colour, medium texture.

Grassland:
No trees, few shrubs.
Identification Characteristics: no trees, light colour and texture.

Cultivation:
Includes active and fallow cultivation. Defined by a boundary, usually of geometric shape.
Identification Characteristics: pattern is geometric, light-dark in colour, texture varies.

Settlements/Tracks/Roads:
Usually dwellings can be seen, with bare ground and cultivation nearby. Tracks and roads are self evident and appear as white lines on photo.
Identification Characteristics: dwellings, lines.

Bare Ground/Rocks:
No vegetation.
Identification Characteristics: No vegetation, very light colour.

DFID Trypanosomosis Research Project

Olambwe Valley

Western Kenya

Grace Muriuki

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Cover Photograph (David Bourn): Visual Appraisal of Olambwe Valley. Note cultivation in foreground extends right up to boundary with Ruma National Park. Dense thicket vegetation on valley floor in middle distance is tsetse habitat.

5. OLAMBWE VALLEY

5.1 Introduction

For its size and relative economic importance, the Olambwe Valley in western Kenya has received an extraordinary degree of scientific attention, with epidemiological studies and vector control activities spanning more than 60 years: from the early days of tsetse trapping and selective bush clearance in the thirties; through repeated ground and aerial applications of insecticides in the fifties, sixties, seventies and eighties; to the use of targets impregnated with synthetic pyrethroids and community managed trapping in the nineties.

Nevertheless, despite thousands of person years of time and effort, and enormous expenditure of public funds, amounting to many millions of dollars over the years, tsetse and trypanosomosis are still found in Olambwe valley; and, at least according to some authorities, the disease still "poses a treat to the local farmers and tourists, as well as to inhabitants of other areas in Kenya where suitable tsetse fly vectors persist" (Wellde et al., 1989a).

How can this be? This case study summarises the history of tsetse and trypanosomosis control in and around Olambwe valley, reviews the reported incidence of sleeping sickness to the present day, and examines this information in the wider context of human population growth, agricultural expansion and environmental change.

5.1.1 Geographical Setting

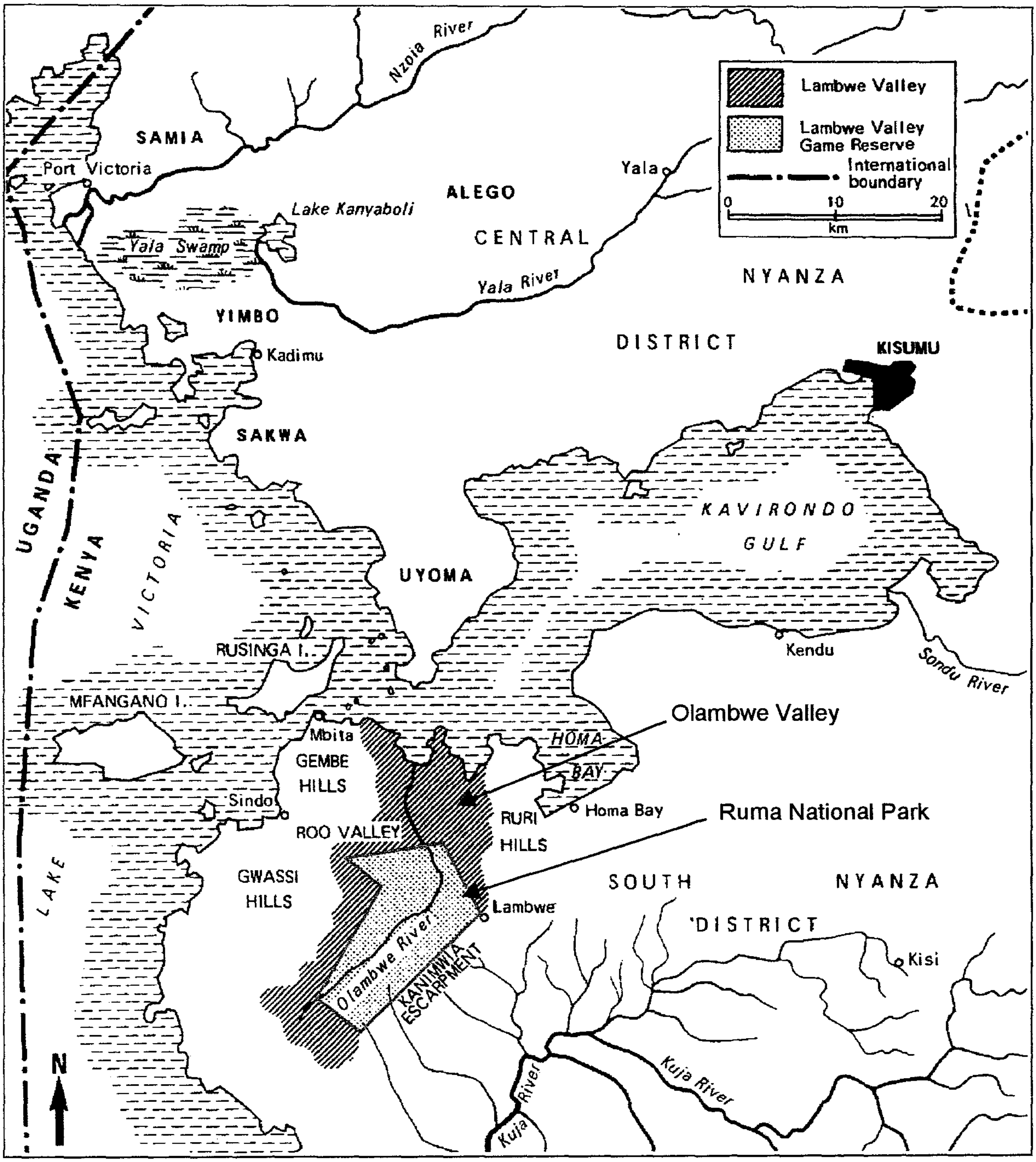
Until recently, the southern Nyanza region has remained relatively isolated from the mainstream of economic activity. To the north are the shores of Winam gulf, formerly the gulf of Kavirondo; to the west, the immense expanse of lake Victoria; to the south, the border with Tanzania; and to the east, the densely settled and intensively farmed Kisii highlands. See Map 1.

Olambwe valley is a major geographical feature of the region, covering some $350km^2$, with Ruma National Park occupying $120km^2$ of its central and upper reaches. The valley is located in present day Suba District, some 72km south of the equator, between latitudes 34° 10’ and 34° 25’ east and longitudes 0° 30’ and 0° 50’ south. To the west the valley is bound by the Gwassi hills, and to the east by the Kanyamwa escarpment; broadening from 7km at Miriya hill in the south, to 14km between Nyadenda and Kamgwagi to the north. A western extension opens out to form the Roo valley at the northern limit of the Gwassi hills. The Olambwe river, which is more of a stream than a river, reaches the shores of Lake Victoria at Kaksingri bay near the village of Sindo.

5.1.2 Topography and Soils

Olambwe valley, itself, separates two mountain zones of volcanic origin, the Gwassi and Gembe hills to the west, and the Kaniamwa escarpment to the east. The Gwassi hills rise to 2,273m at Wiratha, and separate the valley from the shores of Lake Victoria. The Kanyamwa escarpment slopes gradually from 1,758m at Gendo in the south, to 1,464m at Kamgwagi in the north. The valley floor itself lies about 75m above the level of Lake Victoria (some 1,200m above sea level), but during a relatively recent stage of tectonic activity the valley submerged below the waters of the lake. Deep porous lacustrine deposits have since been overlain with dark clays, with an extensive area of poorly drained "black cotton" soil extending over much of the valley floor. Elsewhere,

Map 1: Olambwe Valley and Environs

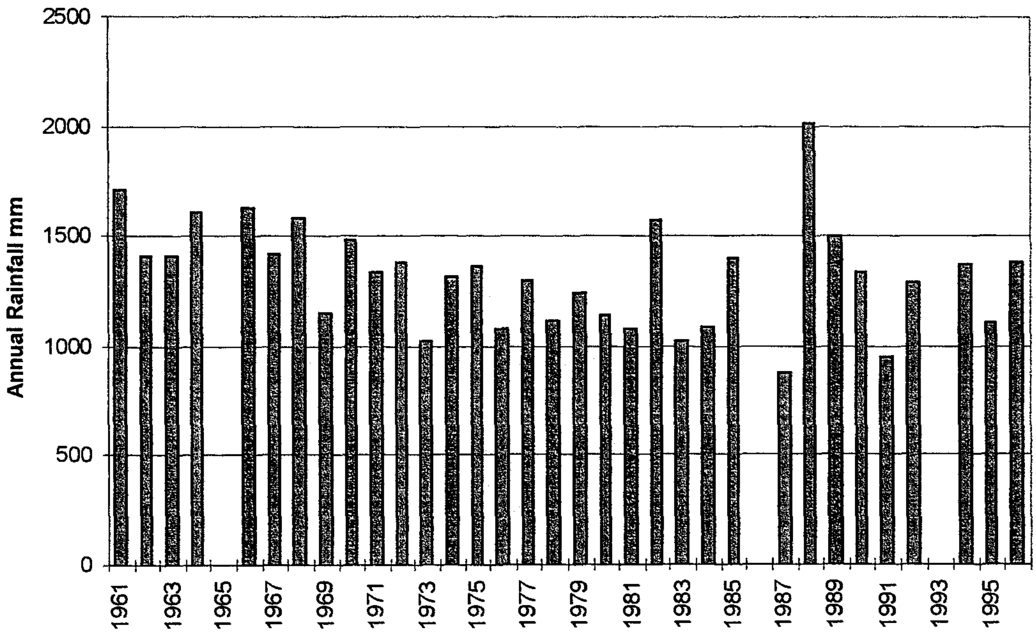


Source: Allsopp and Baldry (1972).

5.1.3 Climate and Rainfall

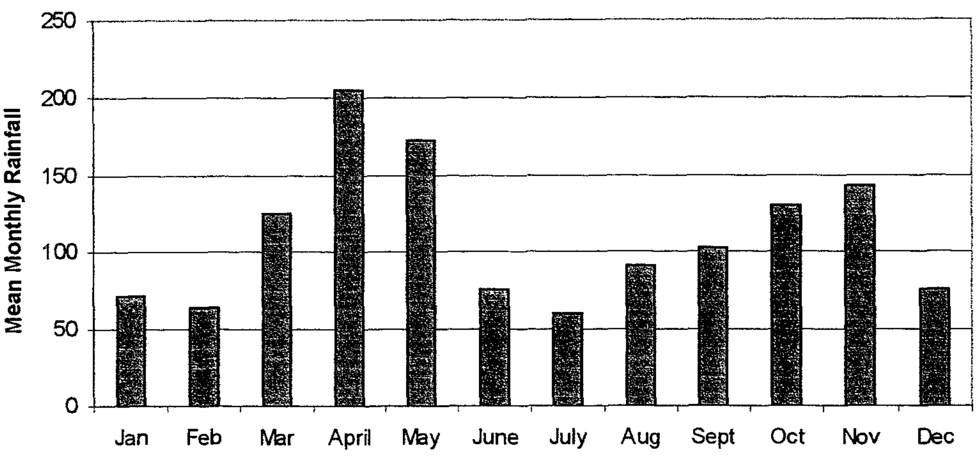
Located just south of the equator and adjacent to lake Victoria, the area has a warm and humid climate, with a mean annual temperature of 22^{0}C, and mean daily minima and maxima ranging from 17^{0}C to 30^{0}C. Long term mean annual rainfall at Lambwe Forest Station for the period 1961-96 is 1,340mm. See Figure 1. Lake shore areas tend to be driest, with annual rainfall of 500-750mm, increasing to 1,250-1,500mm on higher ground further inland.

Figure 1: Long Term Annual Rainfall



Normally, there is bi-modal pattern of annual rainfall, with the long rains extending from March through June, and the short rains from September to November. See Figure 2. The highest rainfall is usually in April, and the lowest in July.

Figure 2: Seasonal Pattern of Rainfall Distribution

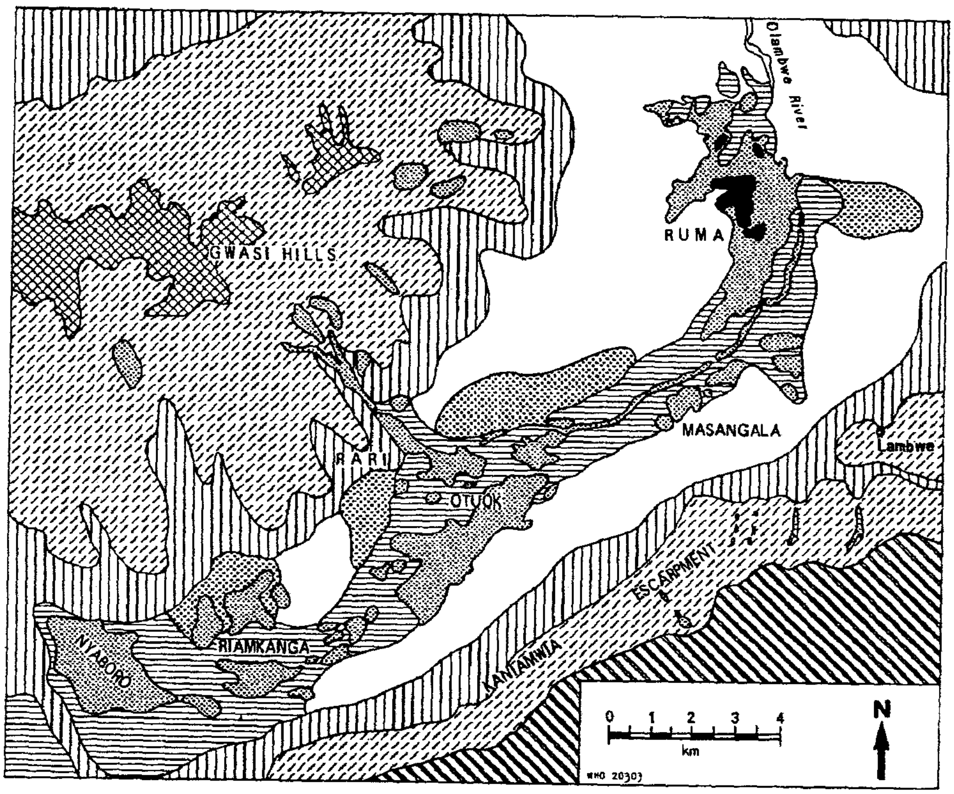


5.1.4 *Agro-climatic Zone and Vegetation*

The region is classified as sub-humid to semi-arid and having a medium agricultural potential. The vegetation of the upper and lower reaches of the Olambwe valley has been described and mapped by Allsopp and Baldry (1972). See Map 2. In addition to cultivated land, they identified eight distinct plant communities, including: Montane Forest, restricted to the summit of the Gwassi hills; three Grassland associations; Acacia Woodland; and three types of Dense Thicket. Whilst their general characterisation of vegetation types is probably still valid, it is clear that the patterns of vegetation and land use in the valley has changed appreciably over the years.

Two major trends are apparent. Outside the National Park there has been a widespread increase in cultivation; whilst inside the Park there has been a general expansion of dense thicket vegetation at the expense of open woodland. For a more detailed quantitative assessment of vegetation and land use change, undertaken as part of this study and based on comparison of aerial photographs taken in 1948, 1961, 1979 and 1993, see Section 5.5, below.

Map 2: Vegetation of the Middle and Upper Olambwe Valley



- Montane forest
- *Hyparrhenia/Combretum* grassland association
- *Hyparrhenia/Balanites* grassland association
- *Setaria/Acacia* and *Themeda/Acacia* grassland associations
- *Setaria/Acacia* and *Themeda/Acacia* grassland associations with dense *Acacia drepanolobium*
- Isolated thicket clumps and *Acacia seyal* woodland
- Dense continuous thicket
- *Euphorbia candelabrum* consociation
- Largely cultivated

Wellde et al. (1989b) comment on the coalescence and expansion of plant communities to produce "a continuous growth of thicket through the centre of the valley and encroachment of thicket into the grassland-acacia areas in the north-west and eastern areas of the National Park. The Ruma thicket has expanded along the northernmost boundary of the National Park and has joined the Masangala thicket to the south. The Otuok and Ramiakanga thickets have also expanded and occupy in dense or isolated clumps most of the south-west and southern borders of the National Park's perimeter. ...... Extensions of bush outside the National Park today include a large growth of thicket and *Acacia drepanolobium* at the northern boundary of the Park reaching as far north as the Homa Bay-Sindo road along the Lambwe River. South of the National Park, at Nyaboro, a large area of thicket which had previously been cleared has partially regenerated."

"Dense vegetation also extends in gullies up the Kaniamwa escarpment and connects with other areas of dense vegetation on the top of the escarpment. A white pine forest, first seeded in 1964 by the Forestry Department, covers the northerly aspects of the escarpment. The thicket in the valley has been the main source of firewood and house poles for people in the area, although the establishment of the National Park and the construction of a game fence in the early 1970s has undoubtedly reduced the entry of local people into the National Park area during the last decade. Land allotted to absentee owners has not been developed in some instances, and many of these plots are overgrown and provide suitable habitats for *G. pallidipes*. Efforts by the local administration to force owners to clear their plots have not been effective." Collection of firewood and building poles has since been curtailed by the establishment of the National Park and construction of a game fence in 1994.

5.2 Historical Perspective

Tsetse and trypanosomosis control in the Olambwe (=Lambwe) valley area has a long and chequered history, the highlights of which are summarised in the timeline in Table 1.

5.2.1 Administrative Jurisdiction

5.2.2 Development Activities

5.2.2.1 Community Services and Infrastructure

Much of the information presented here was obtained during the course of PRA discussions with local communities.

5.2.2.1.1 Roads

A reasonably good tarmac road links Homa Bay to Nairobi. A murram road connects Homa Bay to the Olambwe valley and a series of lesser rural roads traverse the area. Kenya Wildlife Service maintains access roads within the Ruma National Park in relatively good condition. A single road runs along the western side of the valley, at the base of the Gwassi hills. Buses, matatus and lorries ply the roads between Homa Bay, Magunga, Sindo and Mbita.

5.2.2.1.2 Water Supply

There is no piped water in the valley. The main water source is the Olambwe river and inflowing streams from both the Gwassi hills and the Kanyamwa escarpment. KWS and other agencies have sunk a few boreholes, some of which are properly protected, others are not. Ponds, swamps, cisterns and earth dams are used as supplementary sources, but are prone to dry up. PRA revealed that the quantity and quality of water supplies were generally considered to be inadequate.

5.2.2.1.3 Electricity and Tele-communications

Table 1: Olambwe/South Nyanza Time Line

	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	<-//->	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936
: Reduction in cattle and wildlife, including bushbuck, id warthogs	■	■	■	■	■	■																																	
:		■	■	■																																			
to be the vector of nagana in cattle in Zululand (Bruce,		■	■			■																																	
epidemic spreads around the shores of Lake Victoria. r move away.							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
ablished to be the cause of human sleeping sickness ted by tsetse (Bruce et al., 1903)														■																									
ness epidemic: Coastline from Sio to Karungu Bay, Kuja Peaked around 1905. Human population decimated.													■	■	■	■	■	■	■	■	■																		
s remains endemic, with occasional epidemic outbreaks																						■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
sickness epidemic: Samia to Uyoma and Kuja river																																■	■						
kness epidemic: Alego-Kadimu, Nyando river, Kuja river																																							
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ind trapping in northern Lambwe valley initially by 1948 had reverted to pre-control levels																																						■	■
ambwe Valley Development Scheme followed by Settlement Scheme																																							
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application of insecticide to lake shore and island habitats nce inOlambwe valley																																							
Game Reserve gazetted																																							
Game Reserve upgraded to National Park																																							
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al studies and community tsetse control using traps outside Park																																							
of Endosulfan. Despite nine cycles of application and a on in catch, tsetse recover rapidly after cessation of spraying																																							
cal studies and tsetse control using targets within Park																																							
r responsibility for tsetse control using targets within Ruma with advice from KETRI																																							
es of sleeping sickness in Olambwe valley and environs																																							

Table 1: Olambwe/South Nyanza Time Line (Continued)

	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
'pest panzoic: Reduction in cattle and wildlife, including bushbuck, ›, bushpig and warthogs																																			
›ox epidemic																																			
› established to be the vector of nagana in cattle in Zululand (Bruce,																																			
ng sickness epidemic spreads around the shores of Lake Victoria. ›eople die or move away.																																			
›osomes established to be the cause of human sleeping sickness be transmitted by tsetse (Bruce et al., 1903)																																			
eeping sickness epidemic: Coastline from Sio to Karungu Bay, Kuja gori rivers Peaked around 1905. Human population decimated.																																			
ng sickness remains endemic, with occasional epidemic outbreaks																																			
d sleeping sickness epidemic: Samia to Uyoma and Kuja river																																			
leeping sickness epidemic: Alego-Kadimu, Nyando river, Kuja river																																			
learance in Kuja-Migori river system																																			
learance and trapping in northern Lambwe valley initially ›sfully but by 1948 had reverted to pre-control levels																																			
›hase of Lambwe Valley Development Scheme followed by ve Valley Settlement Scheme																					?	?													
ieldrin ground spraying in Kuja-Migori river system																																			
ic ground application of insecticide to lake shore and island habitats sh clearance inOlambwe valley																																			
ve Valley Game Reserve gazetted																																			
ve Valley Game Reserve upgraded to National Park																																			
al Park downgraded to Game Reserve																																			
Reserve upgraded to become Ruma National Park																																			
panosomiasis Project: Ecological studies and experimental aerial tion of Dieldrin. Tsetse recover rapidly after cessat ion of spraying.																																			
lter Reed Army Institute of Research Trypanosomiasis Study. SS stic unit established at Magunga in 1982.																																			
›cological studies and community tsetse control using traps outside National Park																																			
›praying of Endosulfan. Despite nine cycles of application and a reduction in catch, tsetse recover rapidly after cessation of spraying																																			
ecological studies and tsetse control using targets within Park																																			
›ke over responsibility for tsetse control using targets within Ruma al Park with advice from KETRI																																			
›d cases of sleeping sickness in Olambwe valley and environs																							1	6	18	78	44	89	79	74	97	29	16	11	22

Table 1: Olambwe/South Nyanza Time Line (Continued)

Event	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Rinderpest panzoic: Reduction in cattle and wildlife, including bushbuck, buffalo, bushpig and warthogs																									
Smallpox epidemic																									
Tsetse established to be the vector of nagana in cattle in Zululand (Bruce, 1895).																									
Sleeping sickness epidemic spreads around the shores of Lake Victoria. Many people die or move away.																									
Trypanosomes established to be the cause of human sleeping sickness and to be transmitted by tsetse (Bruce et al., 1903)																									
First sleeping sickness epidemic: Coastline from Sio to Karungu Bay, Kuja and Migori rivers Peaked around 1905. Human population decimated.																									
Sleeping sickness remains endemic, with occasional epidemic outbreaks																									
Second sleeping sickness epidemic: Samia to Uyoma and Kuja river																									
Third sleeping sickness epidemic: Alego-Kadimu, Nyando river, Kuja river																									
Bush clearance in Kuja-Migori river system																									
Bush clearance and trapping in northern Lambwe valley initially successfully but by 1948 had reverted to pre-control levels																									
Initial phase of Lambwe Valley Development Scheme followed by Lambwe Valley Settlement Scheme																									
DDT/Dieldrin ground spraying in Kuja-Migori river system																									
Periodic ground application of insecticide to lake shore and island habitats and bush clearance inOlambwe valley																									
Lambwe Valley Game Reserve gazetted																									
Lambwe Valley Game Reserve upgraded to National Park																									
National Park downgraded to Game Reserve																									
Game Reserve upgraded to become Ruma National Park																									
UN Trypanosomiasis Project: Ecological studies and experimental aerial application of Dieldrin. Tsetse recover rapidly after cessat ion of spraying.																									
US Walter Reed Army Institute of Research Trypanosomiasis Study. SS diagnostic unit established at Magunga in 1982.																	?								
ICIPE ecological studies and community tsetse control using traps outside Ruma National Park																									
Aerial spraying of Endosulfan. Despite nine cycles of application and a 99.9% reduction in catch, tsetse recover rapidly after cessation of spraying																									
KETRI ecological studies and tsetse control using targets within Park																	?								
KWS take over responsibility for tsetse control using targets within Ruma National Park with advice from KETRI																									
Reported cases of sleeping sickness in Olambwe valley and environs	26	18	13	15	12	13	13	3	62	35	25	59	30	12	13	0	2	9	3	0	0	0	0	0	0

5.2.2.1.4 Health

During the course of PRA, it was reported that important diseases in the past had been: malaria; sleeping sickness; diarrhoea; cholera and other water borne diseases; boils; and smallpox. Presently, the most important diseases were considered to be: AIDS; malaria; amoebiosis; infertility; impotence; cancer; and sexually transmitted diseases; malnutrition; and curses.

In the past, health facilities were restricted to Kamgwagi Forest Camp Health Centre; Homa Bay District Hospital; and Kisii Hospital. Nowadays, many more health facilities were available to the valley residents, including: Kamgwagi; Ogongo; Homa Bay District Hospital; Mirogi Mission Hospital; God Jope; Sindo; Nyadenda National Youth Service Camp; Ponge; Nyatoto; Sindo; UNICEF community health workers; Magunga; Tonga Mission Hospital and Kigua.

Use of traditional medicine was greater in the past. Reasons given for decline include: restricted asses to the principal source areas: Ruma National Park and the hills occupied by the National Youth Service.

5.2.2.1.5 Education

A recent social survey indicated that farmers in the valley had attended school for an average 4.4 years; 28% of household heads had had no formal schooling; 54% of household heads had had primary education from standard one to seven; and only 2.% had received education beyond secondary school. Currently, there are 22 primary schools and three secondary schools in the area, but education facilities were generally considered to be too far apart and inadequate.

5.2.2.2 Settlement and Development Projects

There have been two major initiatives to encourage people to settle and promote rural development in the Olambwe Valley: the Lambwe Valley Development Scheme in the early fifties, and the Lambwe Valley Settlement Scheme in the mid sixties.

Plans for the settlement and development of the Olambwe valley were formulated in the forties after the end of the Second World War, but implementation did not begin until the early fifties. The Lambwe Valley Settlement Scheme was jointly undertaken by the East African Trypanosomiasis Research Organisation (EATRO) and the Kenya Government's African Settlement and Land Utilisation Board. A settlement officer was appointed in February 1952. Prospective farmers were allocated land in four settlement blocks at the northern end of the valley, and a strategy of discriminative bush clearance was employed to remove tsetse habitat. Bush clearance on uncultivable land was undertaken by paid labour, but settlers were expected to clear their own land themselves. Bush clearance by settlers was slow, and at the end of 1953 it was decided that paid labour should be employed to speed up the process.

Large-scale settlement did not really get underway in the valley until the mid sixties, when 1,400 families settled at its northern end. Extensive tracts to the south were set aside for Government agriculture and forestry projects, and the final eradication of tsetse was planned. A major problem arose, however, when Homa Bay Council decided that the valley should remain in its natural state, as a game reserve and potential tourist attraction. The plan could, therefore, not be implemented as originally envisaged, and many new settlers abandoned their holdings for fear of further outbreaks of sleeping sickness. However, many landholders returned when it was learnt that the World Health Organisation had begun experimental tsetse control in 1969. New immigrants joined them, and the population of the valley increased substantially during the 1970s.

5.2.2.3 Lambwe Game Reserve/Ruma National Park

In the early thirties there were an estimated 500 elephants in the area, with 200 being counted in a single herd. Lion, cheetah and rhinoceros were also present in the valley (Lewis, 1936). An initial attempt to drive the elephants out of the valley was unsuccessful, even though many elephants were killed in the process (Nimmo, 1931). A further attempt in 1948, with the combined efforts of Game Department staff and Police from surrounding locations, eventually succeeded in driving the elephants through Gor Lango, over the Kaniamwa escarpment, and on into Maasailand. The former seasonal migration of wildlife to and from the Mara-Serengeti plains no longer takes place because of dense settlement of the land separating the two areas (Wellde, 1989b).

In 1966, whilst plans to clear and develop the southern Olambwe valley for agricultural purposes were being prepared, as part of the Lambwe Valley Development Scheme, an eminant local politician prevailed upon the Homa Bay Council to preserve the area in its natural state as a protected area. The success of the National Reserves and Parks in other parts of the country in attracting tourists, and the supposed economic benefit to be derived from them, are likely to have influenced the Council decision.

The interest of the Game Department in acquiring a large area of the valley for their purposes also played a role in the decision by local authorities to abort the government's development plans for he Olambwe valley. The establishment of the 120 square kilometre Game Reserve prevented further land and bush clearance for agricultural purposes, which had been so successful in eradicating *G. pallidipes* and sleeping sickness from the northern and Roo areas of the Olambwe valley. Members of the Ministry of Agriculture, especially those in the Veterinary Services Division responsible for tsetse control, were opposed to the establishment of the reserve, because of warnings made previously by others of the serious medical risk which would be incurred if *Glossina pallidipes* were not eradicated (Ivens Cochrane, 1956).

Subsequently, in 1968, a major national and international tsetse control initiative was launched, which ultimately failed to eradicate the vector. The status of the game reserve was upgraded to the Lambwe National Park in 1975. For reasons, which remain somewhat obscure, the area was downgraded to game reserve status in the following year. Seven years later, however, in 1983, the area was reinstated as the Ruma National Park.

5.3 People and Agriculture

Various historical records and descriptions indicate that Olambwe valley was extensively settled and densely populated by people and livestock at the turn of the century:

"The treeless plain running north and south from Homa Bay to Karungu was dotted endlessly with villages; on the level of the plain from one spot I counted over 90 homesteads" (Milne, 1908, quoted by Wellde et al., 1989b). Milne's map of the area shows that sleeping sickness was found at the mouth of the Olambwe river, but not further upstream in the valley proper.

Subsequently, however, for reasons which are not exactly clear, but which may well have included conflict between ethnic groups and/or the outbreak of disease, there appears to have been a substantial decline human population.

Writing of personal field experience in the mid-thirties, Aneurin Lewis, an agricultural entomologist working for the Veterinary Research Laboratory at Kabete, commented that there was evidence that century. On the hills there are definite traces of habitation by an energetic tribe. Stone walls and terraces may still be seen on Kiangogo Ugoro and the slopes of Ruri and Iringa. *[These were still evident in 1997 - author*]. Disused water holes and dams can be found in the valley and there is clear evidence of cultivated patches of land which has not long been abandoned."

"In the administrative records of 1908 it is stated that cattle were fairly plentiful in Kabwai, Kasigunga and numerous in Kaniamwa.... In Kisingiri the report of the year 1911 states 'There has been a great deal of sickness among the livestock in recent years, which is now somewhat depleted'...... Europeans speak of numerous cattle in the valley in 1915. One gathers from the present native inhabitants that heavy mortality from malaria and human sleeping sickness among the tribes on the lake shore, especially Kasigunga, gave rise to a fear that caused a steady evacuation of the area. As the people fell back the menace seemed to follow them. It extended and destroyed cattle and the people were forced to retreat up the Lambwe. Disease then attacked the cattle from other directions also..... [Witchcraft was suspected, and one ruling chief was murdered by the elders for poisoning the grass and water. This was a signal for people to leave the valley in large numbers to go to Tanzania.] The present chief and many elders state that only after most of the people had left did the bush become thick and beyond their control ......" (Lewis, 1936; quoted by Ford, 1971).

According to Wellde et al. (1989b), local people believe that a major migration from the area took place in the early 1920s, along with people from Kaksingiri, Gwassi and Gembe. Many of these people moved to Suna or Kadem, or to Tanganyika, as it was then. By the mid twenties the valley was virtually uninhabited and was settled by people from Kaniamwa. Their cattle, however, suffered high mortality and most people decided to return to their former homes, leaving only five families to stay on herding goats.

Plans for settlement of the area were formulated in the late forties by the East African Tsetse Research and Reclamation Organisation, in conjunction with the African Settlement and Utilisation Board and the Kenya Game Department. (GoK, 1951). Although some migrants from Tanganyika moved into the area and settled on the Nyadenda and Kaksingiri border at about this time, large scale settlement did not begin until some 1,400 families settled in northern Lambwe Valley during 1965 and 1966, as part of the Lambwe Valley Settlement Scheme (GoK, 1966).

The development plans included the eventual eradication of *G. pallidipes*, and allocation of large tracks of land in the southern part of valley for Government agriculture and forestry purposes. A major problem arose, however, when Homa Bay Council decided not to implement the plan fully and utilise the valley in its natural state as a game reserve. As a consequence, many new settlers left the area. However, with the advent of the WHO/FAO/UNDP experimental aerial spraying project during 1969-72, at least some of these people returned and they were joined by fresh immigrants, which contributed to the increase in human population during the seventies.

5.3.1 Population Size, Growth Rate and Density

Census returns for Olambwe valley and its immediate environs, summarised in

Table 2, demonstrate an almost four-fold increase in the number of inhabitants, from 42,000 in 1948 to 154,000 in 1989. With a total enumeration area of 1,400 square kilometres, including Ruma National Park, overall population density in 1989 was 110 people per square kilometre.

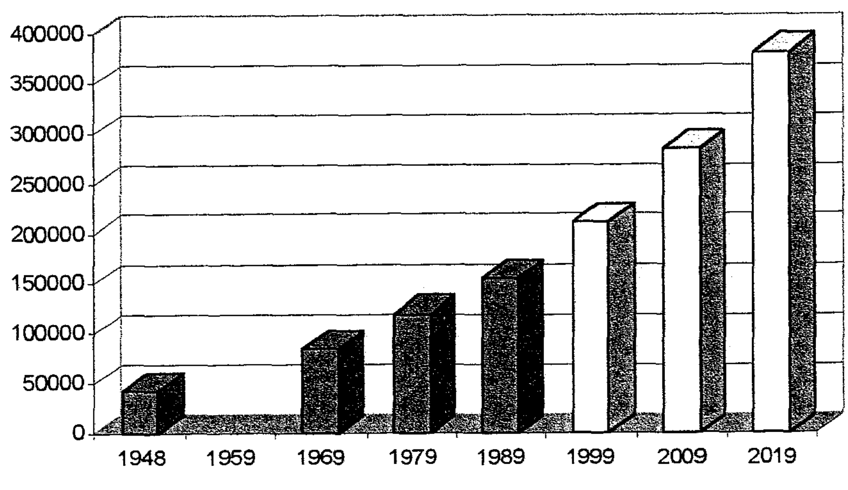
Population growth between 1979 and 1989 was 2.9%. Census returns and population projections, based on this growth rate, are illustrated in Figure 3. On this projection, there will be 381,000 people in the Olambwe region by 2019, and population density will be 272 per square kilometre.

Table 2: Human Population Census Returns - Homa Bay District

Admin. Area	1948	Location	1969	1979	Sub-Location	1989
North Nyokal	14,128	Kanyamua	22,191	25,885	Lambwe	16,749
West Nyokal	10,990	West Nyokal	22,532	25,643	Gembe	22,945
Gwassi	10,466	Gwassi	15,885	23,402	Kaksingri	16,873
Kasigunga	3,386	Olambwe	8,527	14,459	Gwassi East	11,222
Kaksingri	2,739	Gembe	9,613	17,705	Gwassi Central	8,582
		Kaksingri	6,364	12,341	Gwassi North	15,134
					Kwabwai	17,335
					Kanyadotto	14,835
					Kan. Kosewe	17,348
					Kan. Kologi	13,143
TOTALS	**41,709**		**85,112**	**119,435**		**154,166**

Sources: GoK (1990) and Central Bureau of Statistics.

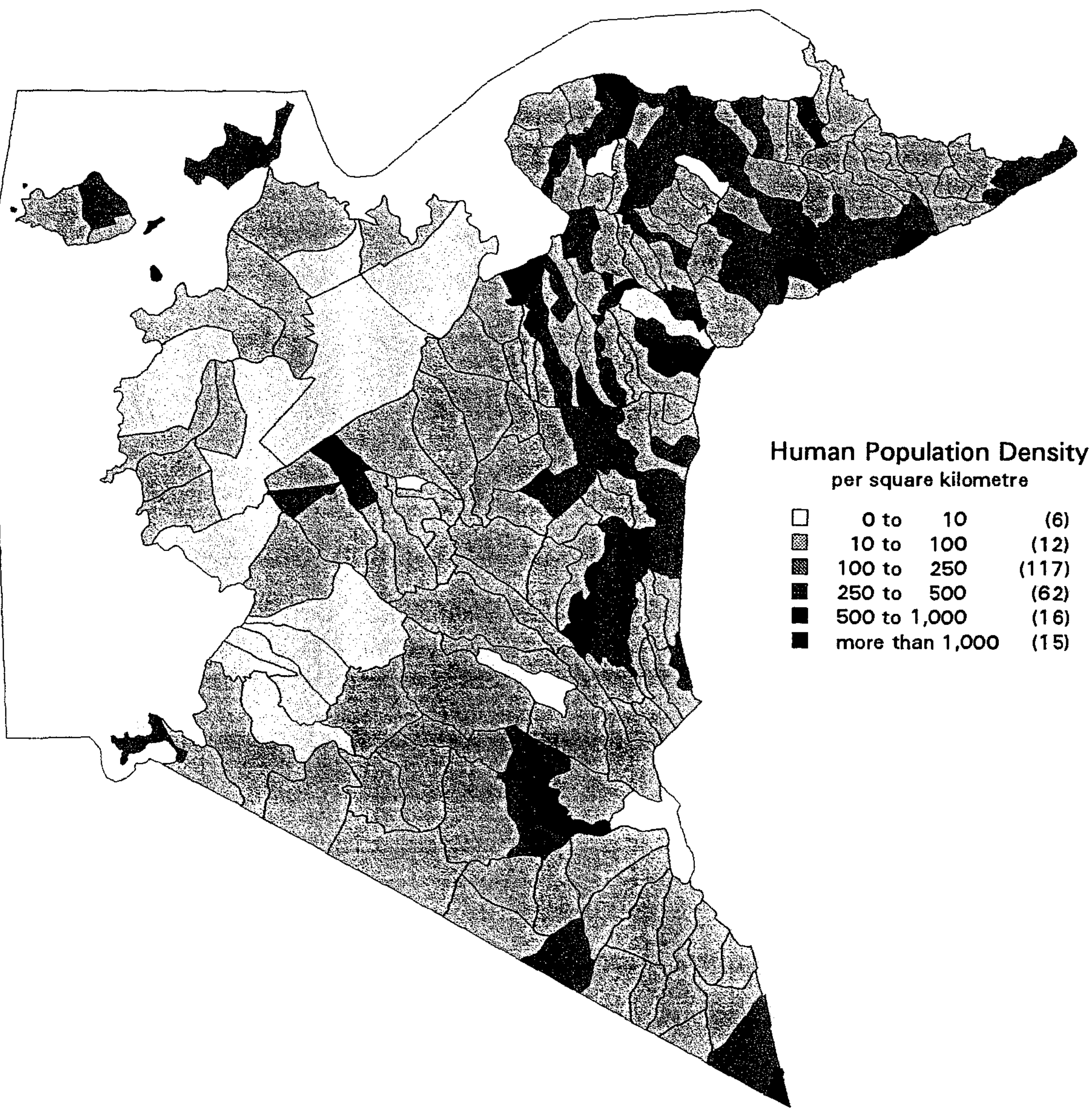
Figure 3: Human Population Growth: 1948-2019



5.3.2 Population Distribution

The distribution of human population in the Olambwe region, as indicated by the 1989 Census, is shown in Map 3.

Map 3: Human Population Density



5.3.3 Ethnic Composition

A variety of ethnic groups are represented in the area. According to the 1989 census, the majority of people are Luo (59%) and Abasuba (38%), with some Luhya (2%), Kisii (1%) and Kipsigis. The Abasuba are of Uganda origin and are concentrated around Kaksingiri.

5.3.4 Land Tenure and Farming Systems

5.3.5 Participatory Rural Appraisal

The primary purpose of Participatory Rural Appraisal (PRA) is to learn from, with and by members of the community (Theis and Grady, 1991). Methods and tools used in Olambwe valley are described in Appendix I. Community perceptions of change and important historical events are summarised in Table 3and Table 4.

Table 3: Trend Analysis

Parameter Assessed	1950s	1960s	1970s	1980s	1990s
Human Population	+	+	++	+++	++++
Household Income	++++	+	++	+++	++++
Human Diseases	++++++	++++	+++	+++	++
Education/Schooling	+	+	++	+++	++++
Rainfall	++++++	+++++	++++	++	++
Extent of Cultivation	+	+	+++	+++++	+++++
Extent of Pastures	++++++	++++	++++	+++	++
Extent of Forests	++++	+++	++	++++	++
Cattle Numbers	+	+	++	++	++++
Cattle Diseases	++++++	+++++	++++	+++	+++
Wildlife Numbers	++++	++++	++++	+++	+
Trypanosomosis	++++++	++++	+++	++	+

+ / ++	Few, small or little
++ / +++	Average to middling
> +++	Many, abundant or extensive

Table 4: Community Time Line

Year	Important Event
1920-30s	"Ndira", very severe cholera epidemic. Elephant invasion. Many people in valley.
1932	Locust invasion, followed by severe drought: Nyangweso. Mass migration to Tanganyika.
1936	Few immigrants started to return, problem with tsetse remained.
1937	Government started bush clearing to reduce tsetse. Elephant and buffalo driven out, but some buffalo remained.
1944	A lot of trypanosomiasis, and livestock was wiped out. Many people migrated to the lake region.
1948	"Debe" drought.
1952	Chief Stekus Seko, used the Chiefs Act to try and resettle emigrants. Mobilised community to clear bush. Magunga established as a Chief's Camp. Primary schools, some of which had started in 1930 but had stalled due to tsetse migration, were re-established at Kyabuya, Miramba, Wiga, and Kisegi.
1955	Tonga Mission started.
1953	Boreholes sunk at Magunga and Kyambuya. Dams at Siala, Agolomuok and God Keyo. Magunga dispensary also started in 1952.
1955-60	Chief Omuto took over as Chief. Lots of heavy rain. More resettlements by immigrants and good development was in progress. More schools at Tanga, Seka, Nyagwethe, Obanga and Kisaku.
1960-66	Mass bush clearing mobilized by Chief Romanus Omuto.
1962	"Lathri" famine, and Great floods.
1964	Announcement for settlement of the valley, and initial settlement. After independence former Kalenjin settlers went back to their original homeland together with their livestock.
1965	Aerial spraying to control tsetse. Sleeping sickness treatment started at Homa Bay District Hospital
1967	Heavy tsetse infestation. Greatly incapacitated people and the process of bush clearing.
1968	Chief Omuto sought government intervention to encourage people to settle in Gwassi. Many from Kakamega, Central Nyanza and Tanganyika came to settle. Government began forced treatment of sleeping sickness. Resettlement by those who had vacated the valley.
1970	Aerial spraying with two aircraft one from Tanganyika and the other from Kenya. The former crashed. Also ground spraying and bush clearing.
1971	Ground spraying around Lake Victoria followed because aerial spraying was not effective. A tsetse control camp was set up at Magunga.
1971/72	Government employed people to do bush clearing and ground spraying. Bush was burned from Ruma National Park up to Magunga over 3 year period.
1973	Burning. People started to cultivate again. Reallocation of land because previous settlers had migrated.
1974	"Kilo" famine
1978	Chief Okang'a became chief of Gwassi.
1979	More co-operative societies, such as fisheries were formed.
1971/72	A tsetse control camp was set up at Magunga.
1981/2	"Gorogoro" drought. Gwassi community, with support of government evicted Kisii community from the hills. Many of local community moved down from the hills to the valley bottom.
1984	"Konyiri kendi" drought
1988/89	Sleeping sickness epidemic.
1993	ICIPE initiated formation of KISABE for tsetse control activities outside Ruma National Park, in Kibwer and Samba sub-locations. Sentinel herd introduced for monitoring.
1994	Community Tsetse Control Committee formed, consisting of 15 blocks, with Chief Jacob as chairman.

5.4 Livestock and Wildlife

5.4.1 Livestock

Colonial administrative records confirm that animal husbandry was well established amongst inhabitants of Olambwe valley at the turn of the century. More recent information about livestock production systems and population estimates for the area has remained elusive.

5.4.2 Wildlife

For its size, the Ruma National Parks supports a remarkable variety of wildlife, including: buffalo, bushbuck, bushpig, duiker, giraffe, hyena, impala, Jackson's hartebeest, leopard, oribi, ostrich, reedbuck, roan and zebra. A herd of 28 Rothschild's giraffe was introduced in 1983. Jackson's hartebeest, Rothschild's giraffe and roan antelope are unique to the Park in Kenya. Small mammals are well represented and there is a wide variety of avian species, including a good range of birds of prey. Black mambas, puff adders and python are also present. Recent population estimates for some of the more common mammalian species are given in Table 5.

Table 5: Ruma National Park Wildlife Population Estimates (1996)

Species	Number	Species	Number
Waterbuck	246	Topi	408
Jackson's Hartbeest (kongoni)*	204	Oribi*	608
Reedbuck	978	Bush Pig	>200
Impala	390	Buffalo	100
Roan Antelope*	30	Hyena	50-100
Rothschild's Giraffe*	67	Leopards	20

Source: Kenya Wildlife Services, July 1996. * Indicates unique to Ruma National Park.

5.5 Land Cover Change

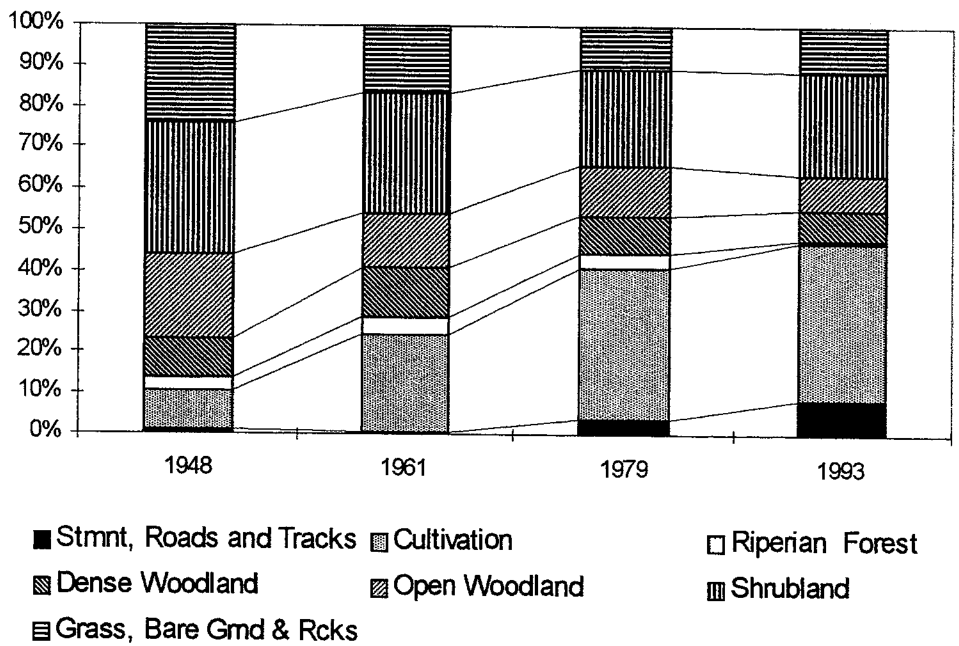
Land cover change at Olambwe Valley was assessed by comparative air-photo interpretation. For details of the method used see Appendix II. Aerial photographic coverage was available for 1948, 1961, 1979 and 1993. Total land area sampled varied slightly from year to year, depending on air-photo coverage, but approximated a total area of 1,000 square kilometres. Results are presented in Table 6and Figure 4.

Table 6: Olambwe Valley Land Cover Change: 1948-1993

Year	Settlements, Roads & Tracks	Farm-land	Riverine Forest	Dense Woodland	Open Woodland	Shrub-land	Grass, Bare Ground & Rocks	Sample Points	Air Photos
	%	%	%	%	%	%	%	n	n
1948	0.85	10.04	2.88	9.51	21.05	31.52	24.15	936	26
1961	0.76	23.74	4.04	12.63	13.13	29.29	16.41	396	11
1979	3.47	37.50	3.47	9.03	12.50	23.26	10.76	288	8
1993	8.64	38.49	0.49	7.50	8.47	25.22	11.20	2268	63

Since 1948, when the Royal Air Force took the first aerial photographs of the Olambwe valley region, there has been an almost four-fold increase in the extent in farmland in the area, from 10 to 38%. This expansion has taken place, in spite the fact that the Ruma National Park occupies a large proportion of the total land area. Surprisingly perhaps, no farming takes place within the Park itself, although land is cultivated up to the very edge of the Park fence in many places.

Figure 4: Olambwe Valley Land Cover Change: 1948-1993



Together with the increase of farmland, there has been a progressive increase in settlement and infrastructure, from about 1% of the land area in 1948 to 8% in 1993.

As Figure 4 clearly shows, this expansion in farmland, human settlement and infrastructure has been largely at the expense of grasslands and woody vegetation cover (woodlands and riparian), which have declined from 24% to 10%, and from 33% to 16%, respectively. It is the latter habitat that is home to the tsetse.

Map 4: Location of Sleeping Sickness Cases in Western Kenya

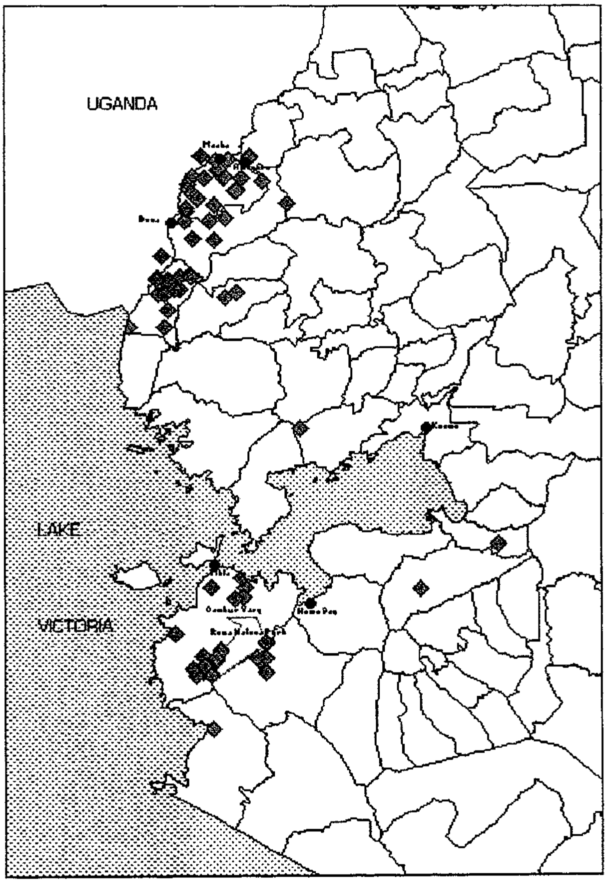
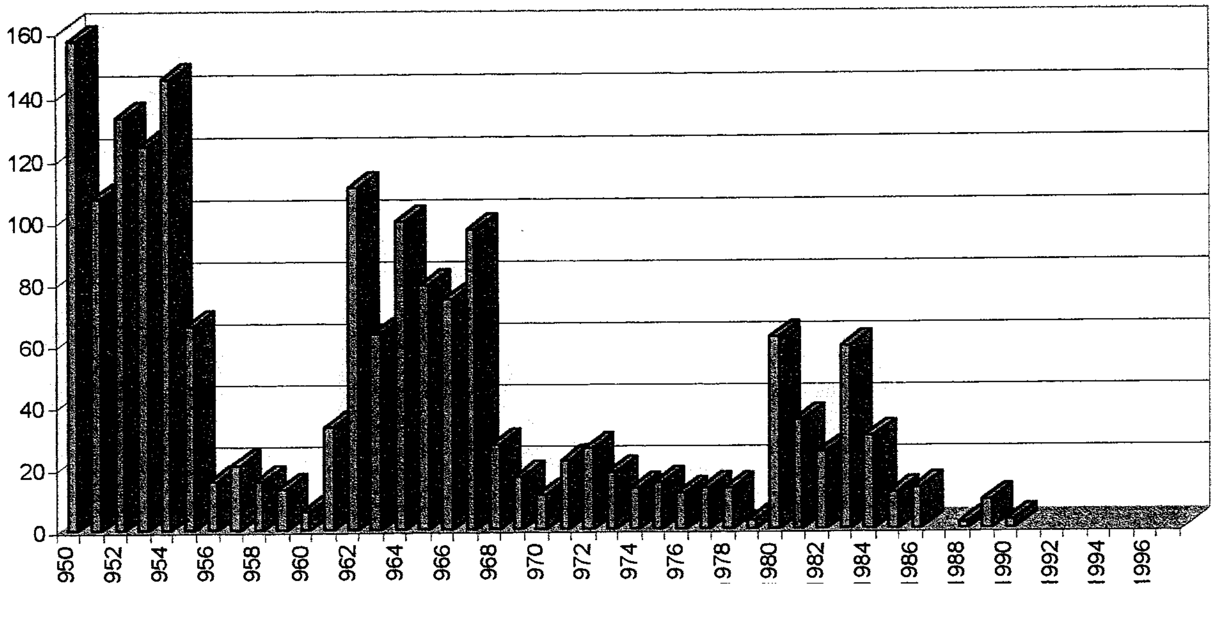


Figure 5: Reported Cases of Human Sleeping Sickness in South Nyanza



5.6 Tsetse and Trypanosomosis

5.6.1 Tsetse Species Present and Distribution

Nowadays, *G. pallidipes* is the only species of tsetse to occur in Olambwe valley, with records of its presence dating back to 1910 (Lewis, 1936). It used to be more widely distributed, but is now confined largely to dense thicket vegetation on the valley floor, most of which lies within the Ruma National Park. (See Map 2.) *G. brevipalpis* was also recorded in the valley in the sixties, but has since disappeared. *G. fuscipes fuscipes* occurs around the lake shore and riverine forest habitats, but not in the valley proper.

5.6.2 Trypanosomosis

5.6.2.1 Human Sleeping Sickness

Since 1950 there have been a total 1,799 recorded cases of human sleeping sickness from Olambwe valley and the wider South Nyanza District. See Map 4 and Figure 5. The number of human sleeping sickness cases was pieced together from various sources:

Kenya Totals:
1943-1957: Morris (1960)
1950-1961: Vaucel et al. (1963)
1953-1964: Willett (1965)
1962-1967: WHO (1969
1968-1978: Ogada (1979)
1978-1996: KETRI Files

S.Nyanza/Lambwe Valley:
1943-1957: Morris (1960)
1950-1961: Vaucel et al. (1963)
1953-1964: Willett (1965)
1959-1970: Baldry (1972)
1959-1984: Wellde et al. (1989b)
1968-1978: Ogada (1979)
1978-1996: KETRI Files

Cental Nyanza:
1943-1957: Morris (1960)
1950-1961: Vaucel et al. (1963)
1953-1964: Willett (1965)
1968-1978: Ogada (1979)
1978-1996: KETRI Files

Two periods of relatively high incidence of sleeping sickness are apparent. The first peak, between 1962 and 1967 coincides with implementation of the Lambwe Valley Settlement Scheme. The second, between 1980 and 1984 corresponds with increasing field presence of various agencies, including: ICIPE, which began studies of tsetse ecology and population dynamics in 1979; and the Walter Reed Army Institute of Research's trypanosomosis project, which established a sleeping sickness diagnostic unit at Magunga health centre in 1982.

At this point, it is perhaps worth noting that a disease survey of 1,340 inhabitants of Olambwe valley in 1978 indicated infection rates of 33% for malaria and 0.1% (sic) for sleeping sickness. (Wellde et al., 1989b).

5.6.3 Tsetse Control Measures

Attempts to control tsetse in the Olambwe valley date back more than sixty years to the mid thirties and have been summarised by Baldry (1972) and Wellde et al. (1989), from which the following brief account has been extracted. Experimental methods for the control of *G. pallidipes* by trapping and selective bush clearance began in 1935, and continued with encouraging results until the outbreak of the Second World War. Despite initial success, vegetation recovered and tsetse bounced back during the war years, and by 1948 the situation had reverted to what it had been before reclamation work had started.

New plans were drawn up for bush clearance and settlement of the area by the East African Trypanosomiasis Research and Reclamation Organisation, and implemented in collaboration with the African Settlement and Utilisation Board, the Game Department and the District Tsetse Control

Initially, settlers were allocated 50 acre parcels of land, but this proved to be too large for effective clearance and control of regeneration, and the allocation was subsequently reduced to 25 acres.

A second barrier of 2,000 acres was cleared between the Kaniamwa escarpment and Ruri hills in 1959. Heavily wooded gullies on the Ruri hills were also cleared. 500 acres of the Sikiri peninsula were reclaimed in 1959 by ground application of dieldrin along paths cut at 200 yard intervals. Aboricides were also used on an experimental basis to reduce the Ruma thicket vegetation, but were unsuccessful.

Further efforts to encourage settlement and development at the southern end of the valley during the sixties, were undermined by the establishment of a Game Reserve in 1966. Objections that the reserve would protect tsetse habitat and maintain a focus of human sleeping sickness were to no avail. A new round of bush clearance followed in an attempt to isolate the reserve from areas of settlement. Problem areas away from settlement in the Gembe hills were ground sprayed with dieldrin.

Experimental aerial application of insecticide was initiated in 1968 with the technical and financial support of the World Health Organisation and the United Nations Development Programme. Over the next three years dieldrin was applied to all major thickets in the Olambwe valley by helicopter, or fixed wing aircraft. The Tsetse Control Section of the Department of Veterinary Services also undertook an extensive programme of bush clearance and ground application of dieldrin.

Despite this onslaught, tsetse persisted. New plans were drawn up in 1972 and spray paths were cut throughout the Ruma thicket, but because of budgetary constraints, the thickets were not sprayed. However, protective barrier and limited habitat spraying of dieldrin continued until 1975, but thereafter were suspended until an outbreak of sleeping sickness occurred in 1980. The initial response was ground application of dieldrin to the periphery of the Lambwe National Park, upgraded from reserve status in 1975. This had a marked effect on the prevalence of sleeping sickness, but concern about the use of dieldrin caused the cessation of the programme and justified the aerial application of endosulfan in 1980/81. Endosulfan application greatly reduced fly numbers and the prevalence of the disease, but flies persisted and recovered to their former levels within a year. A further round of aerial application of insecticide took place in 1983, this time using pyrethrum, but this had no significant effect on tsetse numbers or in the prevalence of sleeping sickness and was a complete failure.

Subsequent field operations reverted to the ground application of insecticide (dieldrin and cypermethrin) and bush clearing, primarily within the park, until a new method of tsetse control, involving the use of insecticide impregnated screens, or targets, was introduced by KETRI in 1988.

In 1994, ICIPE and the UK Natural Resources Institute initiated a study to promote and assess the sustainability of community-managed tsetse-trapping in a limited area of tsetse infestation centred on the Nyaboro thicket, adjacent to the south-western boundary of the Ruma National Park.

5.7 Environmental Concerns and Lessons for the Future

5.7.1 Environmental Concerns

- Expansion of bush land and potential habitat within Ruma National Park.
- Land pressure resulting in cultivation of hillsides and soil erosion on the Gembe hills.
- Loss of biodiversity through expansion of agriculture.
- Continued survival of Park threatened by rising demand for land to farm in surrounding areas - potential loss of protected area status and biodiversity.
- Local communities express concern about water born diseases, but acknowledge that human health in general has improved.
- Quantity and quality of water supply.
- Social impact of development, increased accessibility and greater population mobility; resulting in loss of cultural values and identity.
- Previous concern about crop damage by wildlife alleviated by installation of park fencing.

5.7.2 Lessons Learnt

- Tsetse still persist in Olambwe valley, more than sixty years after control measures were first instigated. Application of scientific knowledge and understanding clearly has its limitations.
- Establishment of white pine forestry plantations on Kanyamwa escarpment in 1964 created new tsetse habitat and extended range of infestation.
- Despite massive increase in cultivation in surrounding areas, tsetse habitat remains and has expanded within Ruma National Park.
- As long as suitable habitats and hosts remain within the Park, it is likely that tsetse will continue to survive as potential vectors of animal and human trypanosomosis.
- Sleeping sickness in the Olambwe valley has subsided and is no longer perceived as a major health problem by local residents, who are far more concerned about AIDS, malaria and water borne diseases.
- Nevertheless, there is some risk of recurrence of human sleeping sickness, from wildlife, livestock or human reservoirs.
- Continued vigilance is necessary and vector control measures should be maintained.
- Vector control measures, currently managed by KWS, should continue to be targeted at primary tsetse habitat within the Ruma National Park, with peripheral community trapping and monitoring, and possible use of pour-ons, as additional safeguards.
- Use of targets and pour-ons are much more environmentally friendly than previous methods of tsetse control

- For sustainability, it is important, wherever possible, to involve local communities in disease control activities, as well as maintaining close collaboration and cordial relations between implementing agencies.

- In areas of intensive land and extensive cultivation, fencing of protected areas is well justified, both in terms of boundary demarcation and reduction in crop damage.

- For sustainability, it is essential that local communities recognise and receive benefits for respect and maintenance of protected area status.

- Timing, co-ordination and consolidation of disease control measures is all important. Tsetse and sleeping sickness control in seventies coincided with, and was consolidated by, increased voluntary settlement in surrounding area.

- Differences in perception of disease control and land use amongst various communities.

- Tsetse and sleeping sickness control can be used as a catalyst for settlement, agricultural expansion and environmental change.

- Trypanosomosis control may be justified as a means of promoting increased productivity through mixed farming.

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APPENDIX I: PARTICIPATORY RURAL APPRAISAL

Purposive Sampling
Information about environmental change in case studies areas was collected from local community groups. Ten to twenty participants were selected to take part in each of the group discussions.

Data Collection at Community Level
Participatory Rural Appraisal (PRA) tools and methods were used to collect information on environmental changes associated with tsetse and trypanosomosis in the case study areas. PRA is a family of approaches and methods used to enable people to present, share and analyse their knowledge of life and conditions, to provide better understanding and more effective development. The main aspect of the PRA is learning from, with and by members of the community (Theis and Grady, 1991). Qualitative surveys were carried out for the purpose of (a) collecting information about local production systems; (b) highlighting major changes on the nature of tsetse and trypanosomosis problem; and (c) identifying environmental concerns. The methods used included; key informant interviews, semi-structured interviews, time lines, trend analysis and participant observation.

Participant Observation
Observation is clearly the most basic method for obtaining information on and about the world around us. Observation is the key method for collecting reliable and valid data over a range of human behaviour. In this investigation, observation of physical features, social differences, behaviour and symbols provided important information for posing central questions. Observational data are supplemented by data obtained by other means. Direct observation was used to gain insights that were later tested by other techniques.

Semi-Structured Interviews
Semi structured interviews were held with community groups. Group interviews provided access to a larger body of knowledge of general community information. Questions were posed in dholuo according to a flexible checklist. Only some of the questions and topics had been predetermined, many questions were formulated during as discussion progressed.

Semi-structured interviews were used to collect information about local production systems, socio-economic circumstances, perceptions of tsetse and trypanosomosis control, and environmental concerns associated with these control measures. Groups of men and women were convened in each of the four areas. For each group 10-20 people were selected from various villages, different social strata with a bias towards age. The longer the period of residence the better. This was important so that participants were able to give information on changes that have occurred over as long a period as possible.

Time Lines
Time lines are rough overviews of events of significance for the history of the group or the area in question (Britha Mikkelsen, 1995). Time lines were important in that, they were used to correlate the changes noted during the semi structured interviewing.

Trend Analysis

Trend analyses emphasise changes in local resource endowments, cropping patterns, ecology, physical and social structure, settlement, population distribution, migration wealth, etc.. During the trend analysis exercise data for about 40 years was obtained. Using flip charts and marker pens, members of each group were asked to draw their own trend analysis diagrams. Trends show qualitative changes over time. Counters were used to provide a measure of change and relative importance. Trend analysis was used to obtain information about the extent of land under cultivation, livestock abundance, human population size, forests, pastures, wildlife numbers, human diseases, livestock diseases, and household income, between 1950s and 1990s. Causes of change were registered for further inquiry.

Key Informant Interviews

A key informant is an individual who is accessible, willing to talk and has great depth of knowledge about the particular issues of concern, here, health, livestock, community structure (Rhoades, 1979). At the community level the list included people who had been born in the area or had been resident for many years. The purpose for the interviews was to collect background information on human occupancy and key historical events, including: introduction of new crops, epidemics, droughts, famines, changes in land tenure, immigration and emigration.

APPENDIX II: AIR-PHOTO INTERPRETATION AND LAND COVER ASSESSMENT

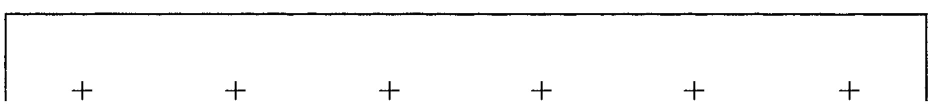
Land cover changes in case study areas were assessed by comparative air-photo interpretation.

Aerial photographic coverage specifications vary from survey to survey; e.g. height above ground (scale); extent of overlap between frames on same flight line; extent of overlap between adjacent flight lines; and film type (black and white, or colour). The method of air-photo interpretation outlined here is based on a technique of land use pattern analysis described by Brunt (1967) and demonstrated to KETRI Environment and Socio-Economic Unit staff using high resolution colour aerial photographs of Nguruman taken in 1991.

Because there is approximately 66% overlap between consecutive frames on each flight line and 33% overlap between adjacent flight lines, there is no need to examine all of every aerial photograph. In fact, if repetitive sampling of the same land area is to be avoided, which it should be, it is only necessary to sample the "unique" central part of every second frame. Given that each print is 9" x 9", the "unique" central part of every second frame is contained within a 6" x 6" portion, with a redundant peripheral 1.5" margin on all sides.

The "unique" central area of every second frame is sampled by means of transparent overlay with a 6 x 6 array of 36 sampling points (Figure 6).

Figure 6: 6 x 6 Array of Air-Photo Sample Points Used for Land Cover Assessment



Each sample point is examined closely and allocated to one of 10 possible vegetation and land use types (see Table 7). A tally is kept of the total number of sample points in each land cover category for each aerial photograph. Individual scores are then summed and converted to percentages for each survey area and period, from which it should be possible to demonstrate quantitative changes in the relative proportion of land cover types over time.

Table 7: Categories: of Vegetation and Land Use Types

Riparian Forest:
Along river coarse and drainages with dense trees (large/mature) and closed or nearly closed canopy.
Identification Characteristics: along drainage/tall-dense trees, dark colour, high texture

Dense Woodland:
Dense tree canopy but not closed, away from riparian zone (drainages).
Identification Characteristics: not along drainage, tall & medium trees, dark colour, high texture.

Open Woodland:
Scattered trees with either grass or shrubs as understory.
Identification Characteristics: fewer trees, scatter, medium colour, medium texture.

Shrubland:
No obvious trees (or very few), low height-shrub covering or scattered on ground.
Identification Characteristics: no trees, medium--light colour, medium texture.

Grassland:
No trees, few shrubs.
Identification Characteristics: no trees, light colour and texture.

Cultivation:
Includes active and fallow cultivation. Defined by a boundary, usually of geometric shape.
Identification Characteristics: pattern is geometric, light-dark in colour, texture varies.

Settlements/Tracks/Roads:
Usually dwellings can be seen, with bare ground and cultivation nearby. Tracks and roads are self evident and appear as white lines on photo.
Identification Characteristics: dwellings, lines.

Bare Ground/Rocks:
No vegetation.
Identification Characteristics: No vegetation, very light colour.