THE IMPACT OF CHANGING LAND USE PATTERNS ON THE NUMBERS AND DISTRIBUTION OF LIVESTOCK AND WILD HERBIVORES IN THE TANA RIVER DISTRICT, KENYA

BY

PATRICK WAKO WARGUTE

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R3T 2N2 WINNIPEG MANITOBA
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A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of Master of Natural Resources Management.

Mr. Patrick Wako Wargute

The University of Manitoba
Natural Resources Institute
177 Dysart Road Winnipeg Manitoba R3T 2N2

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a practicum entitled:

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ON THE NUMBERS AND DISTRIBUTION OF LIVESTOCK
AND WILD HERBIVORES IN THE TANA RIVER DISTRICT, KENYA.

Submitted by: Mr. Patrick Wako Wargute
in partial fulfillment of the requirements for the degree, Master of Natural Resources Management (M.N.R.M).

Faculty Advisor: Dr. R.K. Baydack

Advisor: Dr. J. MacMillan

Advisor: Dr. E. Onyebuchi

Advisor: Dr. R. Riewe

Chairman of the Oral Examination:
Dr. F. Berkes

Director, *Natural Resources Institute:*
Dr. F. Berkes
Signature

Date: Mar. 10 / 1992

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LIST OF ACRONYMS

AFC - African Farmers' Corporation

CBS - Central Bureau of Statistics

CITES- Convention on International Trade on Endangered Species

CIDA- Canadian International Development Agency

DFSRD- District Focus Strategy for Rural Development

DRSRS- Department of Resource Surveys and Remote Sensing

ESR- Economic Survey Report

FAO- Food and Agriculture Organization of the United Nations

GDP- Gross Domestic Product

GIS- Geographic Information System

GNS- Global Navigation Systems

KREMU- Kenya Rangelands Ecological Monitoring Unit

LANDSAT- Earth Observation Satellite

NDP- National Development Plan

NIB- National Irrigation Board

NRI- Natural Resources Institute

RSO- Rear Seat Observer

SRF- Systematic Reconnaissance Flight

TARDA- Tana and Athi Rivers Development Authority

TLU- Tropical Livestock Unit

TRDA- Tana River Development Authority

TRDDP- Tana River District Development Plan

UNDP- United Nations development Programs

UTM- Universal Transverse Mercator

ABSTRACT

The intent of this study was to examine the impact of changing land use patterns on the numbers and distribution of livestock and wild herbivores in the Tana River District, Kenya.

A multi-method approach of aerial surveys, questionnaires, interviews and secondary data sources were employed to realize the objectives.

Results indicate that changes in land use patterns and types have created conflicts that led to the reduction of the range and affected distribution of pastoral livestock and wild herbivores. Land use changes, such as irrigation are possibly responsible for reduction in the numbers and distribution of pastoral livestock and wild herbivores. Parks, reserves and ranches have also reduced the range of pastoral livestock. The creation of ranches has yet to affect wild herbivore distribution because of minimal development of the ranches but in future, wild herbivores may be affected.

Other factors responsible for reduction in numbers include diseases and pests, drought and poaching. Poaching is directly responsible for the decline in elephant and rhinoceros populations. The droughts of 1979 and particularly that of 1984 also contributed to reductions in numbers of livestock and wild herbivores.

Orma pastoralists attribute the curtailment of the grazing range of their stock to the influx of Somali pastoralists. Overgrazing due to this influx and large herds of livestock have rendered some range areas bare.

To alleviate the land use conflicts strategies recommended include: multiple land use practice; continued conservation of animals in parks and reserves; compensation of farmers for losses suffered; provision of corridors for access to grazing and watering areas; and allowing pastoralists into reserves during periods of drought.

CHAPTER I

INTRODUCTION

1.0 Preamble

Wildlife and livestock resources contribute to the Kenyan economy. Wildlife is the primary factor supporting the tourism industry and has been the highest foreign exchange earner since 1987. It contributed Ksh 6 billion in 1987 and Ksh 7 billion in 1989 to the national economy (NDP 1989; ESR 1989). The livestock component, besides provision of foreign exchange, also serves as the protein food source of the nation.

For sustainable and continued use of these resources, their management requires inventories of their numbers and distribution, which also provides a base for prediction of future changes. Information on numbers and distribution are crucial for various planning and management needs like habitat use, establishment of new wells, dips*, ranches, grazing blocks, marketing strategies, development of tourist facilities, setting cropping quotas, designing park and reserve boundaries, identification of watering areas, basic migratory routes, areas of high species density and diversity, and patterns of movement (Norton-Griffiths 1978).

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*structures containing chemicals in which livestock are washed to eliminate parasites like ticks.

The Tana River District (area 39,072 km^2) is one of the rangeland districts (Figs. 1 and 3), where the land is still used by the people in traditional pastoralism and agriculture, and is representative of the less developed areas in the country. However, changes in land use systems are evident, whereby the lower Tana River basin has in recent years become the focus of much development activity (TRDA 1974).

The Tana River (largest river in Kenya) is considered to have the greatest irrigation potential in the country, in addition to its considerable potential for improved livestock production and tourism (FAO 1973).

Irrigation schemes for cotton and food production have been initiated, livestock production systems have been established and other activities have been planned as well. Furthermore, new game reserves have been gazetted to protect wildlife and promote tourism.

These developments, particularly establishment of irrigation schemes and ranches are necessitated by the country's rapidly expanding human population (Table 1). The country has one of the highest birth rates in the world, standing at about 4% annually (NDP 1989). The district's population has also been increasing (Table 3). A challenge to feed this growing population is evident and calls for increased food production through improved methods of production (Govt. of Kenya 1986).

Figure 1. Map of Kenya Showing the Location of the Study Area (shaded).

Table 1. National Population Estimates, 1962-1993

Year	1962	1969	1979	1988	1990	1993
Population (in millions)	8.6	10.9	16.1*	22.7	24.4	27.2
Rate of increase	3.0	3.3	3.8			

Source: National Development Plan, 1989.

* Adjusted for underestimation

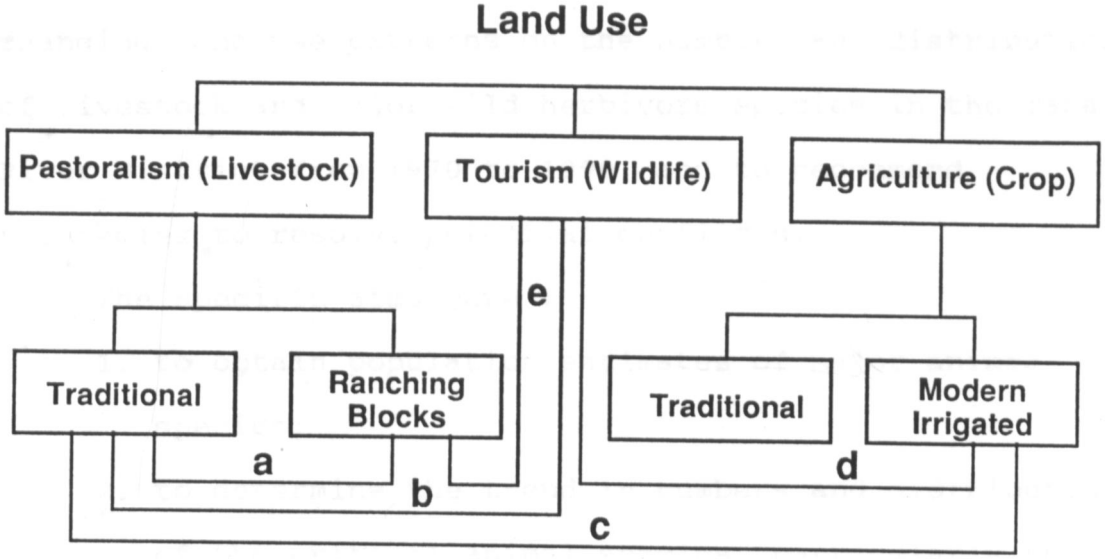
This factor alone, which is believed to be the principal driving force, is likely to have effects on the traditional land use practice patterns, and in effect, will have a major bearing on the numbers and distribution of livestock and wildlife in the district.

1.1 Issue Statement

Land development strategies initiated by the increasing human population, have generated changes in land use patterns throughout Kenya. These changes are likely to have implications on the animal resources of the Tana River district, particularly on numbers and distribution of animals in space and time.

Pastoralists in the area face problems of decreased grazing land, the former grazing ranges of their stock having being taken by wildlife parks and reserves, ranches, irrigation schemes and other agricultural activities. Wildlife is also facing similar land use conflicts and competition from agriculture and pastoralism (Fig. 2).

Poaching of wild game species, particularly the elephant (Loxodonta africana Blumenbach) and rhinoceros (Diceros bicornis Linnaeus), has been on the increase in the last 15 years. Overgrazing and destruction of vegetation, resulting from the conflicts of land use types and from overstocking, are other problems. On the whole, there is a lack of well synthesized information on the resources of the district, particularly for wildlife and livestock.



a - Ranching Versus Traditional Pastoralism - ranching reduces grazing range for Pastoral use.

b - Traditional Pastoralism versus Wildlife - competition for resource use

c - traditional Pastoralism Versus Modern Irrigated Agriculture - irrigation reduces range for pastoral use

d - Wildlife Versus Modern Irrigated Agriculture -- irrigation reduces range for wildlife use

e - Ranching (blocks) Versus Wildlife - ranching reduces range for wildlife use

Figure 2. Land Use Types and Conflicts in the Tana River District.

1.2 Objectives

The principal objective was to examine the impact of changing land use patterns on the numbers and distribution of livestock and major wild herbivore species in the Tana River District from 1970 to 1990, and to recommend strategies to resolve potential conflicts.

The specific aims were :

1. to obtain population estimates of major animal species;
2. to determine the trend in numbers and distribution of the critical animal species, particularly the elephant and rhinoceros over the years;
3. to determine seasonal patterns and movements, distribution, and densities of animal species;
4. to obtain socio-economic information to understand past and present land use patterns; and
5. to suggest solutions and recommend measures for pastoral livestock management and conservation of wildlife species and habitat.

1.3 Research Hypothesis, Scope and Delimitations

1.3.1 Research Hypothesis

Changes in land use patterns have reduced livestock and wild herbivore numbers and distribution generally.

1.3.2 Research Scope and Delimitations

This study considered pastoral livestock and large herbivores, but not small herbivores and carnivores due to the survey methodology involved. Substantial land use data was gathered from the study area. This was possible with help from the district administration. However, some areas were inaccessible due to remoteness and lack of roads. The study also investigated wild herbivores and livestock because of the similar dietary relationship (i.e, both are herbivores) and the possible competition that may occur in the face of land use changes.

1.4 The Study Area

Kenya (Fig.1) is situated approximately between 5° 02' and 4°40'S and 33° 55'E and 41° 55'E, with a total area of 580,367 Km^2 constituting 11,230 km^2 of water, and land surface of 569,137 km^2 (Ojany and Ogendo 1973).

The country has broad contrasts in climate, vegetation, topography and land use patterns. The prominent physical features include the Great Rift Valley and mountains of various heights ranging from 2,000 m to 5,000 m above sea level that include Kenya (5230 m), Elgon (4,320 m), and Aberdares (4,000 m). The highlands, mostly in the central region are cool, wet and generally over 1,500 m. The coastal plains are humid, hot and wet. The semi-arid and arid areas are dry, hot and have erratic rainfall, often below 600 mm.

Most of the highland areas are under agriculture and constitute about 20% of the land surface of the country, supporting about 80% of the country's population whereas the rangelands (arid and semi-arid areas) comprise about 80% of the country's land area and support about 20% of the country's population. These are mainly the homes of the pastoral communities, their livestock and wildlife.

The study area, the Tana River District (Fig. 3), is located in Southeastern Kenya in the Coast Province. It lies approximately between the Equator and 3° 15' south and 38°37.5'and 40° 41' east with an area of about 39,072 km^2. The district is bordered by Garissa and Lamu to the east and northeast, Isiolo and Meru districts to the north, Kilifi and the Indian Ocean to the southeast, Taita-Taveta to the south, and Kitui district to the west.

The general environmental description of the area constituting climate, topography, geology, and soils are detailed in the following subsections.

1.4.1 Climate

The rainfall in Tana River District is bimodal with two rainy and two dry seasons annually. The April-June rains are generally brought about by the South-East Monsoons, while the November-December rains are brought about the North-East Monsoons (Moomaw 1960; Ojany and Ogendo 1973).

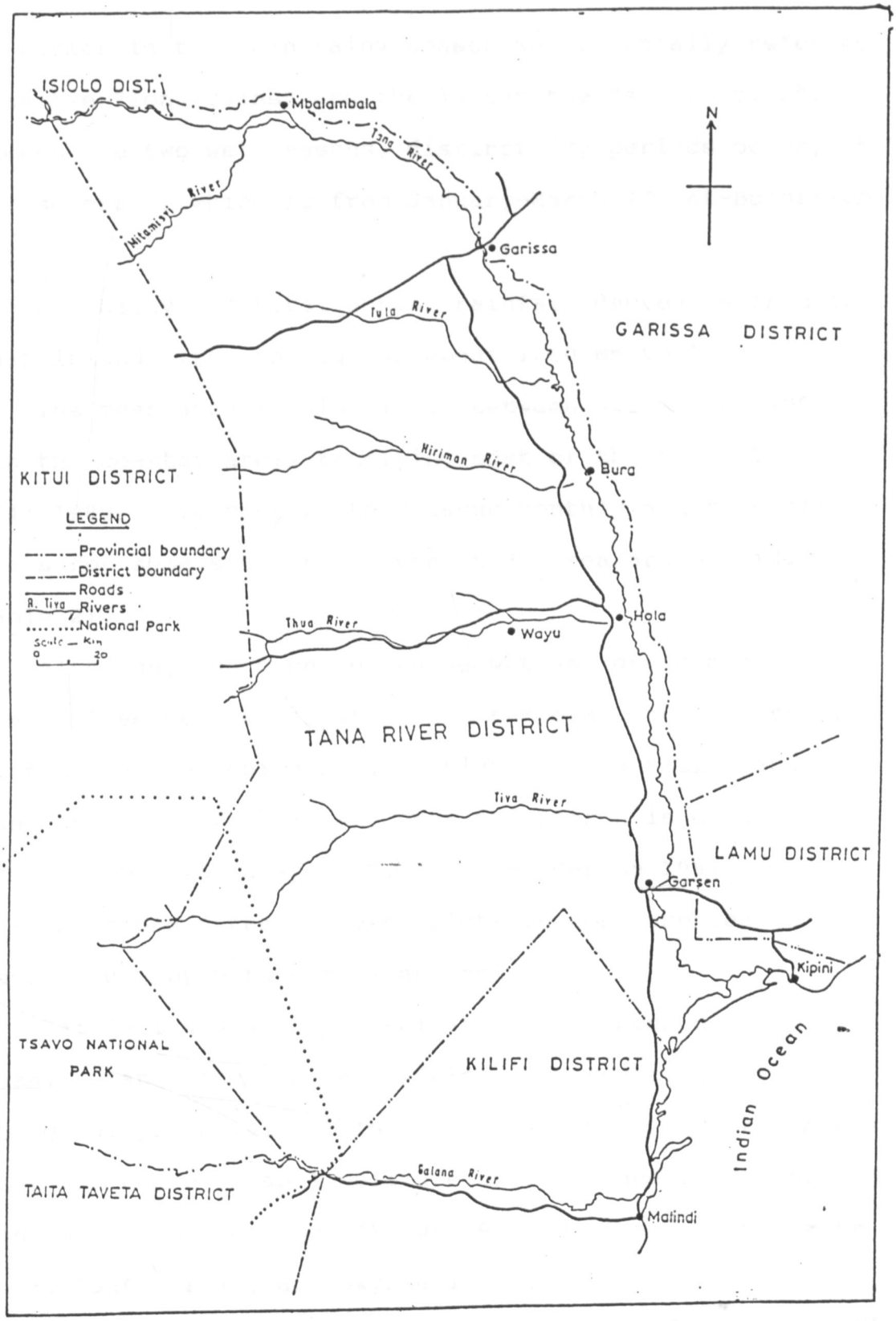


Figure 3. The Study Area: Tana River District.

Source: Allaway, 1979.

The former is the main rainy season and is locally referred to as the "long rains" and the latter the "short rains". Between the two wet seasons, distinct dry periods occur, the most severe of which is from January-March (Trent-Bunderson 1981).

Basically the total annual rainfall decreases from the coast inland, from as high as about 1000 mm to 300 mm (Fig 4). The mean annual rainfall is between 300 mm and 400 mm with the coastal areas receiving most of the rain (TRDDP 1984; 1989). To clarify this issue monthly and rainfall totals for some stations in the study area are provided (Table 2).

Although, the onset of these wet and dry seasons is more or less regular, spatial and temporal variability of rainfall in the region is very high. The duration and quantity of rainfall in any year and season is erratic and unpredictable (Allaway 1979; Trent-Bunderson 1981). This therefore often has unpredictable consequences on resource use by both people and animals.

Rainfall and evapotranspiration have been used to classify rangelands in East Africa in terms of their ecological potentials. This is because these factors have a great influence on soil moisture and subsequently affect plant and animal ecology (Brown 1963; Woodhead 1970; Pratt et al. 1966; Pratt and Gwynne 1977).

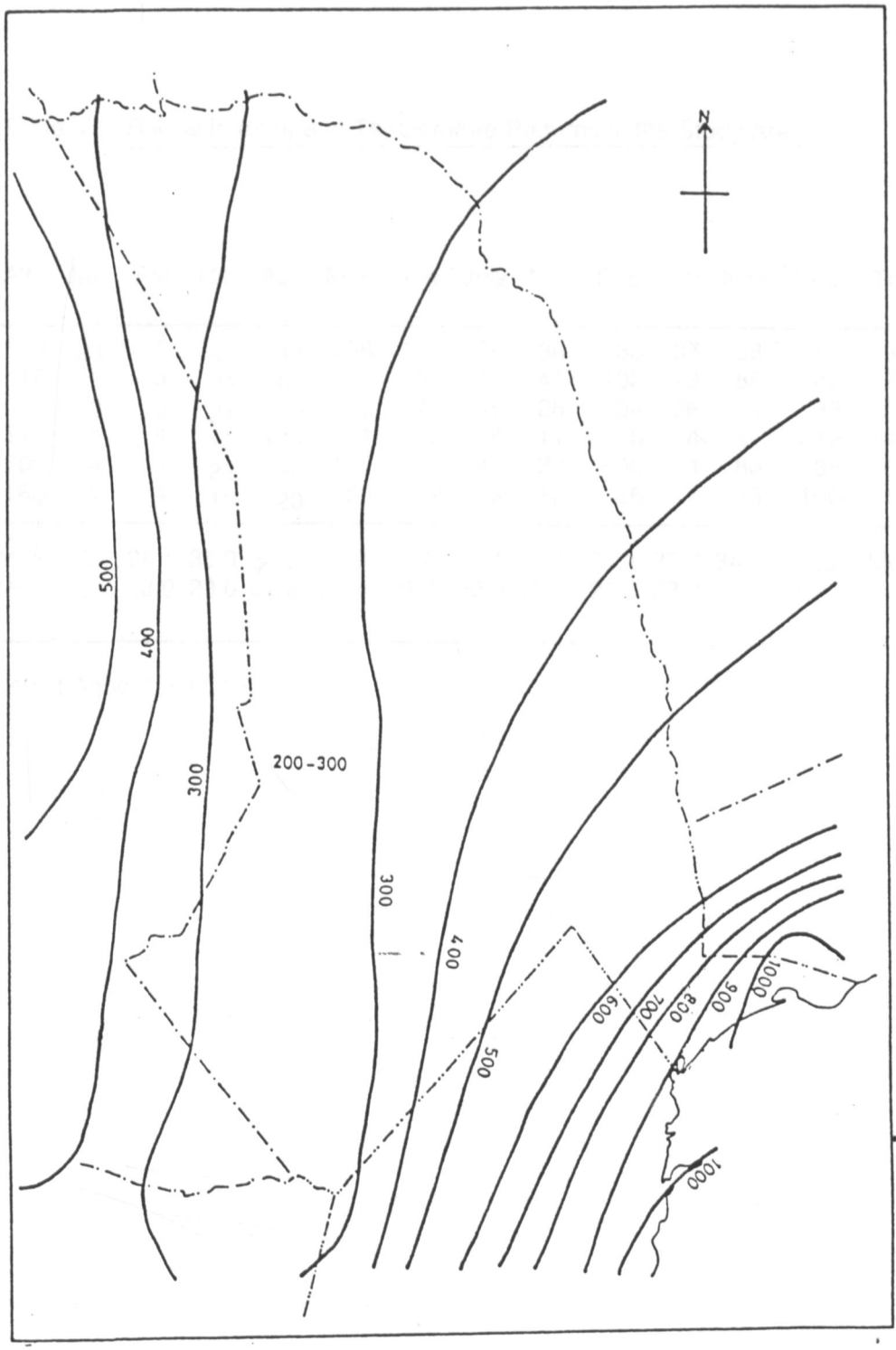


Figure 4. Average Annual Rainfall (mm) in the Tana River District.

Source: Braun et al, 1982.

Table 2. Rainfal in (mm) and Temperature Patterns in the Study Area.

Station	Alt. (m)	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Kipini	3	23	8	41	140	298	123	66	36	33	37	58	84	947
Ngao	15	15	9	25	95	108	67	44	41	102	73	85	40	705
Kurawa	5	3	5	21	80	123	75	46	26	54	36	74	33	575
Bura	110	2	4	12	150	61	13	4	11	5	4	52	112	431
Mnazini	300	14	-	23	90	109	70	40	38	100	74	80	38	676
Madogo	160	2	4	15	120	50	12	3	12	66	7	53	100	449
Tempera-	Max.	38	36.1	35.9	30.3	31.9	31.8	30.1	30.1	31.1	32.2	34.7	32.5	Mean
ture	Min.	23	23.0	23.0	22.8	22.9	21.4	20.0	19.1	21.0	23.2	23.7	2.9	
(0°C)														

Source: District Agricultural Office

The study region is mostly within ecological (eco-climatic) zone v (arid), with parts in the zone vi (very arid), and parts towards the coast within iv (semi-arid), iii (dry sub-humid to semi-arid), and ii (humid to dry sub-humid) (Pratt et al. 1966; Pratt and Gwynne 1977) (Fig.5). Woodhead's (1970) annual index of available water (which incorporates soil water storage) places most of the Tana River District between index 10 and 30, with higher values towards the coast (Fig. 6). The above indices are derived from total annual rainfall, evapotranspiration, soil water change and storage, and water surplus and deficit.

The study area lies within 1-3° of the equator and is near the coast, hence temperatures vary little annually and evaporation rates are 2000-2500 mm throughout the year (Rep. of Kenya 1980). The district is hot and dry with temperatures between 19°c and 38°c, the hottest period being in January, February, and part of March (TRDDP 1984). The mean and monthly maximum and minimum temperatures and the daily ranges of the mean at various stations are given (Table 2). In contrast, from the coast inland, rainfall and relative humidities drop considerably (Allaway 1979).

1.4.2 Topography, Geology and Soils

The area is flat or gently undulating, but near the coast there are low beach ridges. Occasional hills outcrop above the flat plains in the south and the dissected country in the north west.

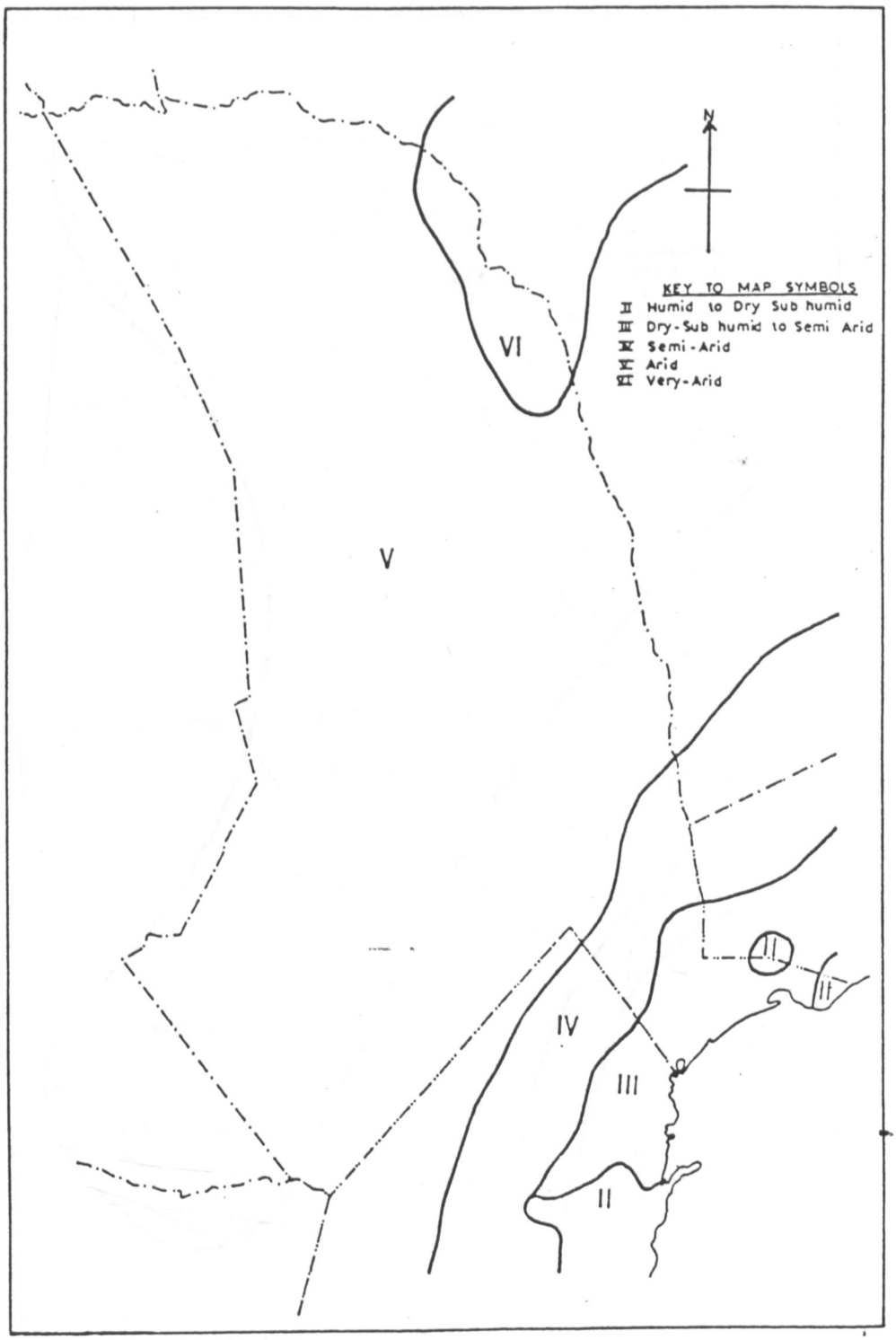


Figure 5. Ecological Zones of the Study Area.

Source: Pratt et al, 1976.

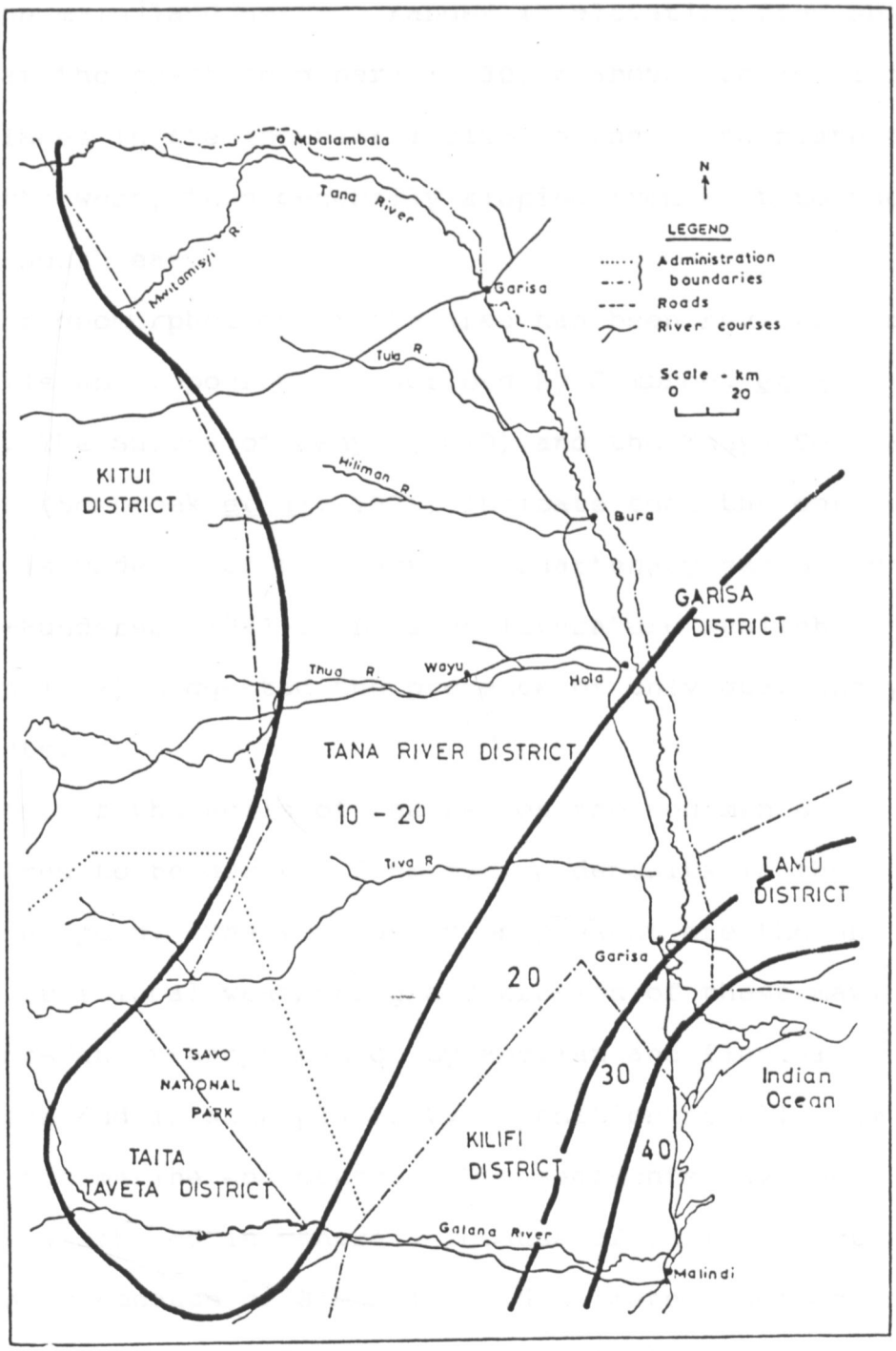


Figure 6. Division of the Study Area According to Annual Index of Available Water.

Source: Woodhead, 1970.

The main land surface ranges in elevation from sea level at the coast to generally 300 m above sea level for most places in the interior including the Nyika plateau in the north west, thus generally sloping from west to the east in the south east.

The geomorphology of the area has been reviewed and the soils and topography described by Sombroek et al. (1976). The Survey of Kenya (1970) and the Kenya Soil Survey Project (Sombroek et al. 1976) indicate that the entire region is made up of tertiary and quartenary sediments (Trent-Bunderson 1981). Earlier literature available (Morgan 1972) suggested the presence of only quartenary sediments.

Most of the soils of the region are sediments considered to be derived from marine deposits in the Pliocene Epoch. The various types present are thought to result from local weathering and erosion of these marine sediments and transportation by aeolian and fluvial processes and in some places by deposition of alluvium on top of the marine sediments. The sediments have been lightly weathered in general, because of their structure and apparently because of a mostly arid climate. Consequently, many soils have high salinity and alkalinity levels (Sombroek et al. 1976).

Sombroek et al. (1976) described and mapped the main soil types in the region mentioned in Allaway (1979). The soils of the Tana flood plain have also been described (Wokabi et al. 1976; Braun et al. 1982; Jaetzold and Schmidt 1983). Flood plain soils are a complex of sands, loams and clays, often layered with alkaline and saline content.

The soils are generally quarternary black cotton with patches of sand, silt and clay on old basement rock. These are found mostly in fairly flat areas and poorly drained soils which are saline, and alkaline clays (solonchaks).

The areas along the Tana River have saline and alkaline clays and alluvium and lacustrine deposits. The coastal strip and river delta areas constitute pleistocene coral rock or crag, recent deposits of alluvial silts, pleistocene marine sands and clays and recent dune sands.

1.4.3 Socio-cultural Information

The major ethnic groups of the district are the Pokomo and the Orma. Other smaller tribes are the Malakote, Korokoro, Boni, Sanye (Wata), Munyuyaya, Somali and the Mijikenda (Fig 7). The Korokoro and Malakote are related to Pokomo, all of whom live along the Tana River occupying the eastern quarter of the district. The Mijikenda (a conglomerate of 9 tribes) inhabit the coastal areas, whereas the Orma occupy the western three-quarters to the west of Tana River.

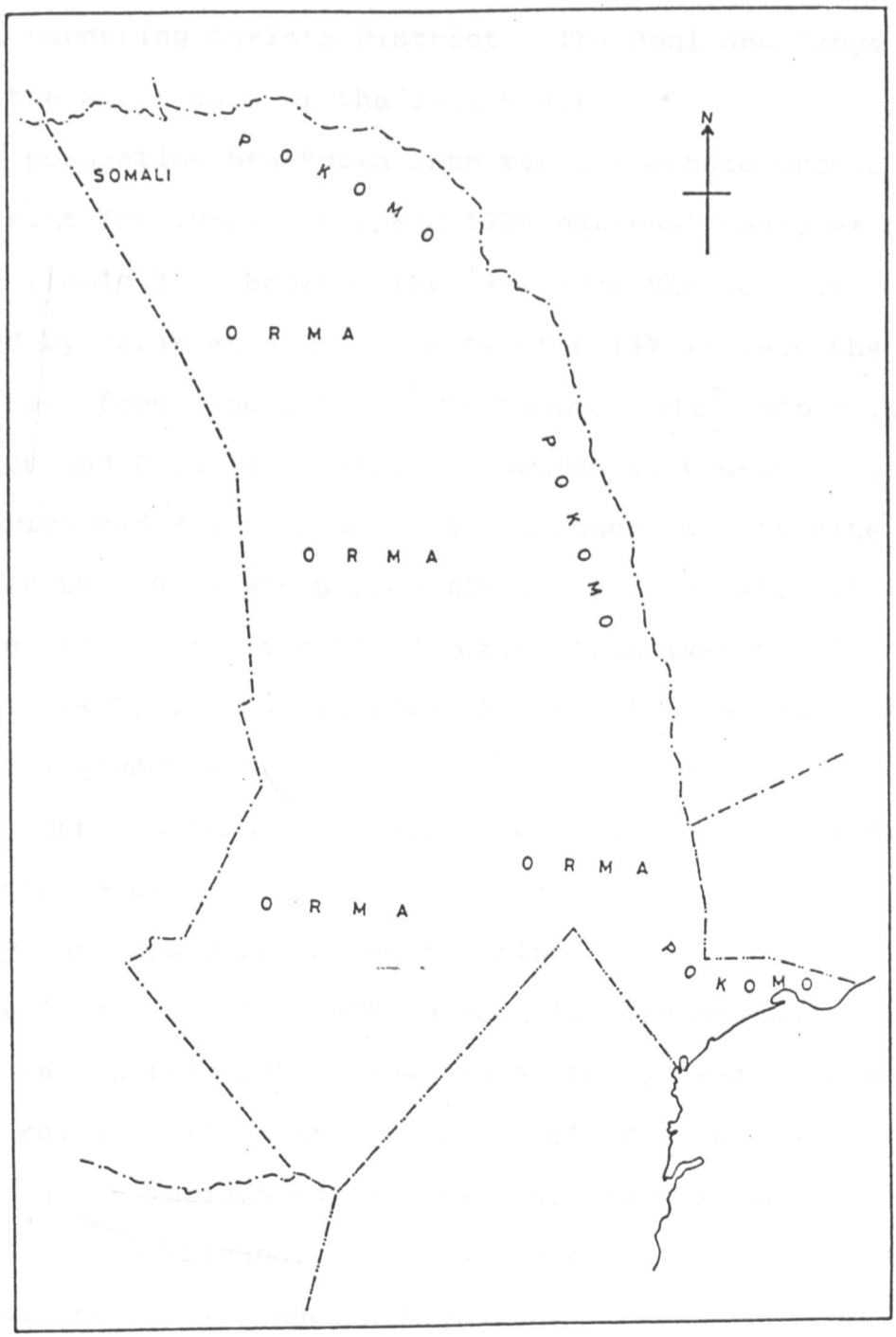


Figure 7. Approximate Location of People and Tribes in the Study Area.

The Somali are found in the extreme northern part of the district bordering Garissa District. The Boni and Sanye live in the areas east of the Tana River.

The population breakdown into various ethnic groups for the district for 1962, 1969, and 1979 national censuses are provided (Table 3). Between 1969 and 1979 the population increased by 82.3% at a growth rate of 6.19% whereas the density rose from 1 person /km^2 to 2 person /km^2 (Ministry of Finance and Planning 1981). According to the 1979 census the district had 92,401 people and an annual growth rate of 5.07% over the 1969-1979 period (TRDDP 1984, 1989). The population projection for the district from 1988 to 1993 are 148,120 in 1988; 162,733 in 1990; 170,475 in 1991; and 186, 839 in 1993 (TRDDP 1989).

The ethnic groups and their major economic activities are described below.

1.4.3.1 Pokomo and other Riverine Tribes

This is a small community practising traditional agriculture and fishing (Allaway 1979; TRDDP 1984). The agricultural activities are at the level of subsistence. The crops grown include maize, cassava, greengrammes, cowpeas, sorghum, banana, rice and coconut. Cotton is the major cash crop grown under irrigation.

These agricultural activities are achieved mainly through rain-fed flood or irrigation-fed means from the Tana River and are limited to the alluvial Tana flood plain

Table 3. Human Population Census Results for the Tana River District, 1962-1979

Year	1962	%	1969	%	1979	%
Ethnic group						
Pokomo/Riverine	20338	69	29124	57	32539	35
Orma	5946	20	15610	31	30607	33
Mijikenda	720	2	1758	3	2488	3
Boni/Sanye	550	2	835	2	225	0.2
Somali	143	0.5	518	1	10402	11
Total	29502	100	50696	100	92401	100

Source: Ministry of Finance and Economic Planning, 1964, 1970.

Ministry of Finance and Planning, 1981.

stretching from Mbalambala in the north to Kipini at the mouth of the Tana in the south (Fig.3), although small isolated patches occur along the seasonal Thua River.

Fishing activities are concentrated in the Garsen Division. The sources are ox-bow lakes and flood lakes, the Tana River and the Indian Ocean. The lakes are Shakababo, Bilisa, and Kongolola, where the methods used are dug-out canoes and traps, and modern technology for marine fishing engaging engine boats, and gill nets. Marine fishing is mainly done around Kipini (TRDDP 1989).

The Pokomo's way of life has remained basically the same since the 1800s and possibly a considerable period before that. Allaway (1979) quoting colonial administrators who worked in the district noted a decline in hunting activity (mostly hippos, crocodiles, elephants and other animals) although traditional agriculture and fishing continue with adoption of modern methods. The Malakote and Korokoro are less involved in agriculture than are the Pokomo (Allaway 1979; FAO 1973).

The pattern of land use by these communities has been mostly shifting cultivation made necessary by ecological conditions of the flood plain, land tenure systems and local ethnic conflicts (Allaway 1979).

1.4.3.2 Orma

Orma are nomads, practising traditional semi-pastoralism. They are the most numerous pastoralists in the district keeping mainly, cattle (Bos indicus), sheep (Ovis aires Linnaeus) and goats (Capra hircus Linnaeus). The Orma raise cattle for subsistence and trade milk and other products, and for decades have marketed considerable numbers of cattle to Mombasa and other areas (Allaway 1979). Other market centres are Bangali, Bura, Hola and Garissa.

The typical pastoral herding systems are described (NIB 1975; Allaway 1979). The herds are kept in two groups. The milking herd comprising lactating cows and calves are maintained near settlements or villages located near sources of permanent water. The other group, the dry herd constitutes the dry cows, heifers and males, which make up the majority of the cattle. This group is usually highly mobile, covering considerable distances in search of good grazing and temporary water holes which are found away from the Tana River, especially after the rains.

In the absence of abundant water sources like rain pans (pools) during the wet season, cattle probably drink every other day (FAO 1973), although longer intervals may be required sometimes.

The seasonal patterns of use of the Tana River District by cattle is generally that of dispersal in the wet seasons when availability of water is widespread, thus allowing the

interior to be used during dry seasons.

Cattle concentrate near permanent water (mainly from wells) in the interior and along the river (Watson et al. 1973; Allaway 1979). The Tana River delta provides important dry season grazing.

The Orma's past way of life is described by Allaway (1979), who notes that their lifestyle has remained almost unchanged to this day in spite of some significant changes in the region. In the late 1940s much of their grazing area was taken up by Tsavo National Park, while the rangeland in the south west was withdrawn to form the Galana Ranch. Additional information about pastoralism in the region are given by UNDP/FAO rangelands survey report (FAO 1973; Allaway 1979).

1.4.3.3 Somali

The Somali are also nomadic pastoralists, occupying the northern part of the district and though they are recent immigrants into the area, they are long time enemies of the Orma (Watson et al. 1973; NIB 1975) and apparently their population has been increasing (Table 3). They are mainly camel (Camelus dromedarius) herders.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter highlights related literature within the span of the study, i.e, 1970-1990. Issues regarding animal numbers and distribution are also dealt with and other environmental attributes such as water and vegetation are discussed. Socio-economic or land use factors are also considered.

2.1 Animal Numbers and Distribution

Available ecological data are for isolated areas of the district where individual researchers have worked. Data on animal numbers and distribution have been collected by various workers (Watson et al. 1973; Dirschl et al. 1978; Allaway 1979; Stelfox and Mugambi 1979; Stelfox et al. 1979; Trent-Bunderson 1981; Kufwafwa 1981, 1985).

Watson et al. (1973) gave numbers and distribution of animals for the whole district, whereas Stelfox and Mugambi (1979), and Kufwafwa (1981) covered 6500 km^2 and 6375 km^2 of the district respectively which constituted only the delta region. Allaway (1979) attempted a near-complete coverage on the elephant only, whereas Trent-Bunderson's (1981) study covered a thin strip extending from Bura to the coast along the Tana River. All these are fragmentary and hence not fully representative of the district.

Dirschl et al. (1978) and Stelfox et al. (1979)

provided results of aerial censuses of livestock and wildlife of the Kenya rangelands collected and analyzed on the basis of ecological units, in which the study district was included. However, district specific data were not given. Stelfox et al. (1979) gave results of livestock and wildlife for 1977 and 1978 censuses along the same line as Dirschl et al. (1978).

A study on the management of large herbivores in Kenya (Rep. of Kenya 1980) provided the numbers and certain aspects of seasonal distribution of some species but seemingly drew much of the information from works of Dirschl et al. (1978) and Stelfox et al. (1979). Furthermore, the "management units" designed comprised Kitui and Tana Districts, but the data are not district specific, therefore of limited use to district planners.

Watson et al. (1973) suggested that movements of people, livestock and wildlife, to and from the Tana River depended on seasons (Figs 8a and 8b). A similar pattern has been reported by other workers (Allaway 1979; Rep. of Kenya 1980; Trent-Bunderson 1981; Kufwafwa 1985).

The animals (livestock and wildlife) move to and from the river during different seasons. During the wet season, movement is away from the river; eastward towards Garissa and Lamu, and westward to the interior of the district. This is governed by availability of forage and surface water. In the dry season, movement is towards the river (Watson et

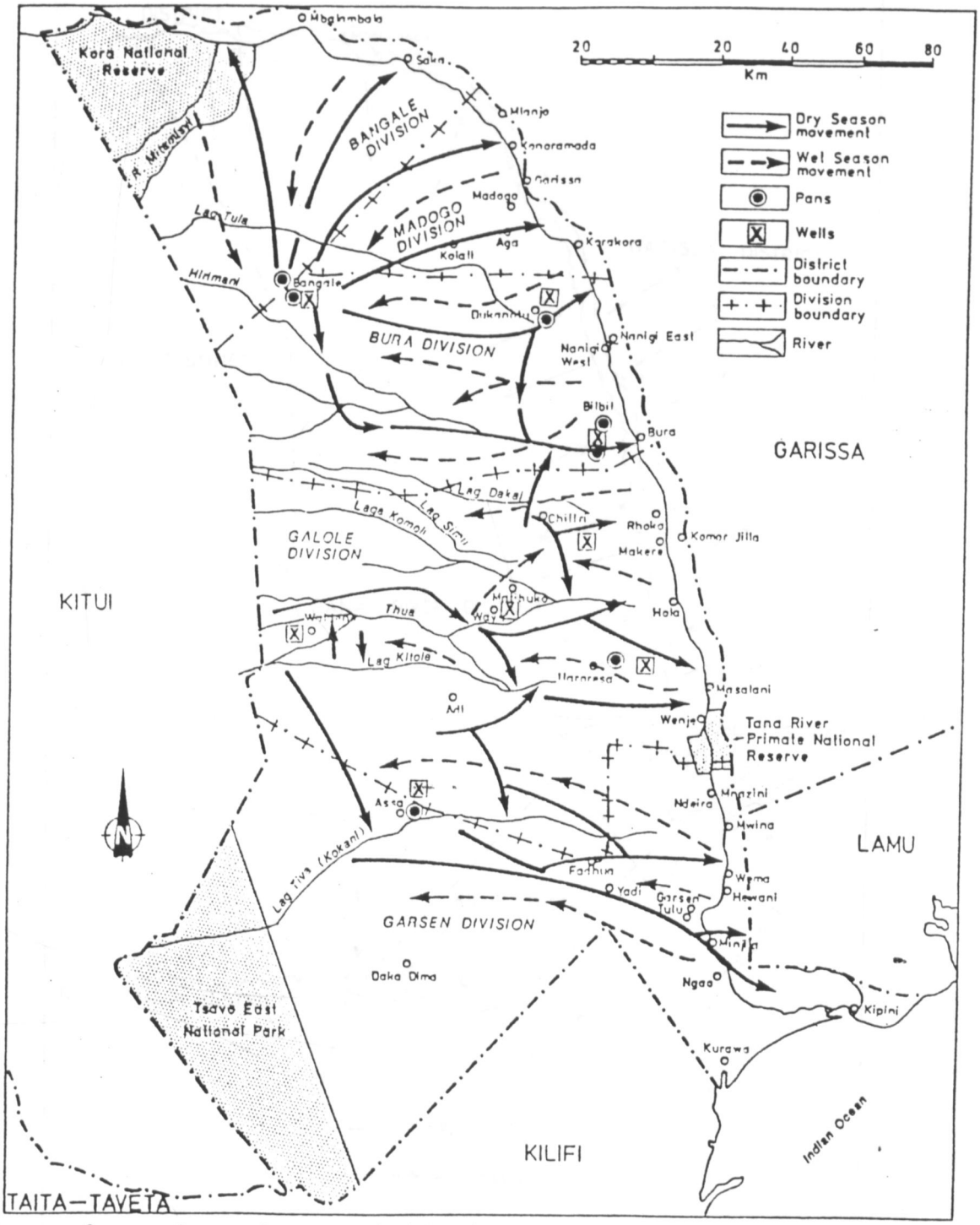


Figure 8a. Seasonal movement of livestock in Tana River District

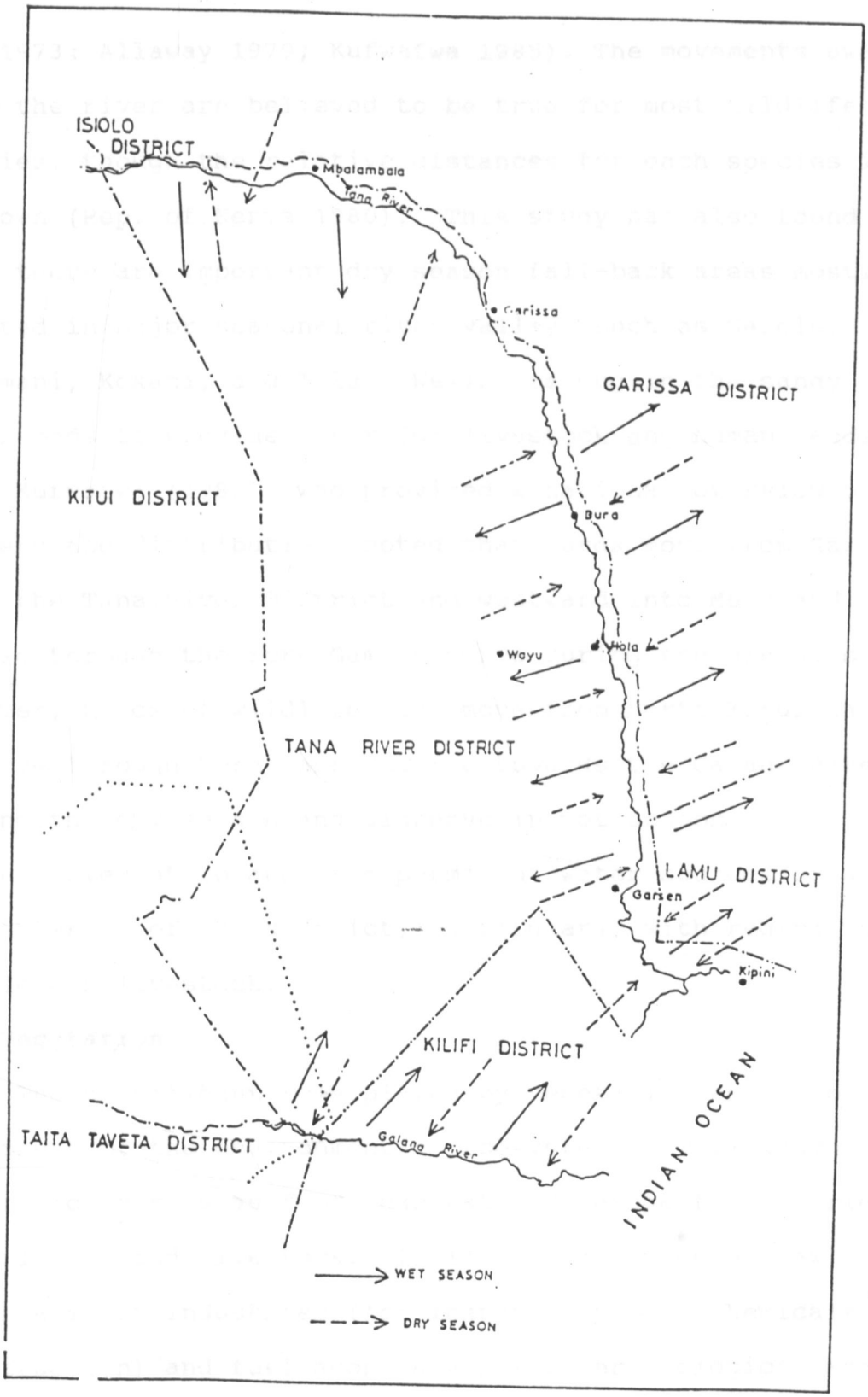


Figure 8b. Seasonal Movement of Wildlife in Tana River District.
Source: Watson et al, 1973.

al. 1973; Allaway 1979; Kufwafwa 1985). The movements away from the river are believed to be true for most wildlife species, though the relative distances for each species is unknown (Rep. of Kenya 1980). This study has also found that there are important dry season fall-back areas mostly located in major seasonal river valleys such as Galole, Hirimani, Kokani, and Tula. Wells are dug in the sandy river beds to provide water for livestock and human needs.

Kufwafwa (1985), who provided a national overview on numbers and distribution, noted that herds move from Garissa into the Tana River District and westward into Meru and Isiolo through the Kora Game Reserve during the dry season. However, herds of wildlife also move from North Kitui Game Reserve through Kora Game Reserve towards the Galana River during the dry season and disperse in wet seasons. Again, movement to and from permanent water sources occur in the interior of the district, particularly with regard to people and livestock.

2.2 Vegetation

The significant role played by vegetation as a biotic component of the environment or ecosystem is well known. Vegetation serves as food, habitat and refuge for a variety of wildlife and livestock. It is also a source of raw materials for industries (for instance paper, chemicals, construction) and fuel among several other ecological and economic uses.

The vegetation of the Tana River District has been described by many workers including Moomaw (1960); Watson et al. (1973); Marsh (1976); Allaway (1979); Agatsiva and Epp (1981); Trent-Bunderson (1981); and Loth (1988). These authors produced maps showing only parts of the study area, but even the complete ones presented information of generalized scale.

Moomaw (1960) gave a very broad description of the vegetation types of the coastal region with only a part of the study area included -- indicating what he referred to as "lowland dry forest" of Manilkara-Diospyros along the Tana River, "lowland moist savanna" type of Afzelia -Albizia/ Panicum in the south-east, Acacia bushland in the drier northern parts and mangrove thickets at the mouth of the Tana River.

Watson et al. (1973) also provided a generalised account of vegetation types, with the areas along the Tana River containing gallery forests and grasslands, while a great part of the study area is classified as bush-woodland and some parts as open-grasslands.

The FAO (1973), described over 75% of the region as bushland, with bushed and wooded grasslands occurring in the south and gallery forests occurring along the Tana River basin.

Allaway (1979) described much of the study area's vegetation as bushland except for stretches of grasslands

and swamps at the lower Tana flood plain in the southeast and flood plain grasslands and bushlands along the river courses in the interior, with bushland thickets in the southeastern areas.

A study on the management of very large herbivores (Rep. of Kenya 1980) indicated that much of the study area had dense, bushed woodlands with some grasslands in the northern half, open grasslands with scattered woodlands and bushlands in the southern half and gallery forests, woodlands and flood plain grassland along the Tana basin.

Trent-Bunderson (1981) mapped only a short strip along the Tana River, with gallery forest, riverine bushland and grasslands as described by UNDP/FAO (1973); Allaway (1979); and Watson et al. (1973).

Agatsiva and Epp (1981) derived a map from LANDSAT imagery which covered only 1940 km^2 of the District, mostly along the Tana River. Much of this area was noted as being dominated by grasslands within the flood plain, a concentration of mangroves along the coastal creeks and bushland along the coast. The area west of the flood plain was described as shrubland. Loth (1988) produced a vegetation map of Kora Game Reserve (1570 km^2), derived from LANDSAT and aerial photographs. The most common structural type was observed as being bushland.

The impacts which utilization and other factors have had on the vegetation of the district are described here

including changes brought about by human influence, fire and climate.

Fire has turned parts of the interior into grasslands, especially the southern parts, where the original cover was dominated by woody plants (FAO 1973; Allaway 1979). Charcoal burning in some places of the flood plain and along the major seasonal rivers has affected vegetation, as have cutting for house and fence construction and clearing for cultivation (Allaway 1979; Loth 1988). It has been suggested that elephants have had no major impact on vegetation change in the interior of the district and flood plain (Allaway 1979; Loth 1988).

About 90% of household energy used in the district is derived from fuelwood or charcoal. Total estimated household needs in 1988 and a projection for 1993 are 158,000 metric tons and 200,000 metric tons respectively, with the main sources being the rangelands vegetation and riverine forests, especially along the Tana River (TRDDP 1989).

The flood plain vegetation has been altered through clearing for cultivation, burning and other activities (Marsh 1976; Allaway 1979; Loth 1988). Marsh (1976) and Allaway (1979) provided quantitative information on forest loss and indicated that forests have generally become smaller, loss probably being due to human activities, primarily clearing for farms, cutting for canoe

construction, burning and occasional destruction by natural phenomena like flooding, i.e during rains. In his study, Loth (1988), reported no significant change in vegetation since 1963 except in the Tana River flood plains to the east of Kora Game Reserve.

Incidence of fire along the Tana Delta and overgrazing due to large numbers of livestock and some wild herbivores and mangrove cutting for boat building and construction are reported as factors responsible for vegetation destruction. Decimation of forests by fire, logging and cultivation along most parts of the coast has occurred (Trent-Bunderson 1981). This author observed that the gallery forest of the Tana flood plain has been reduced by cultivation, charcoal burning, construction of dwellings and canoes. Remnants of this forest are in small fragments along the River north of Garsen.

The destruction of vegetation, especially woody types does not augur well, particularly for wildlife, who need it for shelter and food. The depletion of forests, especially the gallery forest is a threat to endemic and rare species of Crested Tana Mangabey and Red Colobus Monkeys.

Some wildlife species prefer forested or woodland habitats for shade, e.g, elephant, buffalo (Syncerus caffer Sparrman) and waterbuck (Kobus ellipsiprymmis Ogilby), hence destruction could have adverse ecological consequences. Moreover, elephants have responded to drastic poaching by

seeking refuge in heavily forested areas (Trent-Bunderson 1981; Loth 1988). To protect these animals and plant species the Tana River Game Reserve was established in 1975.

On the whole, the destruction of vegetation of any type contributes to wildlife habitat loss or change and hence constriction of their ranges and resultant reduction in numbers, factors which can place premium on their survival. The Government of Kenya is seriously concerned about the destruction of vegetation, an important natural resource. In this light, it has instituted active afforestation programs in many parts of the country. Several areas have been proposed for establishment of forests covering an area of about 400,000 ha (Table 4, Fig 10; TRDDP 1984).

2.3 Surface Water

Surface water (rivers, pans, ox-bow lakes) and shallow wells are limiting factors in the lives of human beings, livestock and wildlife. The locations of principal water sources in the interior of the region have been discussed (FAO 1973; Allaway 1979) (Fig 9).

The Tana River is the major permanent river in the area. Its water originates from catchment areas in the highlands several hundred kilometres to the north on the slopes of Mount Kenya and the Aberdares. The river flows eastward as far as Garissa, and changes its course southward into the Tana River District, and empties into the Indian

Table 4. Proposed Forest Development Areas in the Tana River District

Division	Place	Size (ha)
Bangali	Bangali	137,137
Bura	Hirimani	126,977
Galole	Woldena	680
	Wayu	38,432
	Matiboke	7,168
	Galole	10,510
Garsen	Kokani	61,440
	Mwena	3,076
	Hewani	2,560

Source: District Forest Office, Tana River District.

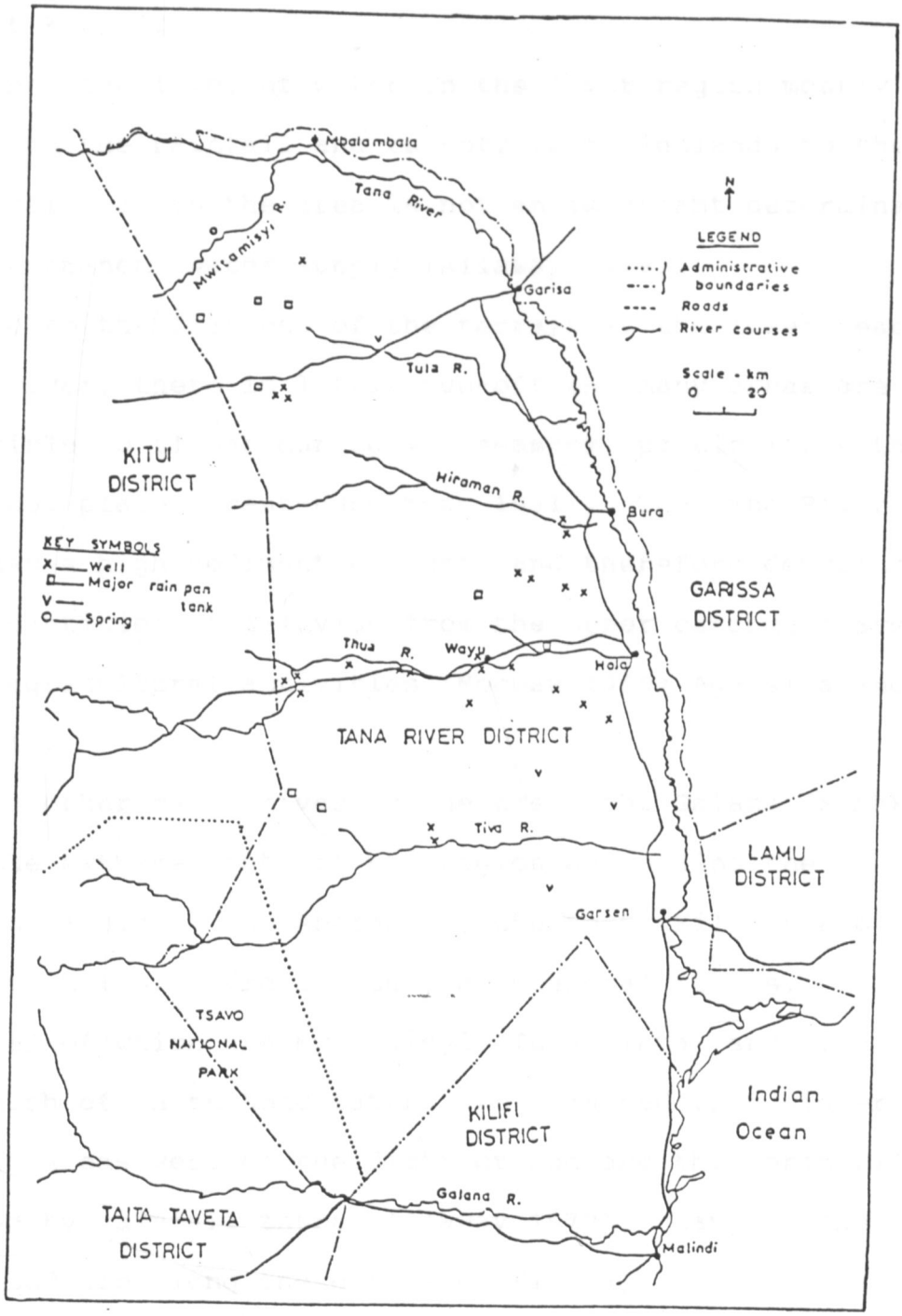


Figure 9. Principal Sources of Water in the Interior of the Tana River District.
Source: FAO, 1973.
Allaway, 1979.

Ocean at Kipini.

Since the level of water in the lower region mostly depends on the rainfall and run-off from highlands to the north, rainfall in the area is not an important determinant of the permanent water supply (Allaway 1979).

Due to the flatness of the terrain at the lower reaches of the river, there is little run-off and many areas are susceptible to floods during wet seasons, particularly the Tana flood plain (Trent-Bunderson 1981). The Tana River water has a high sediment content, and therefore deposits great quantities of alluvium from the upper catchment areas due to agricultural activities (Moomaw 1960; Agatsiva and Epp 1981).

The other major river in the area, the Galana (Sabaki), is in the extreme south of the region and drains the southern slopes of the Aberdares, the north Kilimanjaro and the Taita Hills. There are several seasonal rivers, principal of which are Mwitamisyi, Tula, Thua, and Tiva (FAO 1973) much of whose head waters are obtained from higher rainfall areas west of the district and are thus primarily affected by rainfall there (Allaway 1979). Many of the wells used are along these rivers (Fig. 9).

Rainfall within the area, however, supplies the most widely dispersed kind of seasonal and ephemeral water sources, the rain pans, the natural depressions which collect and hold rain water (over 1 m and less than 100 m in

diameter). During periods of favourable rainfall, these sources provide abundant and well dispersed water supplies (Allaway 1979).

Water is an indispensable resource which has a tremendous control on the life of any organism including man and other animals. Its availability governs animal movements- its availability permits and its absence prohibits, dispersal and other movements (Allaway 1979).

Seasonal mobility depends on water abundance. During wet seasons the animals spread out due to widespread availability of surface water, whereas in dry spells the movement is restricted to permanent sources.

A comprehensive account of surface water abundance has been compiled by FAO (1973) and Allaway (1979) as shown in Figure 7. This information is reliable as far as permanent sources and certain seasonal rivers are concerned but not for point sources like wells and surface dams. Many of these sources have been constructed as part of development efforts of the District Focus Strategy for Rural Development (DFSRD).

These new sources will obviously influence the distribution of animals and livestock, particularly during the dry seasons. Several water supply projects and programmes are at advanced stages of planning and implementation (TRDDP 1984).

2.4 Land Use

The socio-cultural information of the district with reference to the past and present land use activities has been mentioned in section 1.4.3. There are three broad socio-economic activities (Fig 10):

a) Agriculture, both traditional and modern irrigated crop farming;

b) Livestock rearing, constituting traditional and developed ranching or grazing blocks; and

c) Tourism, based on wildlife.

2.4.1 Agriculture

Agriculture plays a dominant role in the Kenyan economy and generates 33% of the national GDP, providing over 75% of employment and over 60% of export earnings (Riugu 1987). Agriculture in the area is characterized by large and small scale irrigation schemes and traditional farming systems.

2.4.1.1 Traditional Agriculture

Traditional agriculture is common along much of the Tana River stretching from Mbalambala in the north to the Tana Delta in the south (Fig 3), principally on the fertile alluvial soils of the flood plain (Allaway 1979).

The need for farmlands has led to clearing of forests by felling or burning. The slash and burning cultivation of the past seems to have subsided and the scope of the farming systems broadened, with modern techniques being adopted. Farm sizes range from 0.5 to 3.0 ha and crops grown are

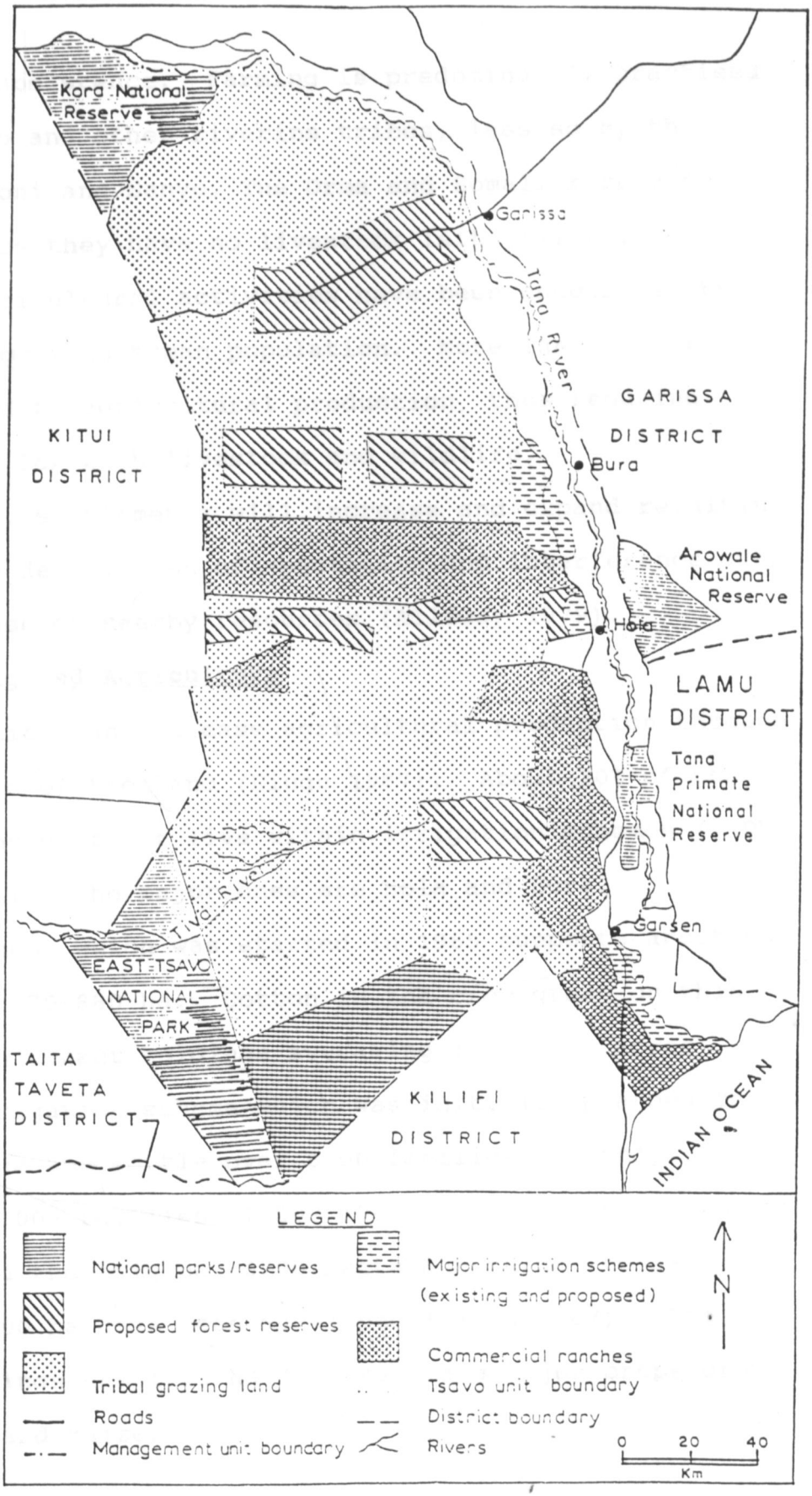


Figure 10. Land-Use in Tana River District.

mainly for subsistence. Farming is predominantly practised by the Pokomo and other riverine tribes, less so by the Mijikenda, Boni and Sanye. The Orma and Somali rarely do farming unless they have no livestock left (Allaway 1979).

More agricultural activities have been encouraged by the rapidly growing human population. More land is likely to be devoted to agricultural production, thus reducing grazing land for both livestock and wildlife. Consequently, settlements will increase and expand resulting in increased destruction of vegetation and interference with wildlife's use of nearby resources (Allaway 1979).

2.4.1.2 Irrigated Agriculture

Irrigation can increase agricultural production through intensive use of the land (Riugu 1987). About 30% of the people in the district live within irrigation schemes (TRDDP 1989)(Fig.11). The major ones are Hola and Bura. The Hola scheme which was started in 1965 supports about 600 families on 870-880 ha. Cotton is the crop grown on this scheme, with tenant holdings averaging 1.6 ha (4 acres). The Bura irrigation scheme which was initially planned to cover 6700 ha and settle over 5000 families has only 750 ha supporting 1000 families (TRDDP 1984, 1989). The Government has reversed the original 6700 hectarage target to 3900 ha of which 2500 ha have been developed (Riugu 1987). The tenant holdings are 1.25 ha (3 acres) and major crops grown are cotton and maize.

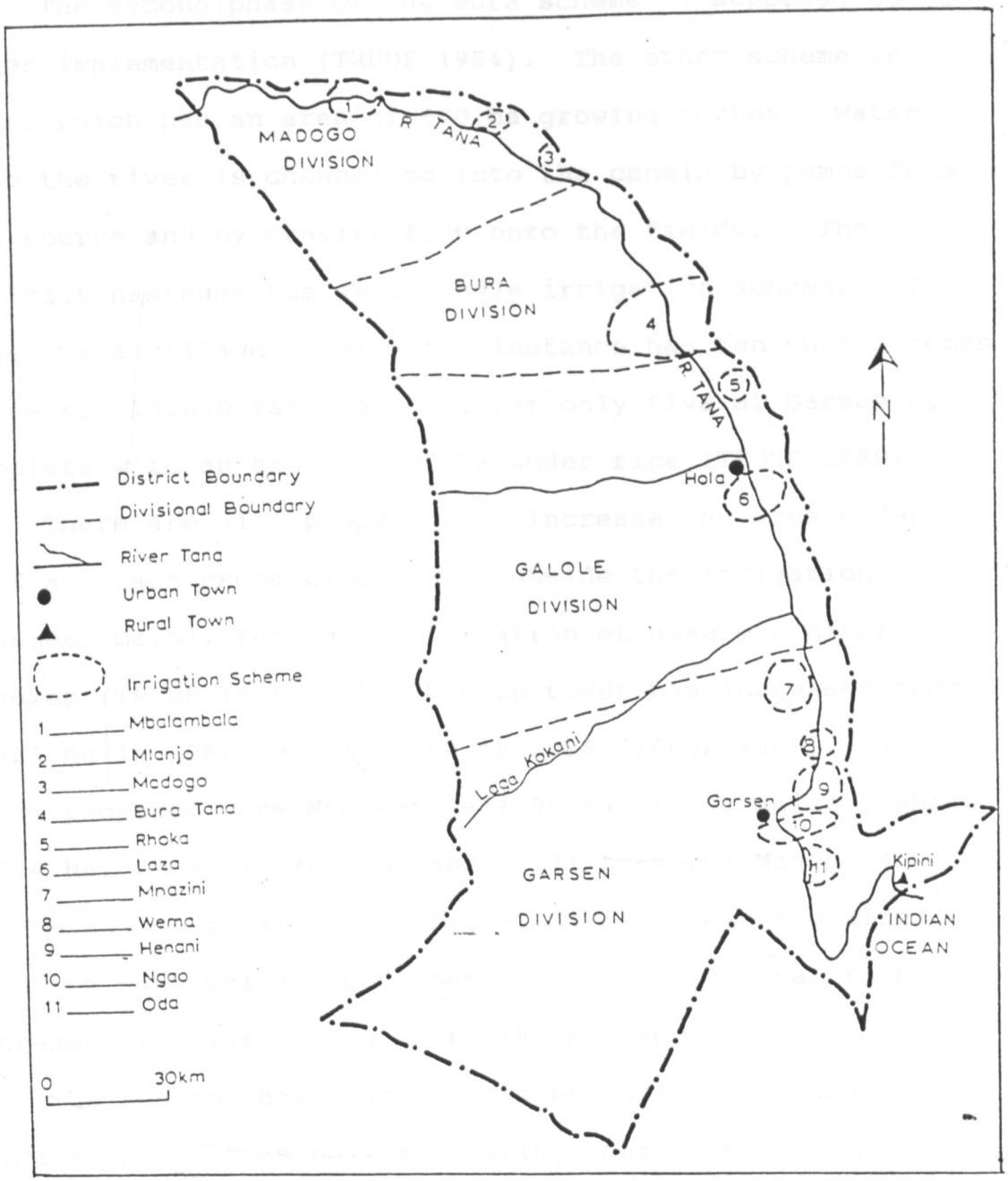


Figure 11. Tana River District Irrigation Schemes.

Source: Tana River District Development Plan, 1989.

The second phase of the Bura scheme is supposed to be under implementation (TRDDP 1984). The other scheme is Tana, which has an area of 600 ha growing cotton. Water from the river is channelled into the canals by pumps from the source and by gravity flow onto the fields. The district has numerous small scale irrigation schemes. The Lower Tana Village scheme, for instance has ten such schemes to settle 10,000 families. So far only five at Garsen are complete with an area of 600 ha under rice (TRDDP 1989).

There are also proposals to increase the area under food and cash crops within and outside the irrigation schemes, mainly through the creation of numerous minor schemes (TRDDP 1984, 1989). Crop cover has increased from 5,624 ha in 1982 to 34,573 ha in 1986 (TRDDP 1989). The areas proposed were Mbalambala (100 ha, rice, maize); Rhoka (36.4 ha, rice, maize) to benefit 91 farmers; Madogo (100 ha); Mlanjo (15 ha) to benefit 32 farmers; and the already existing Tana Delta Rice Scheme at Garsen (500 ha) to be increased to over 16,000 ha by TARDA (TRDDP 1989).

The schemes have had effects on pastoralism and wildlife by increasingly alienating them from their traditional grazing areas as the land under irrigation increases. The Hola scheme is off the flood plain and so competition from animals may be minimal, but the smaller schemes and Bura (with their areas expanding and being in the flood plain) will be expected to have significant

effects (Allaway 1979).

Furthermore, livestock keeping or grazing of stock without license in a gazetted area is prohibited under irrigation rules. Nevertheless, these rules have not been adhered to in the Bura scheme because settlement is still continuing and the problems of pastoralists in the surrounding areas have not yet been adequately considered (Riugu 1987).

2.4.2 Livestock

This is an important form of natural resource use by people in the area. There are two categories involved: traditional pastoralism and developed ranching.

2.4.2.1 Traditional Pastoralism

Traditional Pastoralism is practised by Orma and Somali people on a communal land tenure system like other pastoralists (Pratt and Gwynne 1977). As in all pastoral communities these people have a traditional right of occupancy under statutory non-customary law. However, the land is owned legally by the state or vested in trusteeship (trust land) to local authorities or council, and the pastoralists have common rights within their own tribal borders to grazing, water supplies, and salt licks (Pratt and Gwynne 1977). However, changes in land use patterns have encouraged mixed farming by these nomads (TRDDP 1984, 1989). The health of their stock has improved through the extension services of the Veterinary Department of the

Ministry of Livestock Development. The establishment of the Veterinary clinic and dips planned, are likely to improve animal health further. Establishment of marketing centres, provision of more water facilities, crushes and two holding grounds at Kurawa and Wenje will also go a long way in helping these nomads.

The problems facing these pastoralists are a scarcity of resources, for instance, water, animal forage, and space, which is compounded by competition from wildlife and arable agriculture. The impact pastoralists have had on vegetation reduction has been pointed out. This occurs when vegetation is set on fire in an attempt to improve grazing for their stock (i.e stimulation of grass growth) resulting in reduction of woody plant cover (Allaway 1979; Loth 1988).

2.4.2.2 Ranches and Grazing Blocks

The history, concepts, planning, and development of ranching and Grazing Blocks in Kenya have been discussed comprehensively (Langat 1986; Muriuki 1986; Mwangi 1986; Sadera 1986). The socio-economic constraints hampering rangeland development are discussed by Aboud (1986).

The ranches in the Coast Province started only recently (1964/65) and more so in the Tana River District (Langat 1986). There are ten ranches in the district most of which are found in the southeastern part of the district in Garsen Division (Fig 10, Table 5). Three grazing blocks have been proposed but not implemented (Table 6). A grazing

ble 5. Ranches in the Tana River District

me	State	Type of Ownership	Size (ha)	# of Shareholders	SU
a-Sa Godana	O	Co-operative	51,000	100	5,100
chu	O	D.A.C	32,000	300	3,200
tangali	O	Private	20,000	100	2,000
ritu	O	D.A.C	42,000	300	4,200
ndertu	O	D.A.C	20,000	300	2,000
lu	O	Church support	20,000	-	2,000
ganda	SO	Private	12,000	50	1,200
ongwe	NO	D.A.C	40,000	300	4,000
yu	NO	D.A.C	60,000	300	6,000
mbe	NO	D.A.C	50,000	100	5,000
lana*	O	Private	607,000	11	6,070

urce: District Range Office, Tana River District.

Part (about 28,000) of this Ranch is in Kilifi District.
Operational
- Semi-operational
- Non-Operational
A.C- Directed Agricultural Company
- Stock Unit, One SU equals 500 kg (a cow and a calf). The Stocking te of a ranch can be obtained considering one stock unit to 10 ha

Table 6. Proposed Grazing Blocks in the Tana River District

Division	Area	Size (ha)
Bangali	Mbalambala	168,350
	Saka	328,200
Madogo	Anole	360,180
Garsen	Assa	150,000
Bura		300,165

Source: District Range Office, Tana River District.

block is a communal grazing land that has been defined by physical boundaries and developed for use by livestock and wildlife (Muriuki 1986). The existing ranches will be improved by provision of firebreaks, water supply, dips, holding grounds, and marketing systems through loans obtained from the Agricultural Finance Corporation (AFC) (TRDDP 1989).

The principal national government objectives of establishment of these ranches or grazing blocks was (and still) is to increase livestock production (provide beef, etc) to increase national income and management of the rangeland resources for the benefit of the people concerned on a sustainable basis (Ministry of Agriculture 1973), as well as educating and settling pastoralists to offer better social services (Swallow 1989). Despite the benefits realized, the establishment of these ranches has certain drawbacks. As more ranches develop the pastoralists (Orma) and the wildlife will be alienated from their traditional grazing areas and the Orma might eventually be organized into group or block ranches (Rep. of Kenya 1980). This may lead them into sedentary existence, an issue that might interfere with wildlife movement. Also, some of the commercial ranches and holding ground have already excluded pastoralists (Allaway 1979). These developments will certainly affect wildlife as well, by reducing their ranges and hence numbers.

2.4.3 Tourism

Tourism is an important economic use of the natural resources in the district, mainly through wildlife, though there is a potential for tourism around Kipini based on its beautiful beach (TRDDP 1989).

There are two game reserves in the area (Fig.10), Kora (area 1720 km^2, gazetted in 1973) in the northwest and the Tana River Primate (area 175 km^2, gazetted in 1975) for Red Colobus, Mangabey, and forest habitat along the Tana in the south east. The latter Reserve is estimated to contain about 30-40% of the remaining monkey species in the world (TRDDP 1989). Part of Tsavo East National Park is also within the district.

Despite the presence of game reserves, tourism volume is low mainly because of inaccessibility (Rep. of Kenya 1980). Plans to promote tourism are under way, involving infrastructural improvements like construction of roads, airstrips, and lodges. There is a plan to develop a tourist circuit connecting Kora Game Reserve to Meru National Park in the north.

The conflict between human activities and wildlife interests have been recorded. Conflicts between the Pokomo and wildlife occur extensively during dry seasons when the animals move towards the Tana River. These do cause depredation such as crop destruction, injury and death to livestock by elephant and buffalo (Rep. of Kenya 1980).

Also, the establishment of the game reserves and Tsavo National Park have taken up part of the pastoralist's grazing land (Allaway 1979).

A factor that has adversely affected some wild game species, is poaching. In fact it is now threatening animals like the elephant and the rhinoceros (Allaway 1979; Trent-Bunderson 1981). The rapid increase in poaching elephants is ascribed to several factors-- spiralling prices of ivory and declining numbers of large-tusked elephants elsewhere in the country. This is enhanced by poachers being better armed and organized, and the limitation of anti-poaching efforts by logistical constraints in patrolling such remote and inaccessible areas (Watson et al. 1973; Trent-Bunderson 1981).

Moreover, proposed development plans involve intensive ranching operations which are inherently sedentary in nature. Unlike the livestock grazing practice of pastoralists, intense ranching would disrupt wildlife movements, a factor that would likely lead to drastic declines in their numbers (Trent-Bunderson 1981).

A very significant factor in the preservation and conservation of wildlife is the awareness and appreciation of the people of the area. It has been observed that the general attitude of the people to wildlife has been that of indifference, with people not knowing why wildlife are preserved (Rep. of Kenya 1980).

CHAPTER III

METHODOLOGY

Introduction

Data acquisition involved several methods which included aerial surveys, field surveys, secondary information from existing literature, schedules or questionnaires and interviews. The data were then analyzed using various statistical methods.

3.1 Animal Data

The method employed in censusing animals is described by Norton-Griffiths (1978), while the population estimates and their standard errors were calculated using the "Jolly 2" method of unequal transects (Jolly 1969) (Appendix A). This method is appropriate because of the non-uniformity of the sampling frame.

The data were collected using single-engined Cessna 185 or twin-engined Partenavia (P-68) aircraft equipped with Global Navigation Systems (GNS 500 series 2), King Radio intercoms systems, and radar altimeters. The survey height, speed and strip width used were 122 m, 190-210 km/hr, and 282 or 304 cm (Ottichilo and Sinange 1985) respectively (Table 7).

The systematic flight lines or straight belt transects used were oriented in a parallel East-West direction due to the flat terrain of the district. Systematic transect sampling, also known as the systematic reconnaissance flight

Table 7. DRSRS Survey Parameters

Date	Flying Height (m)	Strip Width (cm)	Transect Spacing (km)	Speed (kph)	Aircraft
1977	91	224	10	150	Cessna
1978	91	224	5	150	Cessna
1980	91	250/415	5	190-210	Partenavia
1981	122	400/490	5	190-210	Partenavia
1982	122	364/400/418	5	190-210	Partenavia
1984	91	263	5	190-210	Partenavia
1985	122	282/304	5	190-210	Partenavia
1986	122	282/304	5	190-210	Partenavia
1987	122	282/304	5	190-210	Partenavia
1988	122	282/304	5	190-210	Partenavia
1987	122	282/304	5	190-210	Partenavia
1988	122	282/304	5	190-210	Partenavia
1989	122	282/304	5	190-210	Partenavia
1990	122	282/304	5	190-210	Partenavia

Source: DRSRS Aerial Surveys

(SRF) method, was chosen because it provides information on numbers and distribution, and it gives information on trends since it is repeatable. It is also cheaper when compared to other aerial sampling methods in terms of aircraft operation expenses and easier navigation and minimal fatigue to the crew. The transect spacing of 5 km (Table 7) was used for the 1990 survey for this study. A transects were made using topographic map sheets of 1:250,000 scale along Universal Transverse Mercator(UTM) grid lines or co-ordinate systems (Wetmore and Townsend 1977).

During the surveys, strip width (the width of the sample transect) was defined by two parallel metal rods hooked to the lower part of the wing and the body of the aircraft (on both sides) and calibrated as described by Norton-Griffiths (1978). Only animals observed within this strip were recorded. During surveys all visual observations of animals by rear seat observers (RSO) within the strip width were recorded using tape recorders. For herds exceeding ten animals, a photo was taken. The photos were then processed and interpreted for animal species using binocular microscopes. Taking photos was based on the assumption that they would be more accurate than visual counts. A correct photo count was then entered in the RSO data sheet. The RSO tape recorded observations were transcribed after flights onto standard data forms, cleaned and then verified for errors and biases using computer

programs (Appendix D).

The data was reformatted into computer datafiles and the "Jolly 2" method (Jolly 1969) calculations applied to the district database using GIS programs to obtain population estimates and their standard errors (Appendices D and E). Population estimates will assume a randomly distributed animal population. Distribution and density maps were generated from these programs, i.e, derived from occupancy maps for each species each year. Densities were calculated as the number of species observed in the strip width divided by the area of the strip width. The assumptions and procedures used in obtaining some of the information are given in Appendix D.

Seasonal movement of animals were determined from dry and wet seasonal data, coupled with information from literature, schedules, and interviews (see section 3.2)

Finally, the data were subjected to statistical analysis methods such as graphical comparisons, comparisons of differences, and examination of trends by regressions.

The stocking levels (densities) of animals were obtained according to Tropical Animal Units where each unit equals 250 kg as given in Table 8 (Ecosystems 1978; Watson et al. 1978; Field et al. 1983; Peden 1984).

The TLU equivalent expresses the weights of animals of various sizes in terms of a common denominator. For example, one elephant has more impact on an environment than

Table 8. Animal Weights (kg) and Tropical Livestock Unit Equivalent (TLU)

Animal	TLU	Kg
Cattle	0.72	180
Donkey	0.6	150
Wildebeest	0.5	125
Zebra	0.8	200
H. Hartebeest	0.5	125
Waterbuck	0.42	105
Thomson's Gazelle	0.06	15
Impala	0.16	40
Sable Antelope	0.5	125
Eland	1.36	340
Lesser Kudu	0.16	40
Oryx	0.4	100
Sheep and Goat	0.072	18
Camel	1.2	300
Elephant	6.9	1500
Kongoni	0.5	125
Topi	0.45	112
Ostrich	0.46	115
Grant's Gazelle	0.16	40
Rhino	3.26	815
Gerenuk	0.1	25
Buffalo	1.8	450
Giraffe	3.0	750
Greater Kudu	0.8	200
Warthog	0.36	90

Source: Peden, 1984.

a sheep.
Thus one elephant is given a weighting of 6.9 TLUs while a sheep has the TLU of 0.072. It should be noted that the TLU equivalent is an approximate value only. The weight of individual animals varies greatly from birth to adulthood, from place to place and season to season. Nevertheless, the TLU provides a useful index of stocking levels. The TLUs were used to furnish average annual densities for each species.

In the survey, the occurrence of elephant carcasses and skeletons were recorded as was done in past DRSRS surveys. The classification of Douglas-Hamilton and Hillman (1979) was used (Appendix B). This method helped in understanding poaching incidence and determined trends over time.

3.2 Land Use Data

These were acquired through appropriate questionnaires or interviews (Appendix C) administered to various ethnic groups either as farmers or pastoralists, Government ministries and agencies such as Agriculture, Livestock, Environment and Natural Resources, range management, wildlife and tourism, and agencies like NIB and TARDA, and private ranches.

In all, 350 farmers and pastoralists were interviewed through mainly open-ended structured schedules so as to get maximum information as possible from respondents. Since the interviews were delivered personally, any difficulty

encountered in understanding were explained to the respondent.

The farmers interviewed lived along the entire course of the Tana River where most agricultural activities occur. Of the 350 respondents, 214 engaged only in arable farming whereas 14 were both farmers and pastoralists.
The pastoralists interviewed were found mostly westward from the river. Out of 350 respondents 122 were pure pastoralists.

Ministries and agencies interviews were conducted with heads of departments using questions shown in Appendix C, and other related questions. In this respect, questions were unstructured,i.e, so as to draw maximum information on respective resource areas. The data gathered were subjected to appropriate non-parametric methods of data analyses involving simple proportions.

CHAPTER IV

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 POPULATION ESTIMATES

A summary of the livestock and wild herbivore populations, their standard errors, densities and stocking levels for various species are given in Table 9.

4.1.1.1 Livestock

Fluctuations in total livestock populations occurred between 1973 and 1990 (Fig 12). Increases of 121±35%*, 32±20%, and 77±20% were observed between 1973 and 1977, 1978 and 1980, 1985 and 1988 respectively. Decreases of 40±14% were indicated between 1980 and 1985, and 46±11% between 1988 and 1990. The 1990 population was 45±16% higher than that of 1973.

These fluctuations are depicted for individual livestock species from 1973 to 1990. The numbers of all livestock species except for camels fell between 1980 and 1985, and between 1988 and 1990, whereas an increase in the overall livestock population is observed between 1973 and 1977, and 1985 and 1988, except for donkeys.

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*121 refers to percentage change of population estimate and 35% refers to change in the standard error.

TABLE 9- ESTIMATED LIVESTOCK AND WILD HERBIVORE POPULATION SIZES AND STOCKING LEVELS IN TANA RIVER DISTRICT, 1973 -1990

SPECIES	1973* P.E.	1973* S.E.	1977** P.E.	1977** S.E.	1978** P.E.	1978** S.E.	1980** P.E.	1980** S.E.	1985** P.E.	1985** S.E.	1988** P.E.	1988** S.E.	1990 P.E.	1990 S.E.
CATTLE	214567	2311	298038	65943	210059	28797	314075	49846	148695	22617	305213	51273	202125	31824
SHEEP AND GOATS	54603	6891	294168	72755	287242	49405	363919	73141	251526	41101	402848	53236	181827	30553
CAMEL	12834	2843	34514	10721	44255	11146	39184	9057	30219	4789	52425	7288	27097	6060
DONKEY	2205	732	1646	604	2837	860	2445	704	1542	481	2313	765	825	304
TOTAL LIVESTOCK	284209	7839	628366	98778	544393	58267	719623	88976	431982	47159	762799	74274	411874	44532
ELEPHANT	44424		8717	3572	3485	1039	4289	1205	1349	507	1053	481	33	32
RHINO	470		267	139	–	–	129	93	–	–	–	–	–	–
GIRAFFE	5604		4937	1292	4781	888	7335	2174	4695	681	4212	553	3466	573
BURCHELL'S ZEBRA	13472		9118	3068	12823	2723	11667	3209	5974	1819	6991	1077	5050	1234
GREVY'S ZEBRA	–		133	132	–	–	1244	525	298	197	224	162	1535	889
THOMSON'S GAZELLE	–		1334	459	2547	733	3067	840	–	–	–	–	875	310
GRANT'S GAZELLE	11179		3291	833	9360	1473	13834	2776	4677	1173	6370	1122	3284	701
KONGONI	–		133	132	335	193	1115	491	–	–	17	17	50	49
IMPALA	549		1023	482	760	313	1587	566	1051	417	1174	501	1287	469
TOPI	2527		4537	2232	8578	3174	10917	5257	1997	950	2693	1624	2690	1191
HUNTER'S HEARTBEESTE	840		89	88	827	434	1587	651	491	246	35	34	561	242
BUFFALO	3863		1690	1222	6814	2678	1544	866	6710	5146	2417	1135	3301	1305
ELAND	2562		4892	2348	2949	1300	1952	747	1209	826	397	276	1848	904
OSTRICH	2353		3647	672	3262	732	4289	1411	1857	411	1070	383	1931	677
WARTHOG	5663		6672	1203	8802	1449	8472	1231	1577	305	2037	408	2558	498
ORYX	7767		10541	3076	15906	3348	11860	2402	3486	660	5455	887	3664	788
LESSER KUDU	1189		1334	425	2167	401	2338	486	1384	289	1554	251	1914	415
WATERBUCK	4436		2980	1759	3999	1059	7421	1910	3153	1215	3073	1463	1040	433
GERENUK	5604		2802	673	4066	531	7078	1113	3399	560	2434	388	2129	476
TOTAL WILD HERBIVORE	112502		68137	7219	91461	6831	101725	8337	43307	6026	41206	3270	37216	3060
TOTAL ANIMALS	396711		696503	99041	635854	58667	823241	89366	475289	45559	804005	74346	449090	44637
TOTAL LIVESTOCK UNITS	175143	6011	278172	65945	226732	38194	300824	52447	162358	25279	313056	49954	191633	32568
TOTAL WILD HERBIVORE UNITS	358360		105890	41128	84601	23322	90623	26910	48896	19521	38199	10715	30879	9225
TOTAL ANIMAL UNITS	351255		384062	77719	311333	44752	391447	58948	211254	31939	351255	51090	222512	33849
DENSITY (TLUs/km^2)														
LIVESTOCK	4.79	0.16	7.12	1.69	5.80	0.98	7.70	1.34	4.16	0.65	8.01	1.28	4.90	0.83
WILD HERBIVORE	9.80		2.71	1.05	2.17	0.60	2.32	0.69	1.25	0.60	0.98	0.27	0.79	0.24
TOTAL	14.59		9.83	1.99	7.97	1.15	10.02	1.51	5.41	0.82	8.99	1.31	5.69	0.87
ANIMAL UNIT RATIOS														
LIVESTOCK:WILD HERBIVORES	0.49		2.60		2.67		3.32		3.33		8.17		6.20	

P.E-Population Estimate
S.E-Standard Error
TLUs- Total Livestock Units
SOURCE:
*- WATSON et al 1973, area, 36558 km^2
**- DRSRS SURVEYS
THE STUDY AREA-39072 KM^2
One Livestock Unit =250 kg.

4.1.1.2 Wild Herbivores

Increases and decreases in numbers of various magnitudes in wild herbivore populations were observed between 1973 and 1990 (Fig. 12). This was also true for individual wild herbivore species over the years. The wild herbivore populations increased by 34±15% between 1977 and 1978, and decreased by 57±10% between 1980 and 1985. The overall wild herbivore population decreased by 40±12% between 1977 and 1990.

A significant regression fit ($P < 0.05$) for the wild herbivore population over the years of survey shows an annual decrease of 4430 animals. This is depicted by the regression line fitted for the period between 1973 and 1990 (Table 10) as:

$P = 113190 - 4430t$, where t = # of years, 1973 = t1, 1990 = t18.

Elephant (*Loxodonta africana* Blumenbach)

Decreases in elephant numbers were evident between 1977 and 1978 by 60±43%, by 69±30% between 1980 and 1985, and by 97±46% between 1988 and 1990. Increases occurred between 1978 and 1980. The 1990 numbers were 97±41% lower than those of 1977.

Rhinoceros (*Diceros bicornis* Linnaeus)

These were observed in very low numbers in 1973, 1977, and 1980. None was recorded in any of the subsequent surveys. Their numbers seem to have declined since 1973.

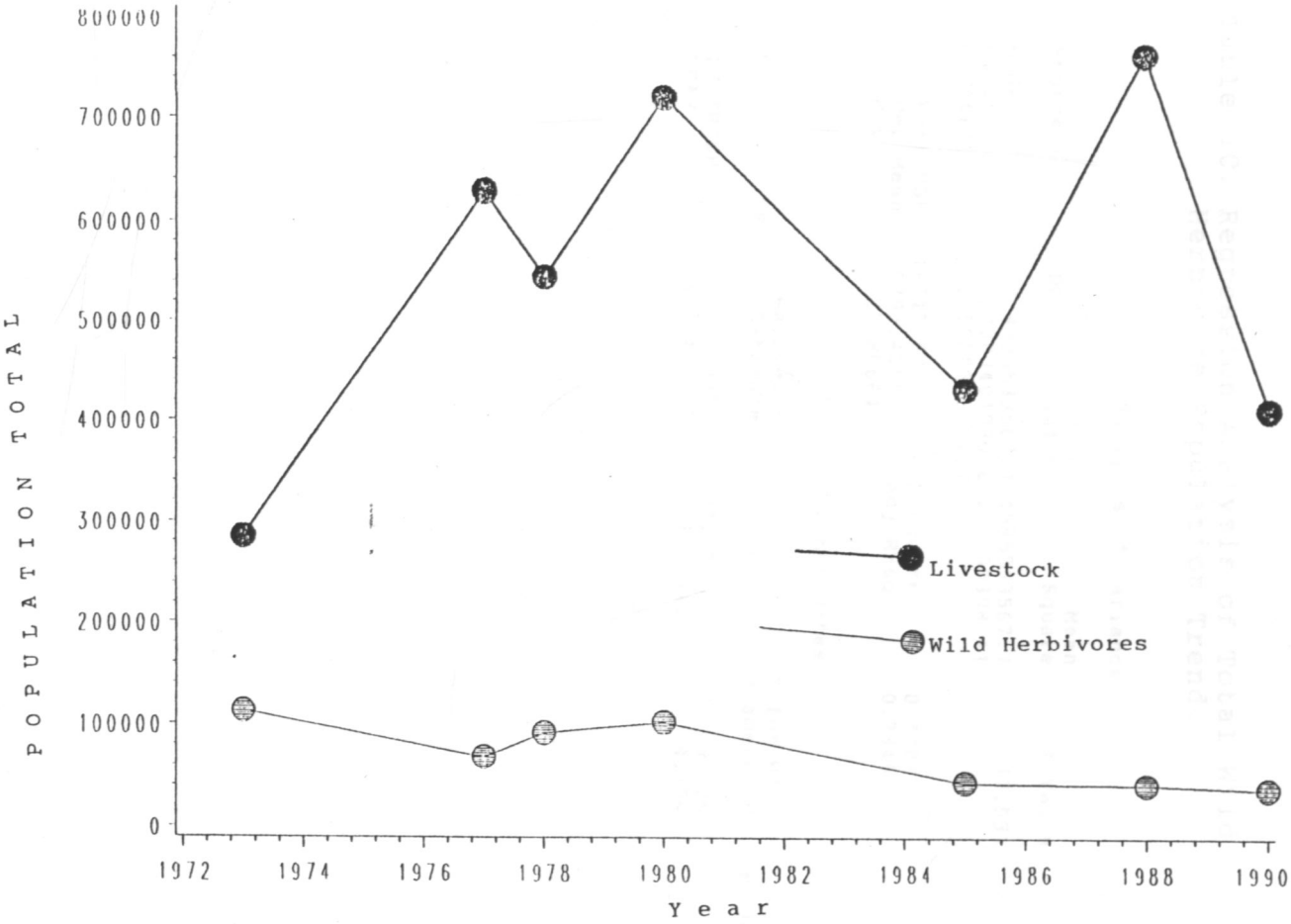

Figure 12. Total Population Trends for Livestock and wild Herbivores in Tana River District, 1973-1990.

Table 10. Regression Analysis of Total Wild Herbivore Population Trend.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	4585533567.1	4585533567.1	17.591	0.0085
Error	5	1303401990.6	260680398.11		
C Total	6	5888935557.7			

Root MSE	16145.59996	R-square	0.7787
Dep Mean	70793.42857	Adj R-sq	0.7344
C.V.	22.80664		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	113190	11807.734100	9.586	0.0002
YEAR	1	-4429.475550	1056.1158443	-4.194	0.0085

Giraffe (Giraffa camelopardalis Linnaeus)

There was no evidence of change in their numbers between 1977 and 1990 except for a decline of 36±31% between 1980 and 1985, and an increase of 53±49% between 1978 and 1980.

Burchell's Zebra (Equus burchelli Gray)

Between 1977 and 1990 there was evidence of decreases of 49±32% and 28±23% between 1980 and 1985, and 1988 and 1990 respectively.

Grevy's Zebra (Equus grevyi Oustalet)

Their population was relatively low between 1973 to 1990 and the highest numbers were recorded in 1990. Their population decreased by 76±45% between 1980 and 1985 and no animals were observed in the 1973 and 1978 surveys. A large increase of 585±403 % was observed between 1988 and 1990.

Thompson's Gazelle (Gazella thomsonii Gunther)

None were recorded in the 1973, 1985 and 1988. A 91±65% increase occurred between 1977 and 1978, and decrease by 71±29% between 1980 and 1990.

Grant's Gazelle (Gazella granti Brooke)

Their populations fluctuated between 1977 and 1990 with increases of 184±51% and 36±35% being observed between 1977 and 1978, and 1985 and 1988 respectively. Decreases of 66±22% and 48±34% were recorded between 1980 and 1985, and 1988 and 1990 respectively.

Kongoni (Alcephalus busephalus Pallas)

None were observed in the 1973 and 1985 surveys. In other surveys between 1977 and 1990, only a few were noted. An increase of 233±158% was observed between 1978 and 1980, and a decrease of 985±427% between 1980 and 1988.

Impala (Aepyceros melampus Lichtenstein)

These were observed in all the surveys and their populations did not change much between 1977 and 1990 except for a decrease of 109±85% between 1978 and 1980.

Topi (Damaliscus korrqum Ogilby)

Their populations had fluctuations between 1977 and 1990 with an increase of 89±86% and a decrease of 82±49% between 1977 and 1978, and between 1980 and 1985 respectively.

Hunter's Hartbeeste (Damaliscus lunatus Burchell)

They were observed in low numbers between 1973 and 1990. Large numbers were recorded in 1973 and 1978 surveys, while the lowest numbers occurred in 1988. Decreases of 69±44% and by 93±51% occurred between 1980 and 1985, and between 1985 and 1988. An increase of 829±498 % occurred between 1977 and 1978.

Buffalo (Syncerus caffer Sparrman)

These were observed throughout the survey period 1973 to 1990. No evidence of change in population was observed except for a decrease of 77±41% between 1980 and 1985 and an increase of 303±174% between 1977 and 1978.

Eland (Taurotragus oryx Pallas)

There was no evidence of change in their number between 1977 and 1988. An increase of 365±238% occurred between 1988 and 1990.

Ostrich (Struthios camelus Linnaeus)

There were fluctuations in numbers throughout the period 1973 to 1990. Decreases of 58±28% and of 42±30% occurred between 1980 and 1985 and between 1985 and 1988 respectively. The only increase in their numbers occurred between 1988 and 1990 and this was by 81±73%.

Warthog (Phacocherus aethiopicus Pallas)

There was no evidence of much change over the years except when there was an increase by 32±28% and decrease by 81±15% between 1978 and 1980, and between 1980 and 1985.

Oryx (Oryx beisa Ruppell)

Their numbers fluctuated over the years. Decrease of 71±21% and 33±32% occurred between 1980 and 1985, and 1988 and 1990 respectively. The only increase was recorded between 1985 and 1988 which was by 57±32%.

Lesser Kudu (Tragelaphus imberbis Blyth)

There was no much evidence of change between 1977 and 1990 except an increase of 62±44% and a decrease of 41±24% between 1977 and 1978, and between 1980 and 1985 respectively.

Waterbuck (Kobus ellipsiprymmis Ogilby)

There were fluctuations in their numbers over the years. There were decreases of 58±31% and 66±50% between 1980 and 1985, and between 1988 and 1990 respectively. The only increase was by 86±29% observed between 1978 and 1980.

Gerenuk (Litocranius walleri Brooke)

There were various changes in their populations between 1977 and 1990. A decrease of 52±18 % occurred between 1980 and 1985 and an increase of 74±30% between 1978 and 1980.

4.1.2 TREND IN NUMBERS OF ENDANGERED SPECIES

The animal species threatened by poaching are the elephant and the rhinoceros (Western 1987). Their numbers have declined to very low levels over the years (Table 9). Their trends have been mainly downwards (Figs 13 and 14).

Table 10 depicts the number of dead elephants expressed as a percentage of live plus dead from 1977 through 1990. Dead elephants were determined from carcasses and bones found in surveys following methods developed by Douglas-Hamilton and Hillman (1979). The percentage distribution ratio of live to dead are shown on Figure 15 and Table 11.

The percentage of live elephants decreased by 60±43%, 69±30 %, and by 97±46% between 1977 and 1978, between 1980 and 1985, and between 1988 and 1990 respectively.
The percentage of dead increased by 178±31%, and by 31±18%, between 1977 and 1978, between 1988 and 1990.

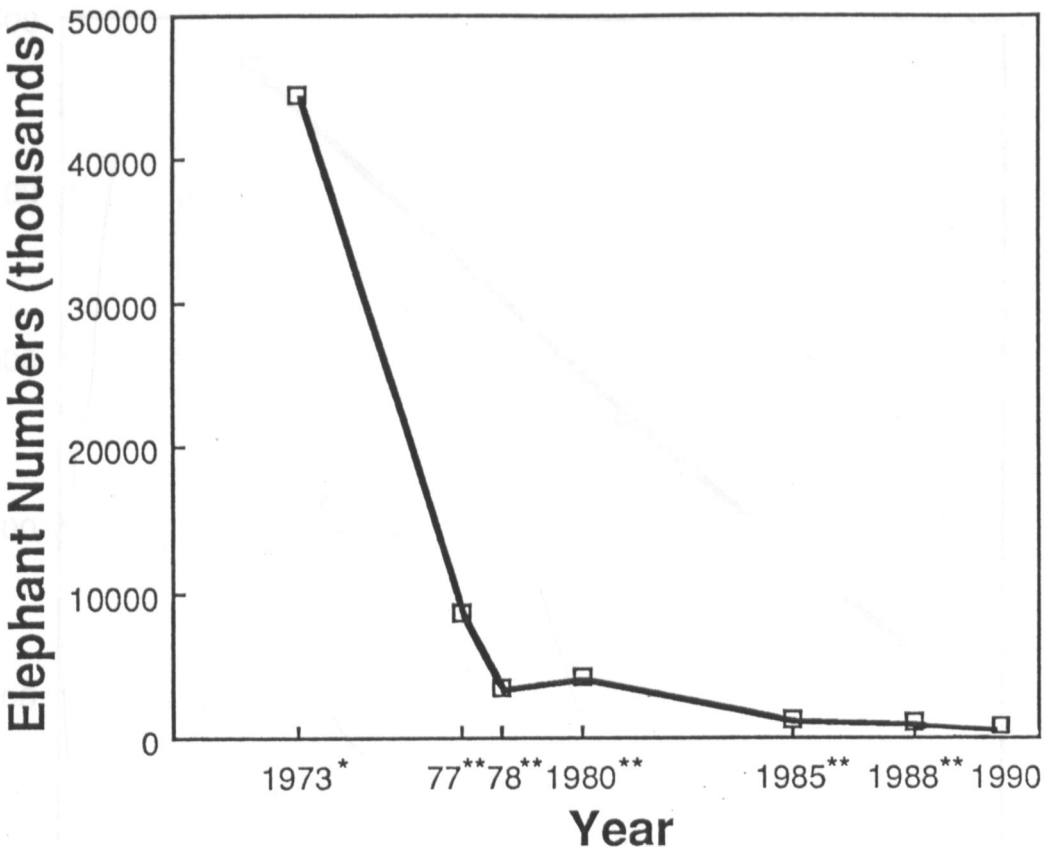

Figure 13. Trend of Elephant Population in the Tana River District, 1973-1990

Source: * Watson et al, 1973

** Drsrs Surveys.

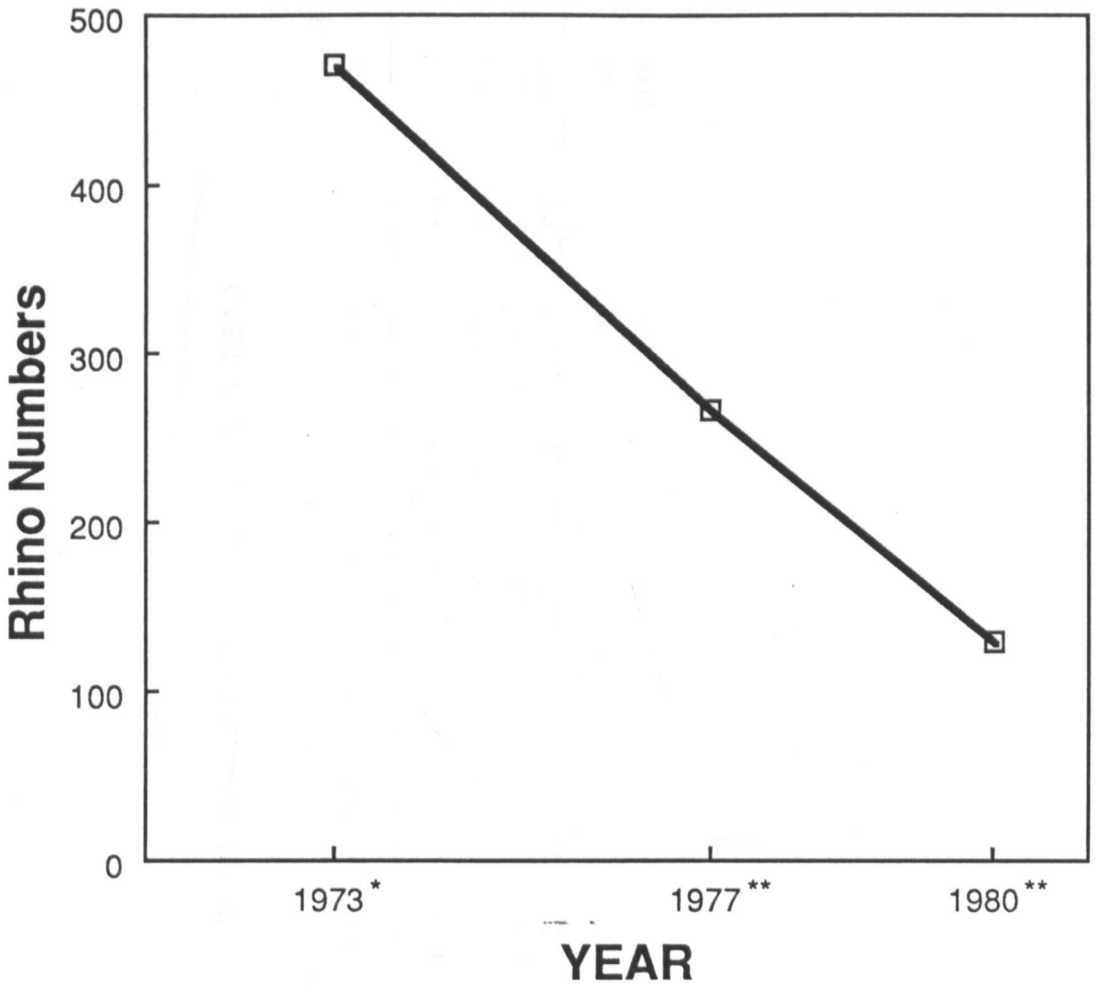

Figure 14. Trend of Rhinocerous Population in the Tana River District, 1973-1980

Source: * Watson et al, 1973
** Drsrs Surveys.

TABLE 11 DEAD ELEPHANTS EXPRESSED AS PERCENTAGE OF LIVE PLUS DEAD

	1977		1978		1980		1985		1988		1990	
	P.E	S.E	P.E	S.E	P.E	S.E	P.E	S.E	P.E	S.E	P.E	S.E
LIVE	8717	3472	3485	1039	4289	1205	1349	507	1053	481	33	32
DEAD	2713	523	7529	644	7764	914	3347	473	2227	339	2922	388
TOTAL	11430	3511	11014	1222	12053	1512	4696	693	3280	588	2955	389
PERCENTAGE	24		68		64		71		68		99	
LIVE:DEAD	3:1		1:2		1:2		1:2.5		1:2		1:99	

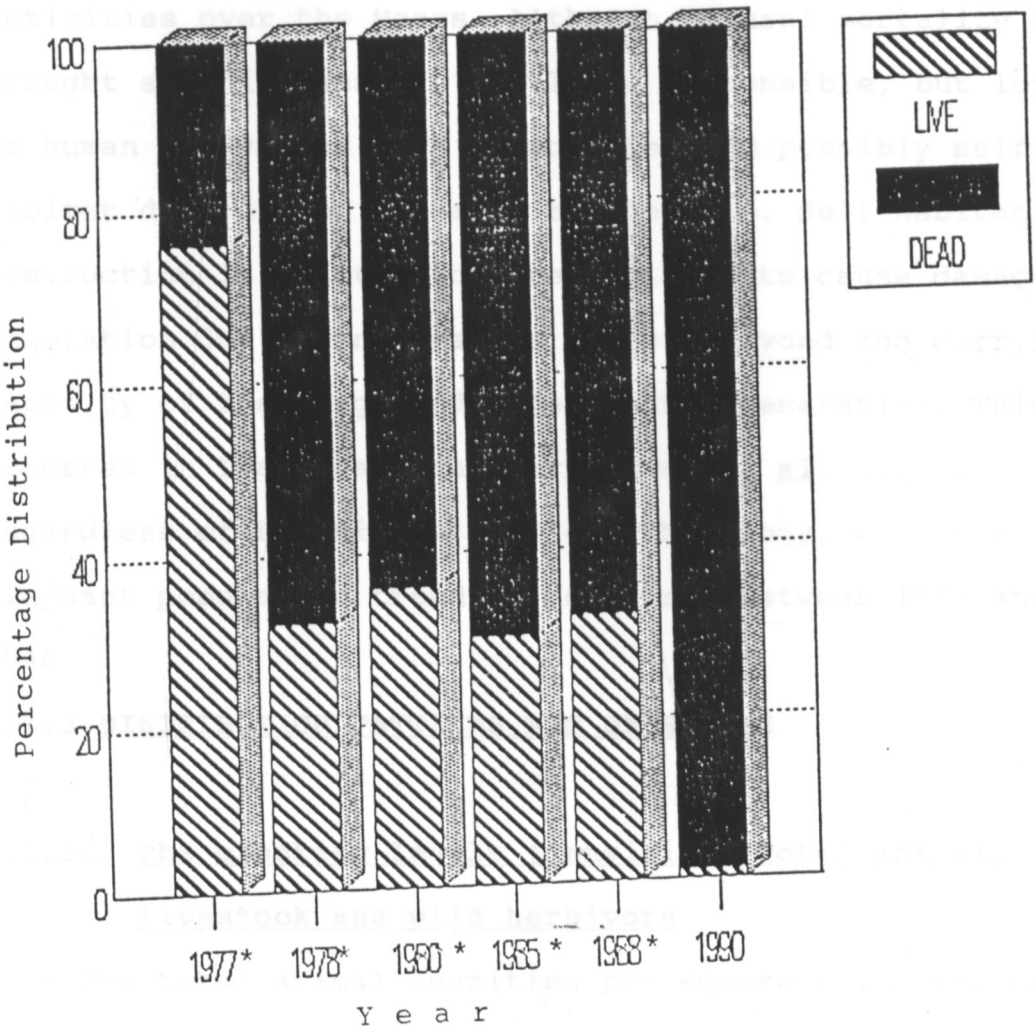

Figure 15. The Percentage Distribution of Live and Dead Elephants in Tana River District, 1977-1990.

Source: * DRSRS Surveys.

From 1977 to 1990, the number of dead animals surpassed the living, an evidence possibly of increased poaching activities over the years. Although natural mortality due to drought and diseases may partly be responsible, but loss due to human activities such as poaching and possibly self habitat destruction are also responsible. Self habitat destruction is a situation where elephants cause damage to vegetation due to increase in numbers beyond the carrying capacity of the range and vegetation regeneration. This occurred in Tsavo National Park (Laws et al. 1975). Regardless of the biases due to methodology, etc. the elephant population trend is downwards between 1973 and 1990.

4.1.3 DISTRIBUTION PATTERNS AND DENSITIES

4.1.3.1 The stocking levels (densities)-Total animal, livestock and wild herbivore

The total animal densities per square kilometre varied widely between 1973 and 1990 (Table 9). High densities were observed in 1973, 1977, and 1980, moderate densities in 1978, and low densities in 1985 and 1990. Large declines of 36±18% and 46±17% in densities occurred between 1988 and 1990,and between 1980 and 1985 respectively whereas increases of 26±24%,and 66±29% were registered between 1978 and 1980, and between 1985 and 1988 respectively. A decline of 42±22% was observed between 1977 and 1990.

Total livestock densities show fluctuations of various magnitudes between 1973 and 1990 (Table 9). Decreases of 50±19% and 39±19% occurred between 1980 and 1985, and between 1988 and 1990 respectively.

Increases in densities of 49±35% and 93±35% were registered between 1973 and 1977, and between 1985 and 1988 respectively. However, there was not evidence of overall change in total livestock densities between 1973 and 1990.

Total wild herbivore densities differed from those of livestock. There was not much change in the total wild herbivore between 1977 and 1990 except a decrease of 46±42% between 1980 and 1985. However, an overall decrease by 70±40% was registered between 1977 and 1990.

4.1.3.2 Distribution and Densities by species, 1977-1990

The density distribution for livestock and wild herbivore species in space and time from 1977 through 1990 are described and shown in Appendix E. The density was within 10 km by 10 km for the year 1977 and within 5 km by 5 km for subsequent years. The years 1977, 1978, 1980, and 1985 were dry years; and 1988 and 1990 were wet years. The above parameters are affected by water and forage availability as determined by seasonality (dry or wet) among other factors.

Cattle

The pattern is more or less similar for 1988 and 1990 as indicated by dispersed nature of distribution explained by widespread availability of water and forage. For the dry season survey of 1977, 1978, 1980, and 1985, the pattern of distribution is similar, though the densities vary slightly. The slight variation in terms of clumpness or sparsity in 1977 is due to difference in transect spacing. Animals were distributed mostly along the Tana River basin, the dry river valleys of the seasonal rivers, permanent wells and grazing land in the central and northern regions. The lower southwestern corner of the district spots lower densities because of presence of Tsavo East National Park, restricted for livestock use.

Sheep and Goat

Similar pattern of densities and distribution as cattle. The same explanation holds true.

Donkey (Equus asinus)

The same explanation as above applied, but their distribution depends on the distribution of villages and settlements, mostly close to water holes. The patterns and densities remained somewhat similar for the dry season mainly concentrated in the central areas (around wells and dry river valleys) and along the Tana River.

As for the rainy season of 1988 and 1990, sparser and less denser in 1990 than in 1988.

Camel

These are mostly found in the northern part of the district. In the dry years of 1977, 1978, 1980, and 1985, the pattern seemed to have remained the same although, they moved further south in 1980 and in 1985.

The densities over the years have remained similar as well. In wet years of 1988 and 1990, they were more concentrated in the north, and relatively more spread out in 1988 than in 1990. Densities were relatively lower in 1990.

Elephant

The pattern of distribution for the dry years seem somewhat similar, but the densities have gone down progressively over these years. The same pattern of decline in densities emerges also for the wet season survey of 1988 and 1990. This species was mostly distributed in the protected areas such as Tsavo East National Park in the southwestern part and Kora Game Reserve in the northwest, and a few forest islands along the Tana River.

Rhinoceros

Very low densities, sparsely distributed in 1977 and 1980 in and close to Tsavo East National Park. None were seen since 1980. Poaching is the reason for this decline.

Giraffe

The distribution pattern and densities were similar in the dry years of 1977 (sparser), 1978, 1980, and 1985. In 1988 and 1990, patterns of distribution were similar, but a lower density was recorded in 1990 than in 1988. There were more clusters in the northern and central regions of the district in all seasons.

Burchell's Zebra

The distribution pattern was more or less similar in 1988 and 1990, but was more widespread in 1988 and less denser in 1990. Higher concentrations were found in the southeastern part of the district and southern region occupied by Tsavo East National Park. In the drier years of 1977, 1978, 1980, and 1985, the species was found concentrated along the eastern regions close to the Tana River, and in 1978 was located in a pocket in Tsavo East National Park. There was not much noticeable change in densities of Burchell's zebra among these years.

Grevy's Zebra

The densities of this species were low and their distribution was sparse. They were found in isolated northern and eastern parts of the district. The distribution patterns varied widely during the dry season survey, 1977 (north), 1980 (central), 1985 (eastern, along the Tana River). The densities of the Grevy's zebra were higher in 1980 than in 1977 and 1985.

In the wet season survey of 1988 the species was found in southwestern parts of the district close to Tsavo Park. The species density distribution was higher in 1990 than in 1988. This variability in distribution pattern could be ascribed to the mobility and adaptation of this species.

Grant's Gazelle

This species was mainly found in the central and southern half of the district. Their distribution pattern looks similar in 1977, 1978, 1980, and 1985 (close to Tana river) except the population density looks less denser in 1977 and 1985 than other dry season surveys.
The distribution pattern and densities were similar for wet season surveys, although their densities were lower in 1988 than 1990.

Thomson's Gazelle

This species was found in southern part of the district in the 1977, 1978 and 1980 censuses. The patterns of distribution were similar and the species was sparsely distributed at low densities. In the 1988 survey no animal was observed. In the wet season census of 1990 the species was mainly concentrated in the south of the district at lower densities.

Kongoni

The Kongonis were observed at low densities and sparse distribution in the north close to the Tana River in the 1977 survey, central close to the Tana River in 1978, higher densities in the south in 1980. The pattern of distribution and densities remained similar in the 1988 and 1990 surveys.

Impala

This species shows low densities and sparse distribution in the wet season surveys of 1988 and 1990. They were mostly found in the southern part of the district. In the dry season surveys of 1977 they were found in the southeast, in 1985 in the south, and close to the Tana river in 1978 and 1980.

Topi

In all years (dry or wet) high densities of the Topi were observed in the southeastern corner of the district bordering Lamu district and the Indian Ocean. The distribution pattern and densities of this species remained the same. This species is migratory.

Hunter's Hartebeest

The densities of this species were low and their distribution sparse and isolated in all years. There seems to be little change over the years. They were found in southeastern part of the district bordering Garissa and Lamu districts close to the Tana River in 1977, 1978, and 1980,

and some pockets in the south along the Galana River in 1980 and 1985. In wet years of 1988 and 1990 the species was found in the southeast and south of the district, but at higher densities in 1990 than in 1988. This species is also migratory.

Buffalo

The buffalo was mostly found in south and southeastern part of the district close to the wetland areas in the Tana River Delta in 1977, 1978, 1980, and 1985. Their densities seem to have remained the same. Also, their pattern of distribution remained the same in 1988 and 1990, although at higher density in 1990.

Eland

This species was found mainly in southern part of the district. The Pattern of distribution remained similar in 1977,1978, 1980, and 1985, but their densities was lower in 1985 than other dry years. Also, the distribution pattern was the same for the wet season surveys of 1988 and 1990, although at lower density in 1988.

Ostrich

This species was widely distributed in the district. The species densities was lower in 1985 than in 1977, 1978, and 1980. A similar distribution pattern and densities apply to the 1988 and 1990 surveys.

Warthog

The warthog was widely distributed, mostly in central and southern parts close to the Tana River in 1977, 1978, 1980, and 1985 but at lower densities in 1985. The pattern of distribution and densities remained similar for 1988 and 1990. This species is common near farmlands and road sides, particularly between Hola and Bura.

Oryx

This species was widely distributed but more in the southern half of the district. Their densities were almost the same in all (wet and dry) years.

Lesser Kudu

This species was sparsely and widely distributed in all years. Their densities were more or less similar over the years as well.

Waterbuck

The waterbuck was found in southeastern part of the district mainly along river courses. The distribution patterns and densities have remained the same from 1977 to 1990.

Gerenuk

This species was widely and sparsely distributed in the district from 1977 to 1990. Likewise, the densities have remained the same over the same duration.

4.1.4 SEASONAL MOVEMENT OF LIVESTOCK AND WILD HERBIVORES

Livestock and wildlife generally move towards the Tana River during the dry season (Figs 8a and 8b).

Livestock are normally moved to permanent wells and major seasonal river valleys in search of water and pasture and should the dry season lengthen, onto the Tana River. The major well sites are Bangale, Wayu, Waldena, Assa, Bilbil, and Dukanotu. The seasonal rivers include Kokani, Hirimani, Galole, and Thua. Important dry season fall-back areas are the flood plain grasslands in the Tana delta, and other flood plains along and close to the Tana River. Herds move northwards towards the Kora National Reserve as well. The survey reveals that there are good grazing areas but without water.

These areas where availability of water is the most significant limitation to pasture use during the dry season include areas between Matoboke and Chiffri close to lag (river) Komoli, areas west of river Hirimani, north of Waldena, Adi, and west of Assa. If boreholes or wells are set in these areas competition for forage during dry season may be minimized. However, concentration of too many wells in a given area may cause localized overgrazing and environmental degradation (Warren and Maizels 1977; Sanford 1983; Livingstone 1991). Sinclair and Fryxell (1985) quote Wade (1974) regarding the effects as " each borehole became the center of its own little deserts".

During the wet season, livestock and wildlife disperse westwards from the Tana River as was also noted by Watson et al. 1973 and Kufwawa (1985). This is indicated by examining the 1980 dry season survey and wet season surveys of 1988 and 1990 (Appendix E) for cattle, sheep and goats. The same movement is also true for wildlife during the wet season. The dispersal is shown by Burchell's zebra, impala, and buffalo, in 1988 and 1990, and elephant in 1990.

The dry season movement is illustrated by Burchell's zebra, impala, elephant, and buffalo in 1978 and 1980, and buffalo in 1985. The movement is mainly towards the Tana and Galana rivers.

4.1.5 LAND USE SURVEY FINDINGS AND ANALYSIS

The questionnaire (Appendix C) which was personally administered formed the basis of this descriptive survey to get a sense of conflicts between wildlife and arable farming and constriction of pastoral-livestock range.

The farmers were mainly from the Pokomo tribe. Other ethnic groups included the Malakote, Munyuyaya, Sanye (Wata), and the Mijikenda. A few Orma and Somali people also practise farming. The farmers on the major irrigation schemes represented most of the major tribes in Kenya and included the Kikuyu, Meru, Embu, Luhya, Kamba, and Luo.

Two of the major irrigation schemes, Bura (Plate 1) and Hola have displaced wildlife and livestock from their former grazing range. Bura's main canal (Fig 16, Plate 2) runs for

Plate 1. Cotton Growing in Bura Irrigation scheme

Plate 2. The Main Canal, Bura Irrigation Scheme

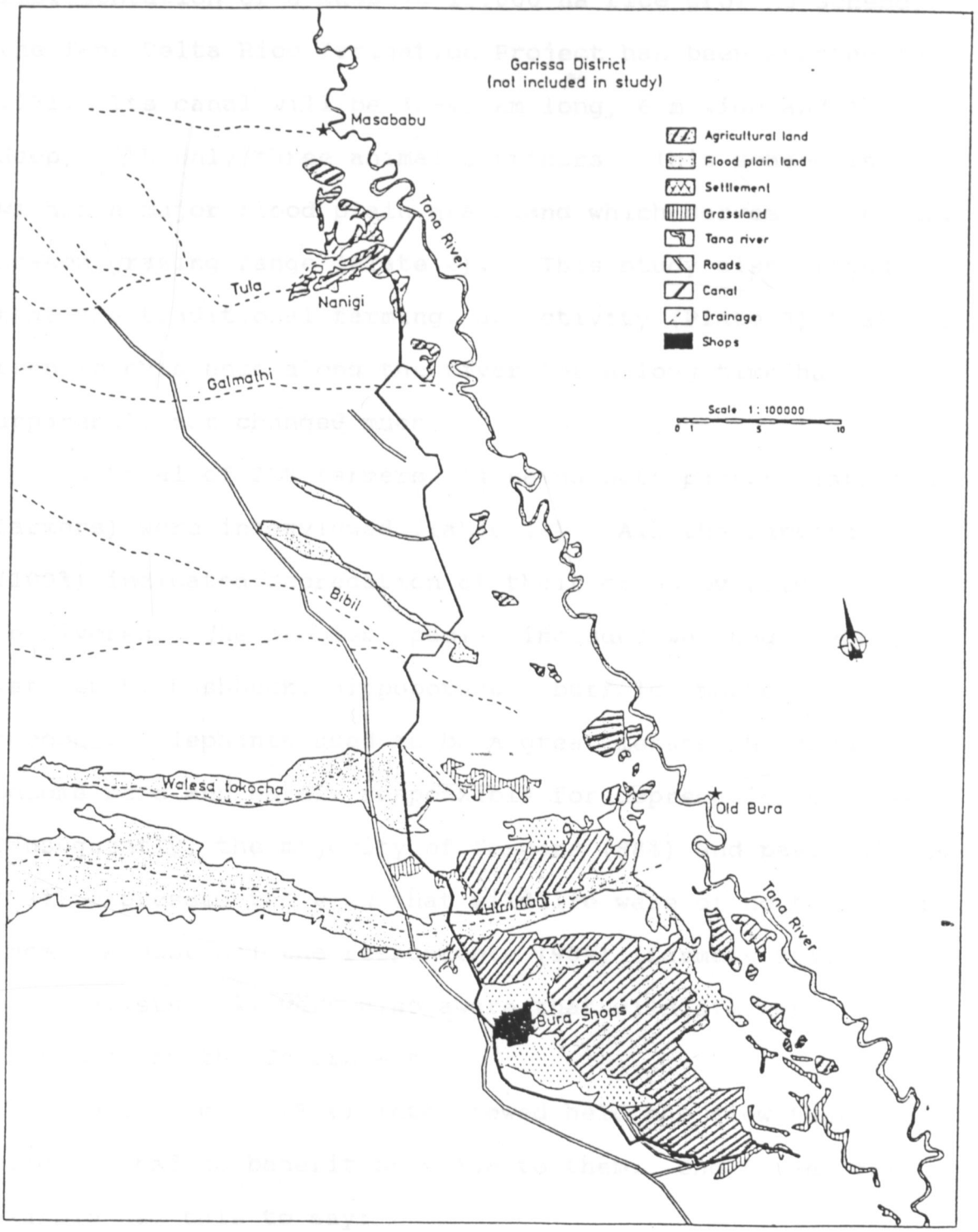

Figure 16. Land-Use and Cover Types for Bura. Adapted from DRSRS, 1991.

58 km and Hola for 17 km along the river. These canals have depths of 2-3 m and widths of 4 m. Also, the implementation of a massive 12,000 ha rice growing scheme, the Tana Delta Rice Irrigation Project has been started in 1991. Its canal will be 32-47 km long, 6 m wide and 1.2 m deep, with only three animal corridors. This scheme is within a major flood plain grassland which serves as the dry season grazing range (Plate 4). This study also, found that the traditional farming, an activity (Plate 3) that has been in existence along the river for a long time has apparently not changed much.

A total of 228 farmers (14 being both pastoralists and farmers) were interviewed (Table 12). All the farmers (100%) indicated depredation of their crops by wild herbivores. The problem species included warthog, zebra, waterbuck, bushbuck, hippopotamus, buffalo, monkeys and baboons. Elephants used to be a great menace but have become rare and hardly responsible for depredation problem. Consequently, the majority of farmers (88%) and pastoralists (82%) expressed the view that wildlife were of no benefit to them. Almost all the respondents (98%) (farmers 98%, pastoralists 99%) were also aware that wildlife were protected by the Government.

Most farmers (88%) interviewed held the view that wildlife had no benefit or value to them. One farmer for example had this to say:

Plate 4. Traditional Farming along the Tana River

Plate 3. Flood Plain Grassland in Danisa, within Tana Delta Irrigation Project

Table 12. Respondent Attitudes Towards Wild Herbivores in Tana River District

	PROPORTION (%)				
LL	Wildlife value:no	Wildlife value:yes	Wildlife *yes/no	Protection aware	Protection not aware
roup					
=350	85	9	6	98	2
arm-					
=214	88	8	4	98	2
asto-					
alists					
=122	82	10	7	99	1
oth					
= 14	100	0	0	100	0

*Denotes a situation where the respondent was indifferent about the wildlife value, i.e answered yes and no.

"What benefit do I get from wildlife when the little I plant is harvested by these animals with no pay from the Government. Furthermore, I can no longer kill any animal for subsistence --the Government had better keep its animals off".

A total of 136 pastoralists (Table 12) that included the Orma (103) and the Somali (19) were interviewed. Similarly, the majority (82%) of the pastoralists were of the view that wild herbivores had no value or benefit to them because of either transmission of diseases (38%) or competition for forage (53%) with their stock, particularly during the dry seasons.

One pastoralist, for instance, responded that he was afraid of hunting for meat because wildlife is the "property" of the Government and no longer "free" as in the past.

Pastoralist interviewees attached loss of their grazing land to parks and reserves (45%), irrigation (32%), drought (21%), ranching (18%), overgrazing (17%), and pests and diseases (2%).

The ranches in the study area are either implemented and developed and operational or undeveloped and non-operational. One of the most developed is Ida-Saa Godana (plates 5 and 6). Each member is allowed a certain number of livestock. Most of the shareholders are pastoralists. On these ranches, owned by shareholders, only members'

Plate 5. Cattle Grazing in Ida-Saa Godana Ranch

Plate 6. Ranch Infrastructure (water reservoirs, dips, crushes) in Ida-Saa Godana Ranch

livestock are allowed. Entry of other livestock is prohibited, contraveners risking heavy fines. However, with payment of water and grazing fees livestock of non-members are occasionally allowed access.

Further, the survey showed that overgrazing and trampling by hoof activity by large herds of livestock were the cause of environmental change according to 82% and 56% of pastoralist interviewees respectively. Overgrazing has also led to destruction of herbaceous vegetation (Plate 7). This effect is common around overcrowded areas such as wells and near permanent settlements or villages. The situation becomes severe during dry seasons when there is scarce forage for both wildlife and livestock. Pastoralists agree that competition is minimal during wet seasons. Pastoralists harboured the view that land degradation was in part due to pressure by large herds of livestock (71%), increase in human population (71%), and unreliable rainfall (42%). Most pastoralists (66%) provided movement of livestock or minimal cutting off trees as methods to ease environmental degradation.

This study revealed that forest areas have been lost to farming, accidental and deliberate fires. Farmers open up bush for agriculture and pastoralists set fires to open up bush to facilitate easy passage of the people and their livestock, to stimulate new growth to obtain better biomass and to kill parasites and pests (Plate 8). These traditional

Plate 7. Overgrazing Scene at Maramtu near Tana River, Madogo Division

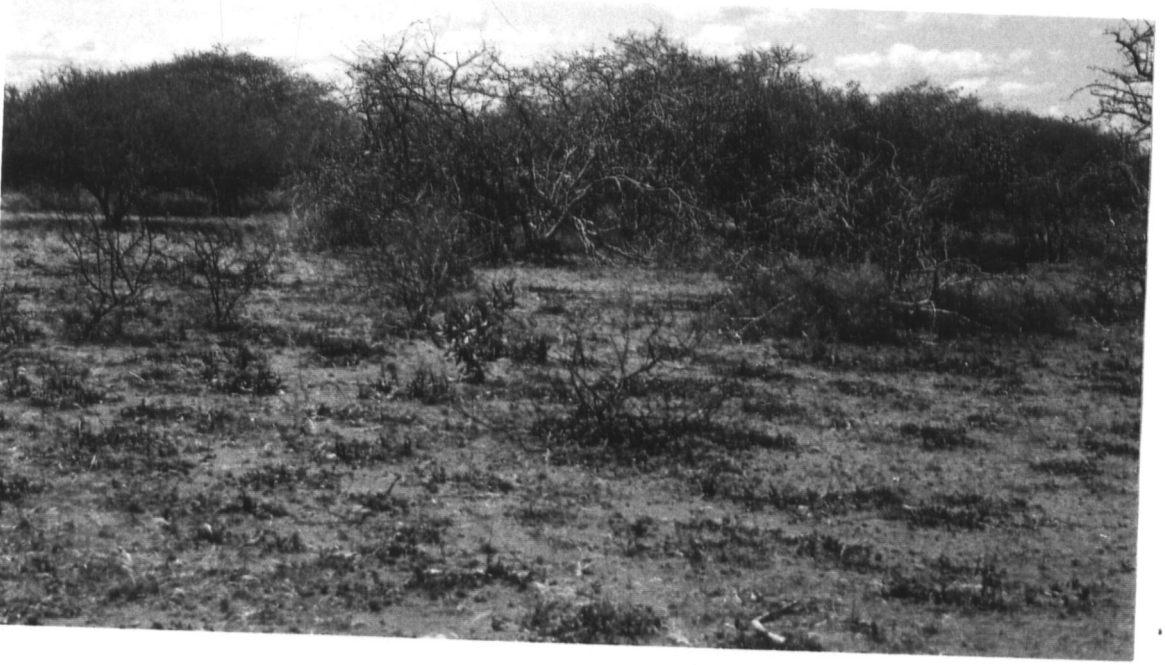

Plate 8. Incidence of Vegetation Burning at Tiltilla, Galole Division

techniques for range improvement and management are also noted by Niamir (1990). The Orma also claim that their grazing areas have been reduced by influx from the Somali people from the Northeastern province (24%).

4.2 DISCUSSION

This section considers seasonal animal movements, the trend of certain species and probable reasons for changes in the numbers and distribution of livestock and wild herbivores over the years.

4.2.1 LIVESTOCK

The 1977, 1978, 1980 and 1985 surveys were conducted during dry seasons, and the 1988 and 1990 censuses during the wet seasons. The animals moved to and from the Tana River district during different seasons. During the drought or dry spell herds move to the Tana River (Watson et al. 1973; Kufwafwa 1985).

During the wet season, animals disperse away from the Tana River, westwards to other parts within the Tana River District, in agreement with Watson et al. 1973 and Kufwafwa 1985. Therefore, surveys conducted during such periods showed either high or low estimates during the same periods, and also affected the pattern and densities of individual species.

There were drought spells which might explain why the densities or the numbers of animals declined. There was a

mild one in 1979, and a prolonged and severe nationwide one in 1984. The latter, was responsible for massive death of both livestock and wild herbivores.

It is difficult to provide a precise estimate of the animals that had died because of the 1984 drought since no complete survey was undertaken immediately before the drought. However, the 1985 census was carried out immediately after the drought, as indicated by the fact that the numbers obtained compared to previous censuses were lower.

Decreases could also be attributed to marketing and emigration. Immigration can also mask the effects of the drought. It should also be noted that in the early 1970s and periods before then raids by bandits (called shiftas) often led to loss and reduction of livestock in Tana River District.

On the average, wild herbivores were slightly less affected by the drought than livestock possibly due to their less dependence on water because of various behavioural and physiological adaptations (Pratt and Gwynne 1977).

The increases in numbers of livestock in some years, i.e, during wet seasons can possibly be explained by natural reproductive recruitment, improved veterinary attention and in some cases due to improvement in survey methodology which improves sampling intensity.

4.2.2 WILD HERBIVORES

The same environmental parameters discussed above influence wild herbivore numbers, densities and distribution, particularly with regard to the 1979 and 1984 drought effects, as evidenced by the decline in numbers of most species between 1980 and 1985. The increases were possibly due to the same factors as for livestock save veterinary services. Most species increased between 1977 and 1978, and 1985 and 1988.

Movement and population dynamics of wild herbivores are also related to availability of food resources. The onset of the wet season improves the range conditions, for example, the water and forage in all areas allows dispersal and movement to areas of minimal human disturbance. This was possibly the case in the above wet years.

However, the decreases in addition to the natural factors such as droughts could be ascribed to poaching particularly for the elephant and the rhinoceros, natural mortality, habitat destruction due to human activities such as agricultural development (irrigation schemes), and competition from livestock as indicated by the ratio of livestock to wild herbivores (Table 9).

On the whole, wild herbivores were slightly less affected by drought than livestock. It should be noted that due to the organization of several species into small herds of various sizes and low densities, there is possibility of

fluctuation in their numbers as also suggested by Kufwafwa (1985). This author also noted that fluctuations of various wildlife species may be attributed to seasonal distribution because some species aggregate during the dry season, consequently increasing transect variance, thus providing estimates with higher standard errors. Furthermore, some wild herbivore species like the topi and Hunter's hartebeest are migratory.

4.2.3 TREND IN NUMBERS OF ENDANGERED SPECIES

The ratio of live to dead elephants had decreased generally from 3:1 in 1977 to 1:99 through 1990 (Table 11), implying an increase in the ratio of dead to live. This is an indication of rapid rise in elephant mortality. Their numbers and distribution have plummeted to very low levels from 1977 to 1990. Despite the Government's effort to prohibit hunting and dealing in trophies by proclamation of an Act in 1976, and strict enforcement by antipoaching forces, poaching continued.

This called for an urgent need for conservation measures both at national and international levels, and finally led to the placement of the elephant under Appendix One of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) in 1989.

Because of the above move I believe the international markets will disappear and the survival of this species

maintained. The main threat was and still is poaching (Cobb 1976; Hillman 1977; Ottichilo 1981; Pilgram and Western 1986; Douglas-Hamilton 1987), but environmental factors such as drought, and the encroachment of man on their habitat are partly responsible.

The rhinoceros, too, has been the victim of poaching for their horns used as aphrodisiac, analgesic and ceremonial daggers (Western 1987) in Asian countries. None has been seen in surveys since 1980. This possibly suggests they have been eliminated there. In fact, the few left in the entire nation are protected in parks and sanctuaries (Western 1987). Like the elephant, this species had long been placed under the Appendix One of CITES but their poaching continued unabated.

4.2.4.1 IMPACT OF AGRICULTURE ON WILDLIFE AND LIVESTOCK DISTRIBUTION

Irrigation Schemes

The irrigation canals mentioned earlier with depths of over 1 m and width of at least 4 m, can act as barriers to animals and prevent access to the river and grazing ranges. The few passages along the lengthy canals allow little movement of animals.

Moreover, the depths and widths can cause accidental animal mortality. Furthermore, irrigation rules and by-laws prohibit entry of livestock into the schemes lest crops are

destroyed.

However, one important observation from the survey was that these canals have turned out to be important sources of water for Man and his livestock, and wildlife. Large herds of cattle, sheep and goats, zebras, and warthogs were common sights. About 32% of the pastoralist respondents attributed irrigation schemes as an activity that reduced their grazing ranges.

Also, most minor irrigation schemes (Fig 11) and Bura are located within the flood plain which serve as important grazing range. This situation will be aggravated further with the implementation of the Tana Delta Rice Irrigation project.

The latter scheme is within a major flood plain grassland (Plate 4) which serves as prime dry season grazing grounds for both pastoral livestock and wild herbivores. Since this area is a critical dry season fall-back area, the density of both wild herbivores and livestock usually increases during the dry season. Consequently, the establishment of this project will lead to even more overstocking and hence overgrazing. Many animals will die as a result, thus reducing their population.

Traditional Farming

The land use survey conducted shows that there has been little evolution in this old activity. This is so because

of less application of inputs such as fertilizers, pests and disease controlling chemicals, and the use of simple farming implements. Also, because of small farm sizes and lack of title deeds access to loans was a problem.

All the respondent farmers reported heavy depredation of their crops by some wild herbivore species. This underlines the conflict that exists between agriculture and wildlife, and implies extension (overlap) of the range of these animals into farmlands. As arable land increases inland, which is the case, wildlife will be pushed further and further away. For the destruction of their crops, the farmers are seldom compensated. This has created hardened and hostile attitudes towards wildlife.

Because of the immediate loss incurred, farmers fail to realize that the money channelled into various development and welfare efforts accrue from tourism. Despite the fact that crop damage is an inevitable part of farming the government should compensate farmers for crop depredation to stem negative attitudes held by farmers. Despite that, 98 % of the farmers were fully aware of protection accorded to wildlife by the Government. Incidentally, farmers reported hardly any case of crop loss resulting from pastoral livestock, indicating that pastoralists rarely go there.

Ranches and Grazing Blocks

The ranches are private property and no longer allow other pastoralists to graze their animals there. Such

exclusions constitute reduced range and distribution for pastoral livestock as expressed by 18 % of pastoralist interviewees. Moreover, the restriction on the number of livestock allowed per member means reduction in the number of pastoral livestock. However, these may be beneficial because overgrazing will be minimized. Furthermore, installation of wells, crushes, dips and range reseeding and animal breeding will improve the quality of poor local stock.

As most of the ranches are undeveloped, wild herbivores have not yet been affected. Even, in the developed ranches wildlife still live undisturbed and in fact benefiting from water development in these ranches.

Ranch managers indicate that wildlife survival was considered when ranch development was being planned, that wildlife will be allowed to live on a sustainable basis. But as the stocking level increases and more developments are instituted (e.g roads, fencing, clearing etc) wild herbivores will be less tolerated, in which case their numbers and distribution will be affected negatively in the future. The Government should pay the ranch or block owners direct monetary benefits to promote good will and commitment to conservation of wildlife (Pratt and Gwynne 1977; Lusigi 1981). This may be necessary especially in the case of wildlife transmitting diseases to livestock. This approach essentially conforms with what Western (1987) referred to as

"people management", where people or communities in wildlife areas should be involved in decisions about conservation and utilization of wildlife that directly affects them, a point also shared by Abel and Blaikie (1986). Further, Abel and Blaikie (1986); Williams and Albon (1988) suggest that the alienation of people in wildlife areas has never worked because of hostility created towards wildlife. Also, the notion of co-management (Berkes et al. 1991; Pinkerton 1991; Potocnjak 1991; Usher 1991; Weiner 1991) where resource users and the government share management responsibilities may be considered, in this case, either with private ranchers or communal or grazing block owners.

Berkes et al. (1991) provide examples of resource use by the Aboriginal people of Canada, Pinkerton (1991) on a case of forestry, fisheries, and wildlife in Canada, Potocnjak (1991) on fisheries in Chile, Usher (1991) on wildlife in Canada, and Weiner (1991) on co-management of wildlife and natural resources in general.

Aboud (1986) notes that the socio-economic constraints in the implementation of range development are disregard of traditional knowledge for livestock and range management and pastoral social organizations and institutions by range planners and implementors. Aboud (1986) suggests blending of modern techniques and local traditional knowledge will help in project implementation and success. This idea is strongly supported in the words of Paul Parker as cited by Niamir

(1990) " an idea borrowed from the people, developed by the agronomist (or ranger or forester) and returned to the people again is much likely to be adopted than something totally alien to the culture". The above opinions emphasize the significance of local knowledge and management systems of natural resources (LKMS)(Niamir 1990) and hence the need for local participation in implementation of ranches and grazing blocks. The above initiative could succeed if pastoralists are educated on the significance of ranching and grazing blocks.

Pratt and Gwynne (1977) indicate that ranching of wild animals has been shown to be a profitable enterprise in Central and Southern Africa, but in East Africa (Kenya, Uganda and Tanzania) exploitation of wild animals for meat and other products was restricted to a few schemes. These authors for example, noted attempts with domesticated Thomson's gazelle, oryx and eland in the present Galana ranch. This proposal was hampered by diseases and legislation. I strongly believe this will be hampered by cultural forces, lack of managerial and technical skills, financial capability by the local people, and marketing problems for the products. Incidentally, such a proposition has been hardly attempted even in other major wildlife areas in Kenya. Therefore, the potential for commercial utilization of wildlife through ranching will be limited. But as mentioned before, the potential for non-consumptive

utilization such as photography and viewing exists, with improved infrastructural development. Also, it is worthwhile to re-introduce consumptive utilization such as hunting by lifting the standing Government ban in the future, subject to population status of wildlife species.

The long term danger of overstocking from wildlife in the ranches or blocks may be contained by culling or cropping (Pratt and Gwynne 1977). The ranchers should be made to believe that wildlife is their "second stock" or what Lusigi (1981) referred to as "second cattle". Also, corridors have been planned for access of both wildlife and livestock between ranch boundaries.

Grazing blocks if implemented will eventually, involve restriction on herd sizes in order to keep herds within the carrying capacity. This may ultimately result in the reduction of animal numbers. Since blocks might not be fenced, wildlife might not be affected. This venture will, however, sedentarize the pastoralists and lead to improvement in the quality of livestock with envisaged development of ranch infrastructure such as water, range reseeding, dips and crushes, and animal breeding, thus achieving the stated aim of improving livestock production.

The settlements created as a result of sedenterization may interfere with wildlife movement and possibly result in more localized use of vegetation for fuelwood and settlement construction. As mentioned earlier, if the idea of wildlife

being their "second stock" is instilled into pastoralists and if benefits from tourism accrue to pastoralists, wildlife may coexist with the pastoralists as they did in the past.

4.2.4.2 IMPACT OF PARKS AND RESERVES ON THE NUMBERS AND DISTRIBUTION OF WILD HERBIVORES AND LIVESTOCK

The creation of parks and reserves are in the interest of wildlife survival, habitats for their biological and ecological welfare. To this end, with suitable habitat wildlife numbers can increase.

As far as pastoralists are concerned, what used to be their grazing range had been lost to establishment of wildlife sanctuaries, and are prohibited from grazing in parks and reserves (Fig 10). Also, there is a plan to create another reserve in the wetland areas of Garsen Division.

Despite, restrictions, livestock move towards Kora National Reserve during dry seasons. The exclusion of livestock from reserves implies reduction in their former grazing ranges and the upset of their former distribution. Pastoralists perceive that they have coexisted with wildlife in the past with minimal competition for resources in agreement with Lusigi (1981).

4.2.4.3 IMPACT OF FORESTRY ON THE NUMBERS AND DISTRIBUTION OF LIVESTOCK AND WILD HERBIVORES

Afforestation will probably have implications on livestock and wildlife numbers and distribution in the future.

Forest areas have been lost to farming, and to accidental and deliberate fires as noted by Marsh (1976); Allaway (1979); Trent-Bunderson (1981); and Loth (1988).

Woody vegetation is also cleared for fuelwood and the construction of animal enclosures and house building. Forestry department is making efforts to establish woodlots for fuelwood supply as is Kenya-Finland Bura Woodfuel Project. This is a joint activity between the Governments of Kenya and Finland aimed at development of suitable tree species for fuelwood in the Bura Division.

As pointed out earlier, pastoralists have traditional techniques of containing such environmental hazards of overgrazing and vegetation destruction by herd movement. For example, cutting only a few branches off a tree for domestic use instead of killing an entire tree is also a conservation measure used by the pastoralists. Niamir (1990) observes selective lopping of trees as a traditional method of range improvement. This procedure leaves the tree alive and continue to grow and reduce environmental degradation such as soil erosion. This emphasizes the importance of traditional ecological knowledge. Such

measures can lead to sustainable use of forage resources.

The establishment of such forest preserves may be beneficial to some wildlife species by creating new habitats but may also interfere with the habitat preference of others. However, for pastoralists this entails further loss of grazing land and reduced range and distribution.

4.2.4.4 OTHER FACTORS AFFECTING LIVESTOCK

Other factors emanating from this study that have possibly led to the reduction of grazing range of pastoral livestock include diseases and pests, influx of livestock and people from the North Eastern Province, environmental factors such as drought brought about by erratic and unreliable rainfall, and overgrazing due to large herd sizes (Plate 7). This problem is prevalent near permanent settlements, wells and major grazing areas near rivers. Security in the northern parts of the district was also pointed out as a factor that could affect the distribution of livestock by pastoralist respondents.

Further, interviewees from the survey indicated that pests such as tsetse flies are common along the riverine vegetation, particularly around Danisa and Wenje in Garsen Division. Therefore, when considering the effects of land use changes on wildlife or livestock, the above issues should be kept in mind.

Interviews conducted showed the common diseases of animals included contagious bovine pleuropneumonia (CBPP), contagious caprine pleuropneumonia (CCPP), foot and mouth, and rinderpest. The government in an effort to reduce transmission of these diseases does restrict herd movements between provinces.

CHAPTER V

5.0 AN OVERVIEW, CONCLUSIONS AND RECOMMENDATIONS

5.1 AN OVERVIEW

Chapter I covered general introduction, the study area and its topography, geology, soils and climate, and socio-cultural information. The research problem is also stated, the research scope and limitations provided, and the objectives outlined. Chapter II examined work done by previous researchers on animal numbers and distribution, pointing out the spotty coverage of the area and hence unreliability of such data for planning purposes for the district. Also, other resource issues which affect numbers and distribution such as vegetation and water have been gathered from documented literature. Likewise, detailed information on land use encompassing agriculture (arable farming), livestock and tourism are provided.

Chapter III presented methods employed in the generation and analysis of data for achievement of objectives of the study. Methods of acquisition and analysis of animal and land use data are detailed.

Chapter IV presented and examined results based on the objectives of the study. These included population estimates, densities and distribution patterns in space and time, the status of some endangered species, seasonal movements and land use changes and impacts. Discussion on the above issues were also considered.

Chapter V gives general inferences and recommendations arising from the study.

5.2 CONCLUSIONS

Land use changes such as more irrigation schemes, ranches and grazing blocks, settlements, and game reserves will continue to occur in the Tana River District, and so will the changes in numbers and distribution of pastoral livestock and wild herbivores. Consequently, conflicts among various land use types such as pastoralism, arable farming and tourism will also intensify. An increasing human population will continue to demand more potential agricultural land to be put under food production to sustain human survival, principally by irrigation. This will negatively affect pastoral livestock and wild herbivores, especially if the flood plain grasslands disappear. The establishment of a wetland wildlife reserve may help wildlife but will affect pastoralists if their livestock is denied access.

Implementation and development of ranches and grazing blocks is a viable option in rangeland management in the face of continuing land use evolution and national government policy objectives mentioned earlier. The past pastoral strategies involving extensive migration and mobility break down when range is reduced and fragmented. What may be possible, though, is "modified migration" with

controlled rotational grazing to coordinate grazing and watering activities (Niamir 1990; Swallow 1989). Ranches and grazing blocks will ultimately diminish land available for pastoral livestock and hence their numbers. This is because the defined land will have the capacity to support a certain population of livestock. Likewise, wildlife living in ranches and grazing blocks will be negatively affected in terms of numbers, distribution and densities and be eliminated in the long run due to the competition that will develop from the carrying capacity and infrastructural developments. Ultimately, because of clash in the land use types, there is the likelihood of negative impacts on existing biodiversity. For example, the long term survival of wildlife will be questionable considering the burgeoning human population (Table 3) which will seek ways to increase food production either through arable farming or livestock production.

Rangelands which have not yet been privatized by enclosure still have the potential to be managed for both livestock and wildlife on a sustainable basis. In this context the concept of multiple land use can be applied to harmonize and reduce conflicts that exist among various land use types, with proper and integrated resource planning and management. So far, the role of local people in changing land use patterns has been limited. The changes which have generated conflicts have been designed by government policy,

but negative consequences of the conflicts of resource utilization are faced by local people. To this end, participation of local people in matters that affect them is crucial. Further, the people should be educated and enlightened on negative consequences (caused by themselves) arising out of the land use conflicts. Aside from land use changes, other factors that include diseases and pests, drought, security, and influx of people and livestock from other provinces contribute to the decline in numbers and distribution of livestock as revealed by the land use surveys and interviews.

Poaching was and still is the primary factor responsible for decline in numbers of elephants and rhinoceroses. In addition, the loss of habitat due to farming activities along the Tana River is partly responsible for the downward trend in elephant population and reduced distribution. Generally, mechanisms for public participation in the use and management of resources in the district is lacking. Therefore, involvement of local inhabitants, in the decision making process on issues that affect them (e.g., crop depredation, future use of wildlife in ranches and blocks, etc.) is necessary. Such involvement will, however, require local socio-political institutions that function properly in order to achieve success. Pastoral livestock move to and from the Tana River during different seasons. During the dry season the movement is

towards the river and during the wet season a general westward movement away from the river. At the early stages of dry season movement, herds utilize the seasonal rivers and the permanent wells in the interior, then onto the Tana River when the drought becomes severe. Also, due to the communal tenure system, overgrazing occurs, particularly during the dry season, when the animals congregate on major grazing ranges and water sources.

5.3 RECOMMENDATIONS

On the basis of the foregoing results, discussion and conclusions, to alleviate or ease the impacts of changing land use patterns on the numbers and distribution of pastoral livestock and wild herbivores and to address conflicts that arise from the changes, the following strategies are recommended to various Government ministries and agencies:

1. Wildlife corridors be established within the present or future irrigation schemes, and farmlands to allow wildlife and pastoral livestock access to the Tana River and remaining grazing grounds. However, the policy implication for Government is the problem of compensating farmers for crop depredation. The Ministries of Agriculture, and Tourism and Wildlife, and the National Irrigation Board (NIB) should be

involved in this regard.

2. Mitigate farmers' losses incurred due to wildlife damage. In addition, the farmers should receive tangible monetary benefits or realize social benefits (schools, health centres, etc) accruing from tourism. This emphasizes the need for tolerance from the people living near wildlife parks, reserves and habitat in the vicinity of farmlands, i.e soften people's attitudes towards wildlife. However, it is difficult to determine what to pay for farmers claims. Nevertheless, the farmers should have input to the decision making process in the determination of the compensation package. Again, the Ministries of Agriculture, and Tourism and Wildlife, and farmers should be involved.
3. Allow nomadic pastoralists limited access to some game reserves, for instance, Kora, by controlled grazing during times of extreme drought under supervision of wildlife personnel and local leaders. This is in line with the concept of co-management, where land resources are managed jointly by the government and resource users. For this idea to work local-level institutional arrangements are necessary. Indeed, this is a flexible way of integrating conservation with traditional land use practices. The Ministries of Agriculture, and Tourism and Wildlife, and pastoralists should be

involved.

4. The concept of multiple land use be employed where necessary. Where the benefit from wildlife use exceeds agricultural use, on the basis of careful weighing of options, with local inputs perhaps involving environmental impact assessments and cost-benefit analysis, wildlife interest prevails and vice versa, This will definately involve some trade-off. In making this trade-off, consideration should be given to the issue of food security in line with National Food Policy. The intent of implementation of the Tana Delta Rice Scheme is to save the country foreign exchange on imported rice, as well as the provision of employment and increased local income. Several Ministries will feature in this including Planning and National Development, Agriculture, Tourism and Wildlife, and Environment and Natural Resources.

5. Important or critical wildlife species and habitat should have continued protection from human influence. Strict and stringent conservation measures both at national and international levels should be exercised to prevent the local extinction of such animals as the elephant and rhinoceros. International efforts towards the elimination of markets for products of these animals

and national antipoaching efforts should be continued and strengthened. Such reserves as the Tana River Primate and the Tsavo National Park should be protected from human interference. However, the local people should be educated on the significance of tourism to the national economy and local needs and the intrinsic value of wildlife. The Ministry of Tourism and Wildlife should actively participate.

6. Implementation of grazing blocks and ranches for pastoral livestock should be attempted. This move with proper planning and assistance from the Government and other institutions will help reduce such "tragedies of the commons" (Hardin 1968) like overgrazing, and hence competition for resource utilization with wild herbivores. Since this entails dealing with cultural issues that have existed for a long time, policy measures to achieve any transition from wholly pastoralism lifestyle to relatively modern livestock practice and management, the government should involve the local people to minimize resistance based on cultural conflicts. The Ministries of Agriculture, Tourism and Wildlife, and Planning and National Development, as well as the pastoralists should work together.

7. Create wells and surface dams, especially in good grazing

areas without water to reduce competition and reduce environmental pressure. This should, however, be dispersed to prevent localized overgrazing and habitat degradation which may result from animal concentration around such water sources. Furthermore, the benefits will go beyond water needs for the animals as it may equally serve the domestic water needs of the pastoralists, thus integrating wildlife management with other local needs. The Ministries of Water Development, Planning and National Development, and local Government should participate.

8. More research should be conducted to understand more specific seasonal movement patterns of both wild herbivores and pastoral livestock to enable proper resource planning and utilization. More frequent annual dry and wet season stratified sampling surveys should be undertaken to attain better insights into the seasonal mobility and distribution of animals.

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APPENDIX A: "JOLLY 2" METHOD OF UNEQUAL TRANSECTS

$$\hat{X}=\frac{\hat{Y}_{(1)}X_{(1)}}{\hat{Y}_{(1)}}\ \frac{Z}{Z_{(1)}}$$

$$Var(\hat{X})=\sum N_i^2\{(\frac{1}{n_i}-\frac{1}{N_i})(s_{xi}^2-2\hat{T}s_{xzi}+\hat{T}^2s_{zi}^2)+\frac{1}{\hat{R}^2}(\frac{1}{n_i}-\frac{1}{n'_i})(s_{yi}^2-2\hat{R}s_{xyi}+\hat{R}^2s_x^2)\}$$

Where $\hat{T}=\frac{x_{(1)}}{\hat{Z}_{(1)}}$

n= number of units in the sub-sample

n'=number of units in the main sample

N= A total population

Y'= counts from main sample

$\hat{Y}'_{(1)}$=sub-sample

$Y'_{(1)}$=Population Estimate

y=Observed count

X=Total number of animals in the population

x=photo count ('accurate')

$\hat{R}$= Estimated ratio of x and y

$\hat{X}$=population estimate

Z=Total area

z=sample unit area

Var= Variance

Source: Jolly, 1969.

APPENDIX B: CLASSIFICATION OF ELEPHANT BONES

The occurence of elephant carcasses is recorded during surveys. The classsification system of Douglas-Hamilton and Hillman (1979) is used and is summarized below:

Elephant Fresh Carcass: Elephants which have recently died. The skin is still present and the flesh has not been eaten or rotted away.

Elephant Bones Rotten: Elephants which have died recently, however the ground around the carcass can be stained and the grass destroyed by the release of decomposition fluids. The presence of this rot patch is the primary criterion for this category.

Elephant Bones Not Rotten (NR): After heavy rains the rot patch may be washed away and grass returns. The skin may remain, however the white skull and bones are clearly visible.

Elephants Bones Grey: After several years, bones weather and become grey in colour. Skeletons no longer form distinct entities.

Source: Douglas-Hamilton and Hillman, 1979.

APPENDIX C: LAND-USE ASSESSMENT QUESTIONNAIRE/SCHEDULE

Name.....Ethnic.....

Group.....Place.....

Farmer (arable).....Pastoralist.....Both....

PART I: PASTORALIST

1) (a) How many times do you move in a year?.....

(b) What factors would make you opt to stay in one place?

i) Availability of water...

ii) Availability of facilities (health, schools, shops)...

iii) Availability of forage for livestock...

d) Availability of security...

iv) What reasons would make you move from place to place?

a) To be near water...

b) In search of pasture ...

c) To avoid animal pests and parasites (ticks, tsetse)...

d) To avoid conflicts with neighbours (name).....

e) To avoid raids...

f) Others (specify).....

2) (i) What domestic animals do you rear?

cattle... sheep and goats...camels...donkeys..

(ii) Do you sell animals? livestock sold....

income Ksh.....

(iii) what are the main constraints to livestock sales?

a) Availability of markets...

b) Accessibility to markets...

c) Low prices offered for animals...

d) Livestock Marketing Division (LMD) inactive in the area...

e) LMD present but does not pay in time for animals purchased....

f) Can not spare animals for sale...why.....

g) Other (specify).....

3) (i) Are livestock agents of environmental change?

YES...NO...

If YES, how do they effect change?

a) Overgrazing...

b) Trampling...

c) Other (specify)...

(ii) Do you think there is pressure on land resources?

YES.....NO...

If YES, what are the main causes of land degradation in the area?

a) No pressure....

b) Pressure due to increase in number of people...

c) Pressure due to restriction on land use...

d) Pressure due to deterioration of rainfall...

e) Pressure due to many livestock...

f) God's will...

g) Other (specify)...

(iii) Are there methods (traditional or otherwise) practised to ensure environmental conservation?

YES... NO.....

If YES, what are they.....

4) State the number of water sources (rivers, wells, etc) used by livestock and specify whether permanent or temporary:

a) Camels.....

b) Cattle.....

c) Sheep and goats.....

5) (i) State the major grazing areas used each year by animals in 4.

a) Any time (where from).....

b) During dry season (where to).....

c) During wet season (where to).....

d) Other (specify).....

(ii) Have the grazing ranges for your stock been affected in any way over the years? YES... NO...

If YES, how?.....

6) (a) Do you belong to any ranch/grazing block

YES (name).... size .....acres.

If NO why not?

i) Not aware such a venture...

ii) Not allowed to join, why? restriction on membership...

iii) Any other (specify)...

iv) Joining reduces livestock number

v) Other (specify)

(b) Do you face any problems on the ranch/grazing block?

YES...NO...

If YES, why?

i) Water...

ii) Veterinary services (dips, drugs, extension services)...

iii) No credit facilities (e.g money for development)

iv) Other (specify)...

PART II: <u>FARMER</u>

1) (a) Do you practise any form of arable agriculture?

YES..NO...

If YES, rainfed... irrigation.....farm size ....acres

List most important crops:

i) Cash.....

ii) Subsistence (food crops).....

2) (a) What types of livestock do you keep on your farm?

Cattle:

i) Exotic breeds (name).....#....

ii) Local breeds.....#....

Sheep and Goats.....#....

Other (specify).....#....

(b) Do you do zero-grazing? YES...NO...

3) (a) What is the source of your farm labour?

i) Own family

ii) Hired human labour

iii) Farm animals

iv) Machinery, own....hired....

(b) Sources of agricultural credits?

i) AFC

ii) Banks

iii) Co-operatives

iv) Other (specify) _____

(c) Do you employ other inputs in your agricultural production?

i) Fertilizers

ii) Agricultural chemicals

iii) Improved seeds

iv) Other (specify)

4) Do you encounter any problems on the farm? YES..NO...

If YES

a) Transport

b) Marketing

c) Credit facilities

d) Diseases/pests

e) Wildlife

f) Other (specify)

5) Is any training offered to improve your farming skills?

YES.. NO...

a) Farmers training centres

b) Extension workers

c) Other (specify)

PART III: <u>BOTH (PASTORALIST/FARMER)</u>

1) (a) Do you encounter any problems from wild herbivores?

YES..NO..., If YES what are they?

i) Competition for resources (water, forage, space)

ii) Harm/injury/ destruction to people, livestock and crops

iii) Disease transmission to livestock

iv) Other (specify)

(b) Do wildlife (faunal) have any value/benefit to you?

YES..NO.. If YES, what are they?

i) Source of foreign exchange

ii) Source of meat

If NO, why not (see 1a)

(c) Are you aware that wildlife is protected/preserved by the Government? YES...NO...

2) (a) Do you sell charcoal? No.(bags).... income Ksh...

How often do you burn charcoal?

Daily...weekly...monthly.

(b) Except burning for charcoal making, is burning done for other purposes? YES....NO..... If YES, for what?

i) Kill pests (ticks, tsetse)

ii) Stimulate grass growth

ii) Open-up bushland for access, agriculture, etc

iv) Other (specify)

APPENDIX D: DRSRS DATA ANALYSIS PROCEDURE AND ASSUMPTIONS.

Data Verification and Formating

Data recieved from the field is keypunched, then transferred to the GIS computer by magnetic tape, and then are ran through the following programs:

CENSORT: Removes extraneous data entry batch numbers and assigns a census-ID to all flights. Forms separate files of FSO (Front Seat Observer) and RSO (Rear Seat Observer) data for each census-ID.

REDIT: Checks all data elements for accuracy and identifies errors for corrections. The number of observations and continuation records are checked as well as validity of observer codes, flight codes, UTM grid Id, and flight direction. Alpha and numeric fields are verified for appropriate data type. Species codes are checked for validity and count values are against predetermined " suspiciously high" count values.

CKUNIT: Checks accuracy of unit numbers and FSO and RSO values for consistency. Identifies errors in continuation codes, missing records, transect direction mismatch, flight code mismatch, observer seat mismatch, and left/right seat observer sequence violation.

REGRESS: Evaluates paired photo and visual counts to calculate a count ratio correction factor according to:

$$\text{Count Ratio} = \frac{\text{Photo Count}}{\text{Visual Count}}$$

The count ratio correction factors are stored for later use for each observer and for each species where the count ratio is based on greater than 5 observations. this multiplicative correction is applied to the visual counts where a photo count is not available for a visual count over 10.

The program also provides observer quality statistics such as the number of photos taken for visual counts over ten and produces a scattergram of the visual and photo count values for each observer.

FORMIT: Subsets RSO data into land use and wildlife/livestock data files and replaces visual counts with paired photo count. Uses count ratio correction factor to correct visual counts greater than 10 that have no corresponding photo count.

COMPARE: A comparison scattergram of left and right seat observer data is prepared for a user specified interval.

REFORM: Sums the observation of left and right seat observers and creates the final format database files from selected RSO and FSO data elements.

Extreme care is taken to ensure that data values are accurate. All errors are corrected through reference to the original data form or through consultation with the observer. In addition observer performance is evaluated.

Data Analysis and Reporting

The verified and formated data sets are read into a database manager for final processing and calculation of population estimates. The population estimates are calculated according to the procedures of Jolly "2" method (1969). All the processing is performed through one program to minimize operator error and ensure uniformity of analysis. The final processing is finalized as follows:

1. Sample units from the data file found within the desired district or study area are selected.
2. Transects are determined and the data values for the calculations for the population estimate parameters are made.

Correction factors for aircraft altitude variations are made to actual strip width according to:

$$\text{Actual strip width (Expected strip width*)} = \frac{\text{Actual flight height}}{\text{Expected flight height}}$$

In addition, a correction factor for partial units at study area boundaries are calculated. This multiplicative correction is applied to the area of the sample strip width and number of animals seen within the sample unit:

$$\text{Partial unit ratio} = \frac{\text{Partial unit area}}{\text{Actual unit area}}$$

3. Population estimates based on Jolly (1969) are generated.

ASSUMPTIONS and SPECIAL CONSIDERATIONS

1. In calculating population estimates it is assumed that animals are randomly distributed. Population estimates for rare animals or animals that are typically observed in groups will be characterized by high standard error.
2. Map density values are calculated based on the animals observed within the strip width, divided by the area of the survey strip width.
3. No correction for visibility bias is made.

APPENDIX E: POPULATION ESTIMATES, DISTRIBUTION PATTERNS, AND DENSITIES OF LIVESTOCK AND WILD HERBIVORE SPECIES IN THE TANA RIVER DISTRICT, 1977-1990

SOURCE: DRSRS SURVEYS.

N.B: INFORMATION FOR THIS APPENDIX CAN BE OBTAINED FROM:

The Natural Resources Institute,
The University of Manitoba,
R3T 2N2, Winnipeg, Manitoba, CANADA.

OR

The Department of Resources Surveys and Remote Sensing,
Ministry of Planning and National Development,
P.O Box 47146, Nairobi, KENYA.

TANA RIVER DISTRICT- ANIMAL SURVEY, 1977

SPECIES	POPULATION ESTIMATES	POPULATION STANDARD ERROR
Cattle	298038	65943
Sheep & Goat	294168	72755
Camel	34514	10721
Donkey	1646	604
Elephant	8717	3572
Elephant Fresh Carcass	667	310
Elephant Bones Rotten	489	164
Elephant Bones NR	1468	374
Elephant Bones Grey	89	88
Rhino	267	139
Giraffe	4937	1292
Burchell's Zebra	9118	3068
Grevy's Zebra	133	132
Thomson's Gazelle	1334	459
Grant's Gazelle	3291	833
Kongoni	133	132
Impala	1023	482
Topi	4537	2232
Hunter's Heartebeest	89	88
Buffalo	1690	1222
Eland	4892	2348
Ostrich	3647	672
Warthog	6672	1203
Oryx	10541	3076
Lesser Kudu	1334	425
Waterbuck	2980	1759
Gerenuk	2802	673

Period of Survey February, August 1977
Strip width: 0.224 km
Transect spacing: 10,00 km
Area sampled: 879 km^2
Total Area: 39072 km^2
Sampling Fraction: 2.25%

Source: DRSRS Surveys, 1977.

TANA RIVER DISTRICT- ANIMAL SURVEY, 1978

SPECIES	POPULATION ESTIMATES	POPULATION STANDARD ERROR
Cattle	210059	28797
Sheep & Goat	287242	49405
Camel	44255	11146
Donkey	2837	860
Elephant	3485	1039
Elephant Fresh Carcass	447	132
Elephant Bones Rotten	1385	336
Elephant Bones NR	5183	514
Elephant Bones Grey	514	143
Giraffe	4781	888
Burchell's Zebra	12823	2723
Thomson's Gazelle	2547	733
Grant's Gazelle	9360	1473
Kongoni	335	193
Impala	760	313
Topi	8578	3174
Hunter's Heartebeest	827	434
Buffalo	6814	2678
Eland	2949	1300
Ostrich	3262	732
Warthog	8802	1449
Oryx	15906	3076
Lesser Kudu	2167	401
Waterbuck	3999	1059
Gerenuk	4066	531

Period of Survey: January, September 1978
Strip Width: 0.224 km
Transect Spacing: 5.00 km
Area Sampled: 1749 km^2
Total Area: 39072 km^2
Sampling Fraction:4.48%

Source: DRSRS Surveys, 1978.

TANA RIVER DISTRICT- ANIMAL SURVEY, 1980

SPECIES	POPULATION ESTIMATES	POPULATION STANDARD ERROR
Cattle	314075	49846
Sheep & Goat	363919	73141
Camel	39184	9057
Donkey	2445	704
Elephant	4289	1205
Elephant Fresh Carcass	86	84
Elephant Bones Rotten	129	64
Elephant Bones NR	4375	668
Elephant Bones Grey	3174	612
Rhino	129	93
Giraffe	7335	2174
Burchell's Zebra	11667	3209
Grevy's Zebra	1244	525
Thomson's Gazelle	3067	840
Grant's Gazelle	13834	2776
Kongoni	1115	491
Impala	1587	566
Topi	10917	5257
Hunter's Heartebeest	1587	651
Buffalo	1544	866
Eland	1952	747
Ostrich	4289	1411
Warthog	8472	1231
Oryx	11860	2402
Lesser Kudu	2338	486
Waterbuck	7421	1910
Gerenuk	7078	1113

Period of Survey: July, September 1980
Strip Width: 0.250 km
Transect Spacing: 5.00 km
Area sampled: 1822 km^2
Total Area: 39072 km^2
Sampling Fraction: 4.66%

Source: DRSRS Surveys, 1980.

TANA RIVER DISTRICT- ANIMAL SURVEY, 1985

SPECIES	POPULATION ESTIMATES	POPULATION STANDARD ERROR
Cattle	148695	22617
Sheep & Goat	251526	41101
Camel	30219	4789
Donkey	1542	481
Elephant	1349	507
Elephant Fresh Carcass	35	24
Elephant Bones Rotten	18	17
Elephant Bones NR	2698	449
Elephant Bones Grey	596	145
Giraffe	4695	681
Burchell's Zebra	5974	1819
Grevy's Zebra	298	197
Grant's Gazelle	4677	1173
Impala	1051	417
Topi	1997	950
Hunter's Heartebeest	491	246
Buffalo	6710	5146
Eland	1209	826
Ostrich	1857	411
Warthog	1577	305
Oryx	3486	660
Lesser Kudu	1384	289
Waterbuck	3153	1215
Gerenuk	3399	560

Period of Survey: October 1985
Strip Width: 0.282 km
Transect Spacing: 5.00 km
Area Sampled: 2230 km^2
Total Area: 39072 km^2
Sampling Fraction: 5.71%

Source: DRSRS Surveys, 1985.

TANA RIVER DISTRICT- ANIMAL SURVEY, 1988

SPECIES	POPULATION ESTIMATES	POPULATION STANDARD ERROR
Cattle	305213	51273
Sheep & Goat	402848	53236
Camel	52425	7288
Donkey	2313	765
Elephant	1053	481
Elephant Fresh Carc.	35	23
Elephant Bones rotten	155	68
Elephant Bones NR	1208	228
Elephant Bone Grey	829	240
Giraffe	4212	553
Burchell's Zebra	6991	1077
Grevy's Zebra	224	162
Grant's Gazelle	6370	1122
Kongoni	17	17
Impala	1174	501
Topi	2693	1624
Hunter's Heartebeest	35	34
Buffalo	2417	1135
Eland	397	276
Ostrich	1070	383
Warthog	2037	408
Oryx	5455	887
Lesser Kudu	1554	251
Waterbuck	3073	1463
Gerenuk	2434	388

Period Of Survey: February, April 1988
Strip Width: 0.282 km
Transect Spacing: 5.00 km
Area Sampled: 2264 km^2
Total Area: 39072 km^2
Sampling Fraction: 5.79 %

Source: DRSRS Surveys, 1988.

TANA RIVER DISTRICT- ANIMAL SURVEY 1990

SPECIES	POPULATION ESTIMATES	POPULATION STANDARD ERROR
Cattle	202125	31824
Sheep & Goat	181827	30553
Camel	27097	6060
Donkey	825	304
Elephant	33	32
Elephant Bones Rotten	215	104
Elephant Bones NR	941	259
Elephant Bones Grey	1766	270
Giraffe	3466	573
Burchell's Zebra	5050	1234
Grevy's Zebra	1535	889
Thomson's Gazelle	875	310
Grant's Gazelle	3284	701
Kongoni	50	49
Impala	1289	469
Topi	2690	1191
Hunter's Heartebeest	561	242
Buffalo	3301	1305
Eland	1848	904
Ostrich	1931	667
Warthog	2558	498
Oryx	3664	788
Lesser Kudu	1914	415
Waterbuck	1040	433
Gerenuk	2129	476

Period Of Survey: March 1990
Strip Width: 0.304 km
Transect Spacing: 5.00 km
Area Sampled: 2368 km^2
Total Area: 39072 km^2
Sampling Fraction: 6.06 %